WAZA
World Association of Zoos and Aquariums

ACTION INDONESIA
GLOBAL SPECIES MANAGEMENT PLAN

Global Species Management Plan for Anoa (*Bubalus* sp.), Banteng (*Bos javanicus*), Babirusa (*Babyrousa* sp.) and Sumatran tiger (*Panthera tigris sumatrae*) 2023-2025




Executive Summary

The goal of the Action Indonesia Global Species Management Plans (GSMPs) is to achieve a stable and secure global *ex situ* populations of anoa (*Bubalus depressicornis* and *B. quarlesi*), banteng (*Bos javanicus javanicus*), babirusa (*Babyrousa* sp.) and Sumatran tiger (*Panthera tigris sumatrae*), and contribute to stable and secure *in situ* populations for each species. Anoa, banteng, babirusa and Sumatran tiger are all threatened taxa found in Indonesia. In the wild, these taxa are threatened primarily by habitat loss and illegal hunting. Due to the banteng being closely related to domestic cattle, they are particularly at risk from disease transmission and hybridisation.

This 2023-2025 Masterplan for the Action Indonesia Global Species Management Plans (GSMPs) is a three-year summary of work. This is complemented by a set of Action tables that will be used to track progress of successful implementation of activities.

Anoa, banteng, babirusa and Sumatran tiger are currently present in the zoos of four regional zoo associations. All regions are participating in the Action Indonesia GSMPs; two regional associations are signatories of the MOU for this partnership, the European Association of Zoos & Aquaria (EAZA) and the Association of Zoos & Aquariums (AZA) in North America, as well as the national Indonesian Zoo & Aquarium Association (PKBSI) on behalf of the South East Asian Zoo Association. Currently, there are approximately 270 anoa, 226 banteng, 194 babirusa and 329 Sumatran tiger held in institutions across these regions. Outside of PKBSI, the genetic diversity for all four taxa is less than 92% of that found in the wild population from which the founders were taken.

Target population sizes for each region were set for the ungulate species in 2016. For the Indonesian populations these were 75 anoa, 100 banteng and 100 babirusa. This is combined with maintaining at least 90% genetic diversity of each species for 100 years. Similar targets were set for EAZA and AZA regions. Sumatran tiger regional and global targets were set in 2012 and revised in 2022. Current PKBSI target population size is at least 100 tigers, with other regional targets between 50-130 tigers each and a global target of 400 tigers. Each program has a regional goal to maintain at least 90% gene diversity for 100 years.

From 2018-2022 there have been successful births in Indonesia, following the recommendations of 6 anoa, 23 banteng, 6 babirusa and 7 tiger births. This is a major success because this is the first time this many births have been achieved following recommendations. We acknowledge all the hard work of the zoos involved. This equates to successful implementation of between 17% and 31% of recommendations per species.

The populations in September 2022 were 35 anoa, 71 banteng, 70 babirusa and 86 tigers. Looking ahead, to maintain a stable or increasing population size an increasing number of births per year for at least the next two to three years for each species are needed. During this phase it is planned for two cycles of recommendations to be implemented, each for 18 months.

By the start of the next planning phase in 2026 it is proposed that the targets set for all regional populations are reviewed, to determine the cost-benefit for strengthening the global population with international transfers in the coming years or future phases of the GSMP programme.

For effective implementation of the 3rd set of recommendations, and future cycles of this process it is essential that there is further strengthening of expertise and knowledge in population management in Indonesia. This can be in the form of brainstorm workshops, additional expertise in PKBSI in population management (to allow for more data analysis to occur in Indonesia), and a greater awareness by the zoo community and Directorate of Biodiversity Conservation of Species and Genetic (KKHSG), Directorate General of Conservation Nature Resource and Ecosystem (KSDAE) is needed of the benefits of implementing recommendations for the conservation of the species and sustainability of zoos.

Genetic data will be included in the 4th set of recommendations for the ungulate species for the first time, and sampling of the Sumatran tiger Indonesian *ex situ* population will be conducted.

From 2018-2022, the Husbandry working group succeeded in developing and publishing husbandry recommendations for banteng and anoa and building capacity through training of 200 zoo staff. From 2023-2025, the working group will support the implementation of the current and future cycles of breeding and transfer recommendations through tailored advice and workshops to Indonesian zoos with a focus on successfully breeding and transferring animals. In addition, guidelines for tiger husbandry will be developed and disseminated.

Following the success of the global awareness raising day, Action Indonesia Day, awareness raising and engagement activities will continue to grow in the next period, alongside capacity building for PKBSI zoo and National Park education staff in Indonesia, and researching and addressing drivers of threats to the species *in situ*.

In support of banteng *in situ* conservation the next three years target is to collect data that will inform a plan for metapopulation management of banteng across Java. This involves analysis of estimates of population size of banteng in four national parks in Java. This will be combined with genetic data from 20 banteng from each of the parks, which is being led by KKHSG. These datasets will provide the necessary information for a Population Viability Analysis model (PVA) to give decision-makers options to maximise the likelihood of successfully achieving a viable population.

For anoa and babirusa *in situ* conservation, park wide population monitoring for Cagar Alam Faruhumpenai, South Sulawesi will be conducted. The GSMP with KKHSG will support the setup of a network and activities of interested stakeholders across the range of these two taxa. This will include holding information sharing calls and capacity building as requested.

We very much appreciated the strengthening relationships with PKBSI and KKHSG. We support greater *ex situ* support for *in situ* conservation efforts, and vice-versa. There have been very significant achievements made by these and all partners across all areas of work since 2016. This new phase for 2023-2025 has ambitious targets that can be delivered building on this strong collaborative team.

Acronyms

AWCSG	IUCN SSC Asian Wild Cattle Specialist Group
AZA	The Association of Zoos & Aquariums
BBKSDA	Nature Conservation Regional Office (*Balai Besar Konservasi Sumber Daya Alam*)
BKSDA	Nature Conservation Regional Office (*Balai Konservasi Sumber Daya Alam*)
BRIN	National Research and Innovation Agency (*Badan Riset dan Inovasi Nasional*)
CCTU	Center for The Conservation of Tropical Ungulates
EAZA	European Association of Zoos and Aquaria
EEP	European Endangered Species Programme
FGE	Founder genome equivalents
GSMP	Global Species Management Plan
IUCN	International Union for Conservation of Nature
IUCN SSC	IUCN Species Survival Commission
JAZA	Japanese Association of Zoos and Aquariums
KKHSG	Directorate of Biodiversity Conservation of Species and Genetics, the Indonesian Ministry for Environment and Forestry (*Direktorat Konservasi Keanekaragaman Hayati Spesies dan Genetik*)
KSDA	Nature Resource Conservation (*Konservasi Sumber Daya Alam*)
KSDAE	Directorate General of Conservation Nature Resource and Ecosystem, the Indonesian Ministry for Environment and Forestry (*Direktorat Jenderal Konservasi Sumber Daya Alam dan Ekosistem*)
MK	Mean Kinship
NGO	Non-Governmental Organisation
PKBSI	Indonesian Zoos & Aquariums Association (Perhimpunan Kebun Binatang Se-Indonesia)
SEAZA	South East Asian Zoos Association
SSP	Species Survival Plan®
TAG	Taxon Advisory Group
WAZA	World Association of Zoo and Aquariums
WPSG	IUCN SSC Wild Pig Specialist Group
ZAA	Zoo and Aquarium Association (Australasia)

Citation

Bailey, C., Burton, J., Islamia, S., Yonathan., Alaze, M., Andrews, J., Chandra, I., Fitzpatrick, M., Forys, J., Frantz, L., Humphreys, A., Hvilsom, C., Leus, K., Pentawati, S., Putnam, A., Semiadi, G., Smith, C., Traeholt, C., Traylor-Holzer, K., Tri Hastuti, Y., Tumbelaka, L.; Wahyudi,H. 2023. **Global Species Management Plan for Anoa (Bubalus sp.), Banteng (Bos javanicus), Babirusa (Babyrousa sp.) and Sumatran tiger (Panthera tigris sumatrae): Masterplan 2023-2025.** *Prepared for WAZA CPM*

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1. Introduction

1.1 Vision and Purpose of the Action Indonesia GSMPs

There are four Global Species Management Plans (GSMP) for Indonesian species. GSMPs aim to bring together partners to promote international collaboration between *ex situ* partners and implement *in situ* conservation activities. The four Indonesian species are anoa (*Bubalus* sp.), banteng (*Bos javanicus*), babirusa (*Babyrousa* sp.) and Sumatran tiger *(Panthera tigris sumatrae)*. By aligning the efforts of all partners, under the Action Indonesia GSMP Partnership, we can achieve greater conservation success.

Our vision is to achieve stable and secure populations of these species both *in situ* and *ex situ*. For the Sumatran tiger the focus is more on *ex situ* conservation efforts, while working with *in situ* partners.

The partnership follows the One Plan approach (Byers *et al*. 2013). We achieve this by building strong links and sharing of expertise between *in situ* and *ex situ* organisations. This includes training, education, and research.

1.2 Background and 2023-25 Phase

The Sumatran tiger is WAZA's longest running GSMP, started in 2008. The anoa, babirusa and banteng GSMPs were initiated in 2016 with all three working together to deliver impact across the three taxa. This is the first phase with full integration of all four GSMPs. This synchronising will help to align the processes of KKHSG and PKBSI, such as in future breeding and transfer recommendations, and allow for broader reach such as improving skills in husbandry and awareness raising, genetic assessment of *ex situ* populations.

This period is the third phase of the ungulate GSMPs. During the first two phases there was significant progress made in defining common goals between regions, relationship building, and implementing two sets of breeding transfer recommendations for Indonesian *ex situ* populations. A lot of focus was on increasing expertise in husbandry and awareness raising in Indonesian zoos. There was also progress in support for *in situ* population monitoring.

This phase 2023-25 will focus on scaling up the work already underway, such as implementing a greater % of the recommended transfers and breeding pairings, and empowering Indonesian zoo staff to conduct more skills sharing. We will also expand work started in the previous phase, for example adding genetic analysis of the Sumatran tiger *ex situ* population to the other three species, supporting additional national parks with population monitoring of GSMP ungulate species. This continues to further strengthen the link of *ex situ* supporting *in situ* conservation efforts, and vice-versa. Greater leadership by Indonesian partners will greatly help to deliver the targets set in this phase.

1.3 This Masterplan Document and Planning for 2023-25

This Masterplan was produced during multiple virtual meetings in 2022, with a final meeting involving all stakeholders on 16th September 2022, hosted by Directorate of Biodiversity Conservation of Species and Genetic (KKHSG), Directorate General of Conservation Nature Resource and Ecosystem (KSDAE). The Masterplan is aligned to the priorities described in the Indonesian National Species Conservation Strategy and Action Plans (SRAK) for these taxa. We used the process described in the IUCN Species Survival Commission Guidelines on the Use of Ex situ Management for Species Conservation (IUCN SSC 2014) to review the *ex situ* roles for each species.

This document describes the planned activities of each Working Group for all four taxa. The last section describes the way delivery will be assessed, using the Theory of Change process. For a recent (2018) status review of the wild populations of each of the four taxa, see the 2018-2021 GSMP masterplan.

1.4 Structure and delivery of the anoa, banteng, babirusa and Sumatran tiger GSMPs

The anoa, banteng, babirusa and Sumatran tiger GSMPs bring together a wide range of partners that contribute in many ways to the delivery of the Goals. The governance and oversight of the GSMPs is led by Conveners and Co-conveners for each taxon that were selected to ensure representation across the zoo regions of this partnership. These individuals are:

- Anoa — Marcel Alaze (EAZA) (pending CPM approval) & Yohana Tri Hastuti (PKBSI)
- Babirusa — Joe Forys (AZA) & Sri Pentawati (PKBSI)
- Banteng — Ivan Chandra (PKBSI) & JT Svoke (AZA) (pending CPM approval)
- Sumatran tiger — Malcolm Fitzpatrick (EAZA) & Ligaya Tumbelaka (PKBSI)

Details of the GSMP governance is described at the end of this section in Table 1.3.

The implementation of activities to deliver the Goals is achieved by ten Working Groups, as described below. The leaders of these Working Groups are shown below in Table 1.1. Each partner institution contributes one of more actions, e.g. zoos contribute through animal management, funding, and expertise, while NGOs contribute expertise and funding. Full list of partners as of March 2023 can be found in Appendix 1 of this document.

The GSMPs have four goals and ten Working Groups to deliver these goals, as described in Figure 1.1.

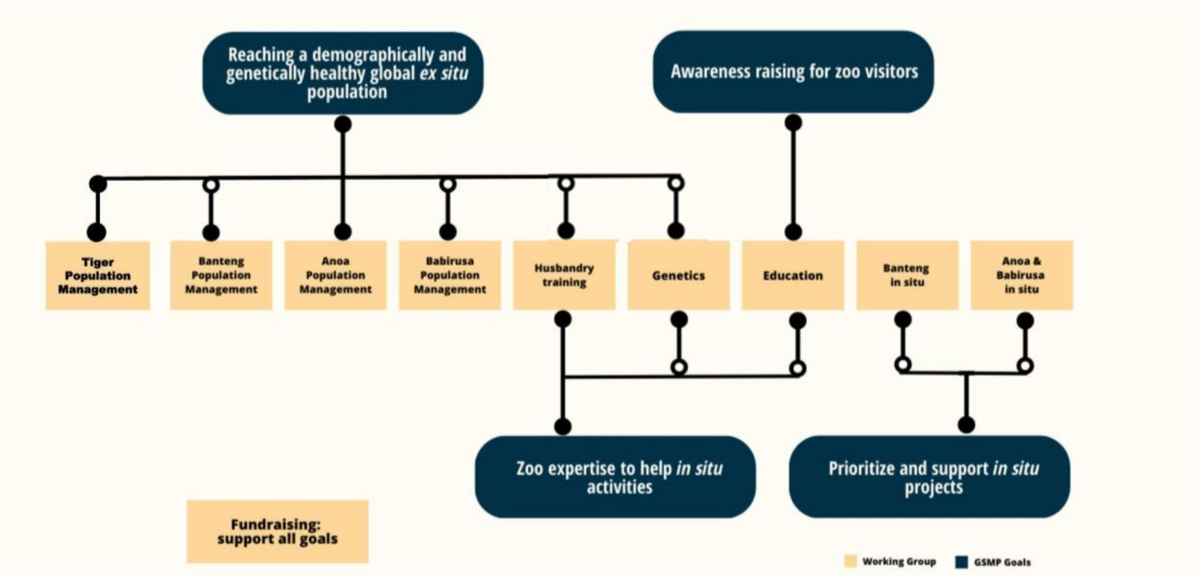


Figure 1.1: Diagram summarising the overarching goals of the Working Groups within Action Indonesia

Six associations or organisations make up the organisational partners: European Association of Zoos and Aquaria (EAZA), Association of Zoos & Aquariums (AZA), Indonesia Zoo & Aquarium Association (PKBSI), International Union for Conservation of Nature Species Survival Commission (IUCN SSC), IUCN SSC Asian Wild Cattle Specialist Group, IUCN SSC Wild Pig Specialist Group. These partners also are the signatories of an MOU (2019 - October 2024) describing the partnership in Indonesia, witnessed by the Indonesian Ministry of Environment and Forestry. In addition, the Zoo and Aquarium Association Australasia (ZAA) and the Japanese Association of Zoos and Aquariums (JAZA) are partners for the Sumatran Tiger GSMP.

The delivery of the Goals is assessed using a Theory of Change process that is described in Section 12. This allows the monitoring of activities, as well as defines the steps to achieving the GSMP Vision.

For all taxa there has not been a major change in rate of decline of wild populations since the last Masterplan in 2018, or any highlighted important publication that means different *in situ* actions are required. So a detailed status review was not included in this Masterplan.

The anoa and babirusa taxa, found on Sulawesi and neighbouring islands face similar threats. The greatest threat is hunting for local consumption and increasingly for trade within Sulawesi, and a secondary threat is habitat loss. The total population estimate for each taxa is not well known, due to limited survey effort. All taxa are in decline, which means they are listed as Vulnerable or Endangered on the IUCN Red List for anoa (Burton, et al. 2016a, b) and babirusa taxa (Leus, et al. 2016, Macdonald, et al. 2016, 2008). The status of banteng is currently

Endangered (Gardner, et al. 2016) and is currently under review for the next Red List Assessment. The quality of population estimates are improving for the Javan subspecies due to our efforts, since the last Masterplan. These do not show significant change in trend. Threats range from hunting, habitat degradation, and competition with domestic livestock, as well as other anecdotal reasons.

Sumatran tigers, considered Endangered, are found only on the Indonesian island of Sumatra where they persist in four main landscapes. Only around 400 wild Sumatran tigers remain, and their primary threats are poaching and habitat loss. Direct killing of Sumatran tigers occurs as a result of tiger-human conflict and poaching for the illegal wildlife trade. Sumatran tigers have lost habitat due to large-scale conversion of forest for agriculture. Through the Tiger SSP's Tiger Conservation Campaign, over $600,000 has been raised since 2012 from AZA-accredited zoos, AAZK chapters, and other donors to support Sumatran tiger conservation efforts. Specifically, the Campaign has supported WCS-Indonesia's efforts in Sumatra's Leuser and Bukit Barisan Selatan tiger landscapes to mitigate human-tiger conflict, support anti-poaching and habitat encroachment patrols, and curb the illegal trade of tiger parts. The WildCats Conservation Alliance initiative also has contributed to Sumatran Tiger Conservation since 1999, granting £1.2 million to 19 different projects from seven project implementers. These projects include the Kerinci Seblat Tiger Protection and Conservation Units (TPCUs) established in 2000 by Fauna & Flora International, that have received annual WildCats grants from the outset. SMART based, intelligence-led patrols, wildlife crime investigations and conflict response teams tackle threats across and around Kerinci Seblat National Park, a key tiger habitat that is home to a population of approximately one third of the remaining Sumatran tigers park.

Table 1.1: Working Group leaders of the Action Indonesia GSMPs for Anoa, Banteng Babirusa, and Sumatran Tiger as well as their GSMP Committee role

Name	Contact details	Affiliation(s)	Committee role
Banteng Population Management			
Ivan Chandra	ivan@tamansafari.net	Taman Safari Indonesia, Indonesia	Banteng Convenor; Banteng Int. Studbook Keeper
Andrea Putnam	asputnam@gmail.com	AZA Adjunct Population Biologist	Banteng population management advisor
Anoa Population Management			
John Andrews	jandrews@lpzoo.org	AZA Population Management Centre, Lincoln Park Zoo, USA	Anoa population management advisor
Yohana Tri Hastuti	yohanavet@tamansafari.net	Taman Safari Indonesia, Indonesia	Anoa Co-Convenor; PKBSI Anoa Coordinator & Regional Studbook Keeper
Babirusa Population Management			
Charlotte Desbois	charlotte.desbois@eaza.net	EAZA Population Management Center, France	Babirusa population management advisor
Sri Pentawati	pipentakbs_94@yahoo.co.id	Surabaya Zoo, Indonesia	Babirusa Co-Convenor
Sumatran tiger Population Management			
Ligaya Tumbelaka	tigressgaya@gmail.com	Bogor Agricultural University (IPB) & PKBSI, Indonesia	Training advisor, Sumatran Tiger GMSP Co-Convenor & PKBSI Sumatran Tiger Regional Studbook Keeper
Kathy Traylor-Holzer	kathy@cpsg.org	IUCN SSC Conservation Planning Specialist Group (retired), USA	Sumatran tiger population management advisor
Genetics			
Gono Semiadi	semiadi@gmail.com	National Research and Innovation Agency (BRIN) & PKBSI, Indonesia	National Research and Innovation Agency (BRIN) Representative
Christina Hvilsom	ch@zoo.dk	Copenhagen Zoo, Denmark	Population geneticist
Husbandry Training			
Amy Humphreys	a.humphreys@chesterzoo.org	Chester Zoo, UK	Banteng EEP Coordinator & Studbook Keeper
Ligaya Tumbelaka	tigressgaya@gmail.com	Bogor Agricultural University (IPB) & PKBSI, Indonesia	Training advisor

Table 1.1 continued overleaf

Table 1.1 continued

Name	Contact details	Affiliation(s)	Committee role
Education			
Charlotte Smith	c.smith@chesterzoo.org	Chester Zoo, UK	Education advisor
Ligaya Tumbelaka	tigressgaya@gmail.com	Bogor Agricultural University (IPB) & PKBSI, Indonesia	Training advisor
Banteng *in situ*			
Carl Traeholt	cat@zoo.dk	Copenhagen Zoo, Denmark	Banteng *in situ* advisor
Hariyawan A Wahyudi	ha.wahyudi@gmail.com	Copenhagen Zoo Project, Baluran NP.	Banteng *in situ* advisor
Anoa and Babirusa *in situ*			
Abdul Haris Mustari	haris.anoa@yahoo.com	Bogor Agricultural University (IPB), Indonesia	Anoa and Babirusa *in situ* Advisor
James Burton	jamesaburton@yahoo.co.uk	IUCN SSC Asian Wild Cattle Specialist Group, UK	Anoa, Banteng & Babirusa *in situ* Advisor; IUCN SSC AWCSG representative
Corinne Bailey	c.bailey@chesterzoo.org	Chester Zoo,	Programme Officer, IUCN SSC Asian Wild Cattle Specialist Group, UK
Fundraising and Communications			
James Burton	jamesaburton@yahoo.co.uk	IUCN SSC Asian Wild Cattle Specialist Group, UK	IUCN SSC AWCSG representative, EAZA Cattle & Camelid TAG Chair
Joe Forys	jforys@auduboninstitute.org	Audubon Nature Institute, USA	Babirusa Convenor
JT Svoke	joseph.svoke.@miamidade	AZA region	Banteng Co-Convenor (pending CPM approval)
Marcel Alaze	alaze@allwetterzoo.de	EAZA region	Anoa Convenor (pending CPM approval)

Table 1.2. Additional Working Group members and advisors

Name	Contact details	Affiliation(s)	Committee/advisory role
Curt Coleman	ccoleman@thewilds.org	The Wilds, USA	AZA Banteng Regional Studbook Keeper
Merel Zimmermann	merel.zimmermann@eaza.net	EAZA, Netherlands	EAZA Executive Office Representative
Badiah Achmad Said	badiahsaid@gmail.com	KKHSG, KSDAE, Indonesia	Indonesian Government Representative
Thomas Kauffels	thomas.kauffels@opel-zoo.de	Opel Zoo, Germany	Advisor
Daniwari Widiyanto	daniwariwidiyanto@gmail.com	KKHSG, KSDAE, Indonesia	Indonesian Government Representative
Linda Penfold	linda.penfold@sezarc.com	SEZARC, USA	Research Geneticist & Reproductive Advisor
Satyawan Pudyatmoko	satyawan_pudy@yahoo.com	Gadjah Mada University, Indonesia	Banteng *in situ* advisor
Desy Satya Chandadewi	desysatyac@gmail.com	KKHSG, KSDAE, Indonesia	Indonesian Government Representative
Tony Sumampau	tsumampau@hotmail.com	PKBSI/Taman Safari Indonesia, Indonesia	PKBSI Representative
Telena Welsh	telena.welsh@pdza.org	Point Defiance Zoo & Aquarium, USA	Anoa SSP Coordinator and Regional Studbook Keeper
Karen Goodrowe	Karen.Goodrowe@pdza.org	Point Defiance Zoo & Aquarium, USA	Tiger SSP Coordinator
Laurent Frantz	laurent.frantz@qmul.ac.uk	Queen Mary University of London, UK	Population geneticist
Julia Klumb	julia.klumb@miamidade.gov	Miami Zoo, USA	Education WG member
Jamie Jackson	jamieejackson@gmail.com	Indianapolis Zoo, USA	Education WG member
Charlotte Dale	c.dale@chesterzoo.org	Chester Zoo, UK	Education WG member, Sumatran Tiger GSMP Education Advisor
Yuliyati Nurmaya	yuliyatinurmaya@gmail.com	Ragunan Zoo, Indonesia	Education WG member
Ida Ayu Janiawati	arijaniawati@gmail.com	Bali Safari Park, Indonesia	Education WG member
Piter Kombo	piter_kombo@yahoo.co.id	Taman Mini Indonesia Indah, Indonesia	Education WG member
Yus Anggoro Saputra	yus.anggoro@ancol.com	Taman Impian Jaya Ancol, Indonesia	Education WG member
Wisnu Wardana	wisnuwardana2012@gmail.com	PKBSI, Indonesia	Education WG member
Eko Windarto	manager_education_tsi2@tamansafari.com	Taman Safari Indonesia Prigen, Indonesia	Education WG member
Christina Dembiec	cdembiec@memphiszoo.org	Memphis Zoo, USA	Education WG member
Samantha Viner	samantha.viner@zsl.org	ZSL, UK	Education WG member
Keni Sultan	keni.s@tamansafari.net	Taman Safari Indonesia Bogor, Indonesia	Husbandry WG member
Josephine Vanda Tirtayani	vanda@gembiralokazoo.com	Gembira Loka Zoo, Indonesia	Husbandry WG member
Ade Diah Safitri	adediah4@gmail.com	Bali Zoo, Indonesia	Husbandry WG member
Afriana Pulungan	rinapul@yahoo.com	Ragunan Zoo, Indonesia	Husbandry WG member

I Nengah Nuyana	nengahnuyana.gdp@gmail.com	Bali Bird Park, Indonesia	Husbandry WG member
Ivy Brower	Ivy.brower@miamidade.gov	Miami Zoo, USA	Husbandry WG member
Prista Dwi Restanti	mpriez87@gmail.com	Batu Secret Zoo, Indonesia	Husbandry WG member
Kukuh Hadi	kukuhadii@gmail.com	Taman Safari Indonesia Prigen, Indonesia	Banteng studbook assistant
Danny Gunalen	dannygunalen@gmail.com	PKBSI/Fauna Land Ancol, Indonesia	PKBSI Conservation Division Representative
Wahyu Murdyatmaka	wahyumoerdya@gmail.com	Alas Purwo National Park, KSDAE, Indonesia	Banteng In-Situ WG member
Wulan Pusparini	wulan.pusparini@lmh.ox.ac.uk	Indonesian PhD Student in University of Oxford	Anoa & Babirusa In-Situ WG member
Dan Beetem	d.beetem@thewilds.org	The Wilds, USA	AZA Ungulate TAG Vice Chair for Cattle species
Anik Budhi Dharmayanthi	anik.budhi.dharmayanthi@gmail.com	National Research and Innovation Agency (BRIN), Indonesia	National Research and Innovation Agency (BRIN), Indonesia

Table 1.3: Governance of the anoa, banteng, babirusa and Sumatran tiger GSMPs.

Taxa	Banteng (*Bos javanicus*), anoa (*Bubalus* spp.), babirusa (*Babyrousa* spp.) and Sumatran tiger (*Panthera tigris sumatrae*)
Committee members	All committee member positions should be reviewed and confirmed at every masterplan development meeting (approximately every 3 years). If changes are proposed, recommendations from the committee should be formally submitted to the WAZA CPM for endorsement (preferably as part of the new masterplan).
Scope of programme	Currently EAZA, AZA, PKBSI and SEAZA, plus ZAA (Australasia) and JAZA for the Sumatran tiger.
Role of programme	The establishment of official GSMPs for banteng, anoa, babirusa and Sumatran tiger has many roles, the prime one being that it will facilitate the transfer of animals between the regional breeding programmes and so establish demographically and genetically sustainable and behaviourally competent global *ex situ* populations. These populations can serve as insurance populations for the wild populations on Java (banteng), Sulawesi (anoa and babirusa) and Sumatra (Sumatran tiger) and establish durable global *ex situ* activities and populations that effectively contribute to the conservation of these taxa. It will also encourage the cooperation of zoos and promote the approval of international legislative bodies e.g. CITES. In addition, the status of a GSMP should help to persuade participating institutions to commit resources in support of the programme. By working together as partners in a global endeavour, husbandry, management philosophy and experiences will be more easily shared, leading to a better and more global approach to banteng, anoa and babirusa management in the future. However, undoubtedly the most important result of this global recognition will be to raise the profile of banteng, anoa, babirusa and Sumatran tiger which should promote their conservation, both within zoos and in the wild.
Regional and institutional GSMP membership	New regional associations and institutions that are outside regional associations and/or regionally managed programmes, can be approached by the committee to join the GSMP, or can apply to the committee themselves. Any decision will be made based purely on the needs of the programme.
Current nominated representatives	Banteng: Amy Humphreys (EAZA), Ivan Chandra (PKBSI) and JT Svoke (AZA). Anoa: Marcel Alaze (EAZA), Yohana Hastuti (PKBSI) and Telena Welsh (AZA). Babirusa: Joe Forys (AZA), Jörg Beckmann (EAZA) and Sri Pentawati (PKBSI). Sumatran tiger: Malcolm Fitzpatrick (EAZA), Karen Goodrowe (AZA), James Biggs (ZAA), Kazunori Yoshizumi (JAZA), Ligaya Tumbelaka (PKBSI) It is the responsibility of each regional representative to update and consult with their participants with regards to relevant GSMP activities. If a representative leaves their position, their region is responsible for appointing a replacement.
GSMP decision making process	The regional programme coordinator or TAG Chair is responsible, when necessary, for liaising between the GSMP and their own region. All decisions will be made by consensus and where an agreement cannot be reached, the Convenors will make the final decision. Where the matter

	under discussion is of a specialised nature, the Convenors will consult with the relevant Advisers.
Global dataset responsibility	Datasets to be maintained by the relevant International Studbook Keeper with assistance from population advisors and regional studbook keepers. Population Advisors and Regional Studbook Keepers will send updates to the International Studbook Keeper as they occur or are requested. International Studbook Keepers: Ivan Chandra (Banteng), Jörg Beckmann (Babirusa) and Marcel Alaze (Anoa), Peter Müller (Sumatran tiger) Population Advisors: Andrea Putnam (Banteng). Charlotte Desbois (Babirusa), John Andrews (Anoa), Kathy Traylor-Holzer (Sumatran tiger) EAZA Regional Studbook Keepers: Tim Rowlands (Banteng), Jorg Beckman (Babirusa), Marcel Alaze (Anoa), Teague Stubbington (Sumatran tiger) AZA Regional Studbook Keepers: Curt Coleman (Banteng), Joe Forys (Babirusa), Telena Welsh (Anoa), Kathy Traylor-Holzer (Sumatran tiger) PKBSI Regional Studbook Keepers: Sri Pentawati (Babirusa), Yohana Hastuti (Anoa), Ligaya Tumbelaka (Sumatran tiger) **Banteng:** Dataset to be maintained by Andrea Putnam (AP), with assistance from Ivan Chandra, International Studbook Keeper; Amy Humphreys, EAZA Regional Studbook Keeper; and Curt Coleman, AZA Regional Studbook Keeper, who will send updates to AP as they occur or are requested. **Babirusa:** Dataset to be maintained by Jörg Beckmann (JB), International Studbook Keeper, with assistance from Charlotte Desbois, Population Advisor, Sri Pentawati, PKBSI National Studbook Keeper, and Joe Forys, AZA Regional Studbook Keeper, who will send updates to JB as they occur or are requested. **Anoa:** Dataset to be maintained by Marcel Alaze (MA), International Studbook Keeper, with assistance from John Andrews, Population Advisor, Yohana Hastuti, PKBSI National Studbook Keeper, and Telena Welsh, AZA Regional Studbook Keeper, who will send updates to MA as they occur or are requested. **Sumatran tiger**: Dataset to be maintained by Peter Müller (PM), International Studbook Keeper, with most institutions entering data directly into ZIMS. Ligaya Tumbelaka, PKBSI National Studbook Keeper, and Kathy Traylor-Holzer, Population Advisor, will send updates on PKBSI tigers to PM as they occur or are requested.
REGIONAL PROCESSES	
Implications for regional management processes	Different regions have several points of reference for decisions regarding breeding /transfers/contraception, etc. and this is not only relevant to the needs of their region, but also to the needs of other regions and of the global population. Therefore, the GSMP report will provide the tools and information that will take into consideration these needs, such as regional needs, current global mean kinship list, etc.
Animal ownership	EAZA – Ownership defined by donation, open exchange or breeding loan. AZA - Ownership defined by donation, open exchange or breeding loan. PKBSI - Ownership defined by donation, open exchange or breeding loan. SEAZA-Ownership defined by donation, open exchange or breeding loan. JAZA - Ownership defined by donation, open exchange or breeding loan ZAA - ownership defined by open exchange or donation

Terms of transfer	Different regions have several points of reference for decisions regarding breeding/transfers/contraception, etc. and this is not only relevant to the needs of their region, but also to the needs of other regions and of the global population. Therefore, the GSMP report will provide the tools and information that will take into consideration these needs, such as regional needs, current global mean kinship list, etc. Transfers must be official programme recommendations in the relevant regions and for Indonesia must follow the Indonesia Ministry of Environment and Forestry regulation no P.83/Menhut-II/2013 on breeding loan. Receiving institutions are expected to pay for all transport costs, which may also include any pre-export health testing/checks, quarantine requirements and/or CITES Import/Export Permits, that will need to be obtained, when and necessary, unless other terms are negotiated and are agreeable with the sending institution. At no point must any money be exchanged between the zoos involved, as payment for banteng, anoa, babirusa or Sumatran tiger. Preference should be given to transfers of banteng, anoa, babirusa or Sumatran tiger both within and among the regions that are actively participating in the GSMP. If a banteng, anoa, babirusa or Sumatran tiger is to be exported to zoos in countries or regions that are not active members of the GSMP, it should be an animal that is not of any demographic or genetic importance to the GSMP/regional programme and also, permission from both the GSMP and the zoo's own regional association must be sought and granted, before any animal is allowed to leave the programme. Members of the GSMP should not receive banteng, anoa, babirusa or Sumatran tiger from within or outside of the programme without first being given a transfer recommendation or consulting with the GSMP.
Organisations leaving a zoo association	This will be dealt with by the appropriate Regional Association.
Lifespan of the current plan	Population status and potential transfers will be reviewed annually. Conference call meetings to take place every three months.
Date report produced	**March 2023**
Reporting schedule	Short annual report to WAZA CPM, global data provided annually to regional members, minutes and 'actions' produced after each meeting and master plan/strategy to go to WAZA CPM for review.
Responsible person(s) for the production of the masterplan	GSMP Convenor (with help of the region's population management advisor and representatives/advisors from other participating regions).

2. Cooperative Breeding Process for Ex-situ Population Management.

This chapter covers overarching aspects of cooperative breeding for population management in Indonesian zoos. This includes defining the goals, describing the cycle of drafting, and implementing recommendations, and capacity development to ensure greater leadership within Indonesia. The following four chapters describe the status of the Indonesian populations of the four GSMP species and the data analysed to produce the breeding and transfer recommendations.

2.1 Ex situ Goals and Targets and Summary of achievements 2018-2022

The Goal of achieving stable and secure *ex situ* populations of the four GSMP species was defined with target population sizes for each region set for the ungulate species in 2016. For the Indonesian population these were 75 anoa, 100 banteng and 100 babirusa. This is combined with maintaining at least 90% genetic diversity of each species for 100 years. Similar targets were set for EAZA and AZA regions. Sumatran tiger regional and global targets were set in 2012 and revised in 2022. Current PKBSI target population size is at least 100 tigers, with other regional targets between 50-130 tigers each and a global target of 400 tigers. Each program has a regional goal to maintain at least 90% gene diversity for 100 years.

In the last phase of the programme there have been successful births for all species, following the recommendations of 6 anoa, 23 banteng, 6 babirusa and 7 tiger births. This is a major success because this is the first time this many births have been achieved following recommendations across multiple species. We acknowledge all the hard work of the zoos involved. This equates to successful implementation of between 17% and 31% of recommendations per species.

The populations in September 2022 were 35 anoa, 71 banteng, 70 babirusa and 86 tigers. Even though there has been breeding, the population sizes for all four species have decreased from 2018-2022, because of a greater number of deaths than births, and because there have not been enough births to replace aging animals. So it is essential during this phase that a far higher percentage of recommendations are successfully implemented to reach the target populations and prevent further decline. See table 2.1 below for a summary of the populations of the four species.

Table 2.1. Summary of population details of the four species

	Targets from 2016	**Population 2018 / 2022**	**Births 2018-2022**	**Percentage of recommendations completed (%)**	**Population change (%)**
Anoa	75	37 / 35	6	20%	- **5%**
Banteng	100	86 / 71	23	25%	- **17%**
Babirusa	100	75 / 70	6	17%	- **13%**

Sumatran tiger	140 (2012 target)	130 / 86	7 litters	25%	- **34%**

We have identified the number of births per year in order to reverse the shrinking size of populations. For the next set of recommendations to achieve stable population size the births per year for each species is: 4-5 anoa, 10 banteng, 9 babirusa , 5-7 Sumatran tiger litters. Once additional information is collected from zoos on the feasibility of implementing recommendations targets will be set.

Once the *ex situ* populations of these four taxa are stronger it is proposed that the targets set for Indonesian *ex situ* populations are reviewed. This review will include the global population, with a possible outcome to define a plan for strengthening the global population with international transfers in the coming years or future phases of the GSMP programme.

We believe that once the recommendation cycle is working effectively for these four species, it provides a model that can then include other threatened Indonesian species that are held in multiple zoos. The GSMP is keen to support this expansion, at the right time.

2.2 Breeding and Transfer Recommendations cycle

During this phase it is planned for two cycles of recommendations to be implemented, each for 18 months. While over the last four years there was just one cycle of recommendations produced. The benefit of short cycles is that data can be updated after 18 months, so that more current information can inform the next set of recommendations.

The cycle of breeding and transfer recommendations can be separated into drafting steps and implementing the recommendations steps. The cycle of drafting the 3rd set of breeding and transfer recommendations began in early 2022 with data gathering from zoos and calls to discuss draft recommendations. The agreed recommendations were presented at a plenary virtual meeting on 16th September 2022. To make sure recommendations reached the decision makers, recommendations were also shared with zoo directors at the pre-meeting of PKBSI Annual Meeting on 24th November 2022 in Bali. The final step of the drafting process was the letter supporting implementation from KKHSG in January 2023.

The implementation phase now begins. Monitoring and evaluation of the implementation will be done by PKBSI every 3 months. PKBSI will liaise with all zoos involved and coordinate with Studbook Keepers, and GSMP's Population Biologists.

In February 2024, and about six months before this recommendation phase ends, preparation for the 4th set of recommendations will be started by PKBSI distributing the population status questionnaires to zoos. This is the start of a new cycle of drafting recommendations. The implementation for the 4th set breeding and transfer recommendations will begin on 5th August 2024 and end on 5th January 2025.

Also for the 4th set of breeding and transfer recommendations results of the genetic analysis of the ungulate species will be used to inform recommendations. This allows for more accurate information on genetic diversity and relatedness to be used, in addition to the studbook information, which includes predicted relatedness. By including this new genetic data, a greater percentage of diversity will be maintained in the populations of all ungulate species. Information about genetic results can be seen in the Genetics Chapter.

The roles of all stakeholders in this process are summarised below:

- PKBSI leads and facilitates the cycle of breeding and transfer recommendations by liaising with studbook keepers, zoos, population biologists and KKHSG. This includes distributing a questionnaire to update studbooks, and arranging multiple calls to draft recommendations, as well as track implementation by zoos.
- The Indonesian studbook keepers are in charge of checking species data such as births, deaths, origins, and age of animals is accurate and inputting local information to the drafting process. They input to revisions of recommendations to adapt to be suitable for local conditions and needs by zoos.
- The GSMP's Population Biologist analyse this data, working closely with the studbook keeper, to provide the basis for the first draft of the breeding and transfer recommendations.
- The zoos that implement transfers and breeding of pairs of animals in their zoo liaise with PKBSI through an Institutional Representative. The zoos are the organisations that take responsibility for implementation, which is a major commitment, considering the staff time and cost.
- The implementation of this program is supported by the Ministry of Environment and Forestry (KLHK) that will be able to simplify and speed up the process of transferring species between zoos. This acceleration is achieved by a letter of support for the recommendations, as well as inputting to specific discussions in certain situations. This will include a letter of support for BBKSDA/BKSDA to facilitate the document completion from each zoo to apply for the transfer permit.

The detailed steps of the cycle and the actions taken by all stakeholders is shown visually in Figure 2.1 below.

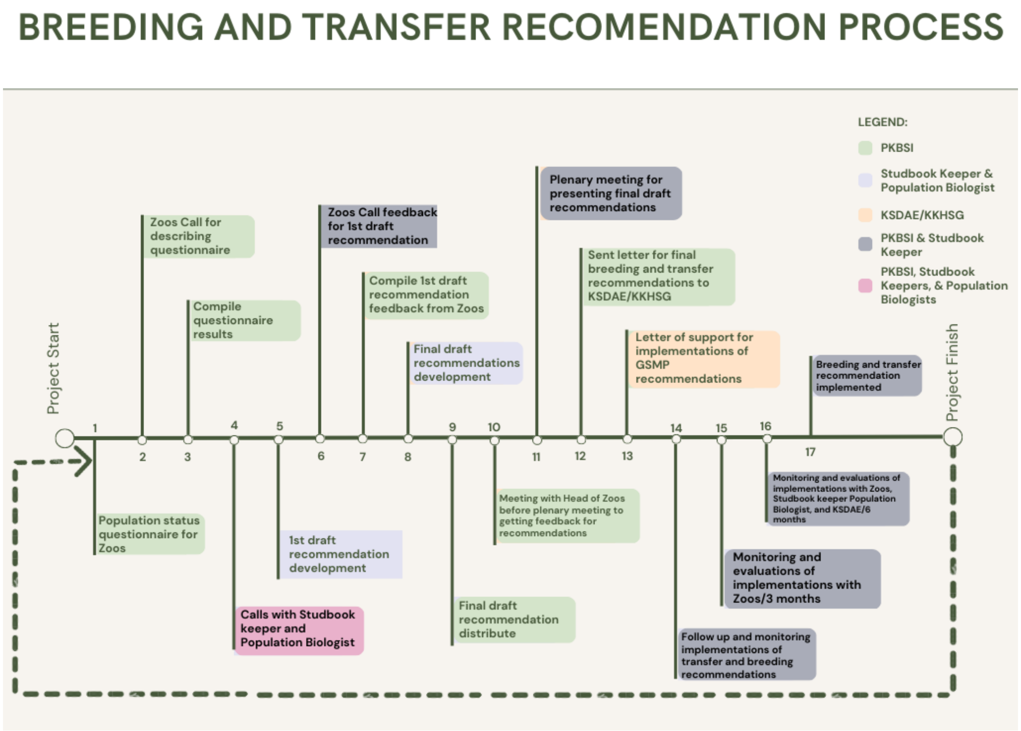


Figure 2.1. The diagram of breeding and transfer recommendations process in Indonesia.

Implementation of the recommendations requires permits submitted by zoos to the Directorate General of Conservation Nature Resource and Ecosystem (KSDAE) through the Directorate of Biodiversity Conservation of Species and Genetic (KKHSG) in accordance with article 39 in Permenhut P.63/Menhut-II/2013 (see Figure 2.2). In the previous period, several zoos had difficulty obtaining permits because some animal documents were incomplete and the process of checking documents took a long time. However, KKHSG conveyed to PKBSI that the licensing process would be expedited as long as the documents submitted by the zoos meet the requirements. It is hoped that the KKHSG's support through an accelerated implementation letter issued during this period will accelerate the implementation of the submission of permits for movement of animals by zoos.

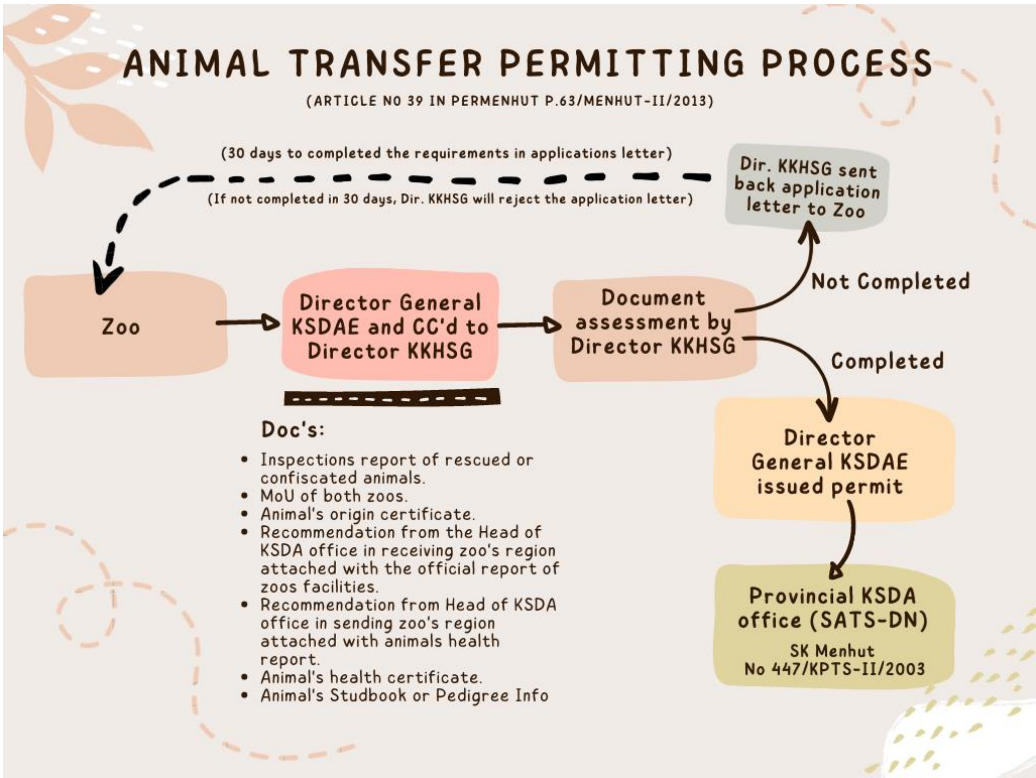


Figure 2.2 The process of Animal Transfer Permitting between Zoos based on Article no. 39 in Permenhut P.63/Menhut-II/2013.

2.3 Capacity and Knowledge of Population Management

For the drafting of the 3rd set of recommendations, this is the first time that PKBSI have led the process. This is a major achievement for PKBSI and shows great progress in their capacity development and support that they provide to zoos. For effective implementation of the 3rd set of recommendations, and future cycles of this process it is essential that there is further strengthening of expertise and knowledge.

There is not a clearly defined plan as to what is an appropriate process for PKBSI and Indonesian zoos at this time. This is an area that will be developed in the coming three years. It is important to consider the national conditions when improving this recommendation cycle and defining how to increase expertise. It is proposed that some brainstorm workshops occur to define the needs. This can be an inclusive process including KKHSG, zoo representatives and input from international experts, as needed.

The cycle of breeding and transfer recommendations has been improved since the 2nd set of recommendations in 2018. However further improvements will likely be required to increase the percentage of recommendations implemented. It is clear that additional expertise in PKBSI in population management will allow for more data analysis to occur in Indonesia, rather than by international experts. It will be valuable if expertise is developed more widely if possible, including studbook keepers and interested zoo staff. A greater awareness by the zoo community and KKHSG is needed of the benefits of implementing recommendations for the conservation of the species and sustainability of zoos. The effectiveness of communication between PKBSI and its members can help improve the implementation of good understanding of cooperative breeding by zoos. This will also ensure a greater percentage of recommendations are implemented.

Improved gathering of data and analysis will help improve the recommendation process. For example, understanding the cause of animal deaths and supporting animal management staff may minimise risks and reduce these. This should help increase population sizes and maintain greater genetic diversity. So a range of new data may be collected from zoos during these three years to understand patterns and improve future recommendations, and husbandry.

3. Banteng *ex situ* Population Management

3.1 *Ex situ* Population Management Strategy

The GSMP population analysis includes three regionally managed *ex situ* populations of banteng. The European population is managed by EAZA as a European Endangered Species Program (EEP). The North American *ex situ* population is managed by AZA as a Species Survival Plan® (SSP). The Indonesian *ex situ* population is managed by PKBSI and includes one non-PKBSI member institution within the range country, Baluran National Park.

Over the short-term, the *ex situ* management strategy of the banteng GSMP will focus on improving management within regions. After all regional programs are fully established, management can be extended to the global population. To better establish all regional populations and allow for future global management, each regional studbook must be fully updated once per year. Data not recorded in Species360's ZIMS for Husbandry online database by non-ZIMS facilities must be passed to the International Studbook Keeper and the International Studbook must be updated in the ZIMS for Studbooks online database. The maintenance of a comprehensive, up-to-date international studbook is the first step towards establishing a global population management strategy. If this can be achieved, future Masterplans will further develop management collaborations between regions.

Even after all regional programs are fully established, the GSMP expects that global management will continue to focus primarily on maintaining demographically robust and genetically variable regional populations with only minimal and periodic movement of animals or genetic material (e.g. gametes) between regions. Only limited movement of animals or genetic material between regions is likely in the foreseeable future due to the challenges inherent in import/export of this species. Much of the focus for import/export of banteng may be in the areas of semen collection, export, and artificial insemination (AI) from Indonesia to the European and U.S. populations. For the next 3-5 years the focus will be on working with the regulations and requirements of various governments and perfecting the necessary techniques for semen collection and AI in the species.

Regions are expected to adopt management strategies that support demographic robustness and the maintenance of genetic variation. The number of breeding recommendations per region should be sufficient to meet target size goals, while specific pairings should prioritize breeding genetically under-represented individuals and limiting inbreeding. When transfers between regions are considered in the future, the GSMP will consider moving animals that can provide a demographic and genetic benefit to the recipient population while not harming the demographic robustness or genetic variability of the donor population.

3.2 Demographic & Genetic Status of *Ex Situ* Populations

Analysis Notes

All analyses were carried out using the new Banteng International Studbook in ZIMS for Studbooks, which combines the studbook data from all 3 managed regions. All data for the European (EAZA) and North American (AZA) population were obtained from ZIMS for Husbandry. Data for the Indonesian population was compiled by Ivan Chandra (Taman Safari, Indonesia) and manually added to the Studbook. Studbook data filters described below were used to analyse the demographic and genetic status of the global population. Each of the three regional populations were assessed separately by filtering for animals from each region based on the PMx project for the global population. Previously created pedigree assumptions were re-evaluated using the new international studbook so assumptions were comprehensive across all regions, whereas assumptions were developed for each region in isolation in previous years. Pedigree assumptions for a total of 46 animals were applied in an overlay to resolve unknown or uncertain parentage and are described in Table 4.1. Life table data was obtained from the global population with no overlay applied. A total of 12 individuals were excluded from the potentially breeding population (i.e. genetic analyses) due to reasons of sterility and advanced age.

Table 3.1: Analytical assumptions for true data added to the international banteng studbook for analysis.

SB#	Sire ID	New Sire ID	Dam ID	New Dam ID	Notes
31	UND	WILD	UND	WILD	SB# 30 and 31 are the only animals that founded the JAKARTA population. Assume wild origins.
42, 46, 47	UND	30	UND	31	Animals have unknown origins. Assume they trace to the JAKARTA population based on studbook notes that animals were 'exchanged from Batavia Zoo, Jarkarta'. Assigned parentage SB# 30 and 31 since they are the only animals that founded JAKARTA population.
57, 58, 104, 117, 118, 774, 822, 848, 850, 967, 1057, 1058, 1060, 1062, 1124, 1324, 1389	UND	30	UND	31	Animals born at JAKARTA with unknown parentage. Assigned parentage SB# 30 and 31 since they are the only animals that founded JAKARTA population.
1584	UND	1102	1487	--	Conceived at DISNEY AK; SB# 1102 was the only male present at the time of SB# 1584's conception.

SB#	Sire ID	New Sire ID	Dam ID	New Dam ID	Notes
208, 230, 283	UND	114	UND	MULT6	Animals born at CATSKILL in the 1960s. Dam is a MULT of two females imported by CATSKILL from MUNICH in 1962. Additional Information: AZA studbook lists CATSKILL as importing 1.1 animals in 1959 (AZA 3 and 4); Clifton Quarantine records list CATSKILL as importing 2.2 animals that year. The two animals listed in the AZA studbook died in 1961 (before any relevant offspring were born) and CATSKILL records from that time appear reasonably reliable. They are assigned no offspring in the AZA studbook and are assumed to have not contributed to the living population. There is a chance that the additional 1.1 animals seemingly imported in 1959 could have contributed to the living population, but that’s believed to be unlikely and corresponding pedigree assumptions have not been made at this time. MULT6 (111, 122)
183, 192	114	--			
719	UND	452	283	--	Captive born at FERNDALE 9/7/81. Search for living males at FERNDALE +/-1mo from conception date (c. 11/26/80) shows SB# 452 is the likely sire based on ages of living males. Aside from him (6yrs), all other males were less than 3 years of age at time of conception.
1594	UND	MULT 16	1368	-	Born at PEACE RV. MULT created from animals known to have been transferred in prior to conception date. MULT16 (1464, 1466, 1522)
993	UND	MULT 7	516	-	MULT based on two males SD-WAP known to have on that date. Born at SD-WAP. MULT created from only two males present at SD-WAP on conception date. MULT7 (574, 894)
1591	UND	1249	1414	-	Likely sire based on other birth records at the time. Born at SD-WAP. Sire assumed to be 1249 because all other offspring born around the same time at SDWAP were assigned that sire.
1643	UND	MULT 17	1567	-	Search for living males at least 1 year of age at SD-WAP +/-1 mo. from 1643's conception date (7/9/2003) shows 1567 as the likely sire.
1777, 1844	UND	MULT 8	UND	MULT9	Born at RUM CREEK. All animals reported as being at either PEACE RV or RUM CREEK are assumed to belong to a single herd. MULT created from animals with birth locations outside of RUM CREEK or PEACE RV that are known to have been transferred into RUM CREEK or PEACE RV prior to conception dates (so MULT represents “founder lineages” for the herd). MULT8 (952, 1416, 1433, 1464, 1466, 1522, 1572, 1660, 1666, 1708, 1571). MULT9 (942, 960, 1001, 1007, 1023, 1029, 1280, 1291, 1361, 1447, 1455, 1467, 1368, 1487, 1491, 1499, 1526, 1528, 1534, 1712).
1865, 1866, 1884, 1965	UND	MULT 10	UND	MULT 11	Born at Rum CREEk. All Animals reported as being at either PEACE RV or RUM CREEK are assumed to belong to a single herd. MULT created from animals with birth locations outside of RUN CREEK or PEACE RV that are known to have been transferred into RUM CREEK or PEACE RV prior to conception dates (so MULT represents "founder lineages" for the herd). MULT10 (952, 1416, 1433, 1464, 1466, 1522, 1572, 1660, 1666, 1708, 1571, 1781) MULT11 (942, 960, 1001, 1007, 1023, 1029, 1280, 1291, 1361, 1447, 1455, 1467, 1368, 1487, 1491, 1499, 1526, 1528, 1534, 1712, 1643)

SB#	Sire ID	New Sire ID	Dam ID	New Dam ID	Notes
2340	UND	1897	UND	MULT12	A simple search for living animals at COTTBUS around time of SB# 2340's birth. MULT12 (1517, 1929, 1943, 1976, 2019, 2040)
50	UND	47	42	-	Only living male at ROTTERDAM +/-1mo of SB# 50's conception in studbook.
2336	2003	-	UND	MULT13	MULT created for likely dams at time of SB# 2336's birth. The two females at the time of 2336's birth was at LISIEUX ZOO at the time of conception, so likely came to TREGOMZOO pregnant. MULT13 (2008, 2014)
2376	2003	-	UND	MULT14	MULT created for likely dams at time of SB# 2376's birth. There were three females at the time of 2376's birth. One female just days over 1 yr of age at birth was excluded from the MULT. MULT14 (1554, 1949, 1973)
418	UND	WILD	UND	HYP1 (30x31)	Records show no other animals into TALLIN prior to SB# 418's birth, but there were many births in Europe by 1973. Make dam a hypothetical offspring of SB# 31 and 30 to capture the possibility that this individual is related to animals that went into BERLIN TP, MUNICH, ROTTERDAM from Indonesia.
504	UND	WILD	UND	HYP1 (30x31)	Search on birthdate of SB# 504 at SURABAYA shows no possible sire/dam was living there at the time. Likely early import of JAKARTA animals to SURABAYA in 1940s (see assumps for SB# 42, 46, 47), so make one parent possible offspring of the pair using a HYP.
627	UND	WILD	UND	HYP1 (30x31)	Many imports from other zoos in Europe around the time SB# 627 entered GELSNKRKN. Make dam a hypothetical offspring of SB# 31 and 30 to capture the possibility that this individual is related to animals that went into BERLIN TP, MUNICH, ROTTERDAM from Indonesia.
849	729	-	UND	MULT15	Dam of SB# 849, must have been living at GELSNKRKN on 4/3/1985. Females SB# 696, 745 and 757 are the only living females at the time of 849's birth. Assume SB# 745 and 757 are less likely to be the dam as they have no recorded offspring and were less than 3 years of age at the time of 849's birth. MULT15 (696-50%, 745-25%, 757-25%)

PMx Software Settings

Studbook data compiled by Steve Metzler and Ivan Chandra

Data current: 2022-06-06

Overlay: ‘analytical overlay GSMP’

Export to PMx:

Primary data file (zims) and demographic input file (csv) filters:

Dates: 1952-01-01 to 2022-06-06

Location = Indonesia

Association: AZA, EAZA

Other Filters: Status = Living

Modifications to PMx project:

Deselect Ringgo (1290) from demographic and genetic population for being deceased.

Zims file modified directly so dam of 1905 (Nina) is 1728 (Yuanda).

Male and female life tables imported from global population with no overlay applied.

Exclusions from Genetic Analyses:

Post-reproductive: 1381, 1651, 1777, 1884, 1730

Sterile: 1993, 1997, 2065, 2408, 2414, 2423, 2424

Demographic Status

Global

Studbook data indicate the GSMP population currently includes 214 individuals (70 males and 144 females) distributed among 29 institutions. The oldest records in the international studbook database come from Europe and Indonesia, with the first recorded banteng entering zoos in 1872 through Berlin Zoo, Germany. Historical records are sparse and likely unreliable, particularly for the Indonesian zoos. The dataset for the North American (AZA) population is likely the most complete due to its more recent founding, with the first animals sourced from Europe in 1959. When data from each of the three regional studbooks were filtered as described above, it was not until ~1950 that records indicated a global population of notable size was being maintained (>10 animals), therefore the demographic analysis was performed using data starting in 1952. Figure 3.1 illustrates the census of the global and regional populations over time. Between 1950 and 2003 the population grew at a rate of ~6% per year (average $\lambda_{1952\text{-}2003}$ = 1.06; Figure 3.2), due primarily to successful captive breeding. The notable decline in population size during 2004 was due to animals in the North American studbook being designated as exiting AZA facilities into the private sector. Given the data available, the global population has grown at a rate of ~3% per year in the last ten years (average $\lambda_{2012\text{-}2021}$ = 1.03; Figure 3.1). The current age structure of the global banteng population is pyramidal in shape with most individuals in the population in the youngest age classes. All age classes are filled, further supporting a demographically robust age structure. Though the sex ratio is skewed towards females with 2.06 females for every male, this type of age structure is compatible with the breeding and social system of this species.

Table 3.2: Population demographics of banteng held in Indonesian, European (EAZA) and North American (AZA) institutions

	Indonesia	**Europe (EAZA)**	**North America (AZA)**	**Global**
Total Population Size	71	107	36	214
Males.Females.Unknowns	27.44.0	32.75.0	11.25.0	69.145.0
Number of Institutions	7	17	5	29

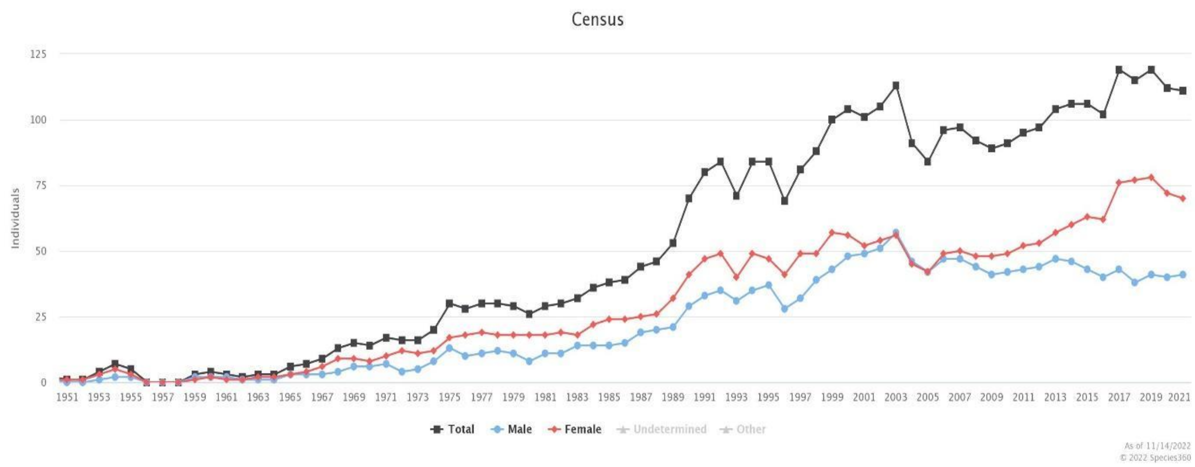


Figure 3.1: Census of Banteng in Indonesian, European, and North American facilities from 1951 to 2021 (census on 31 December).

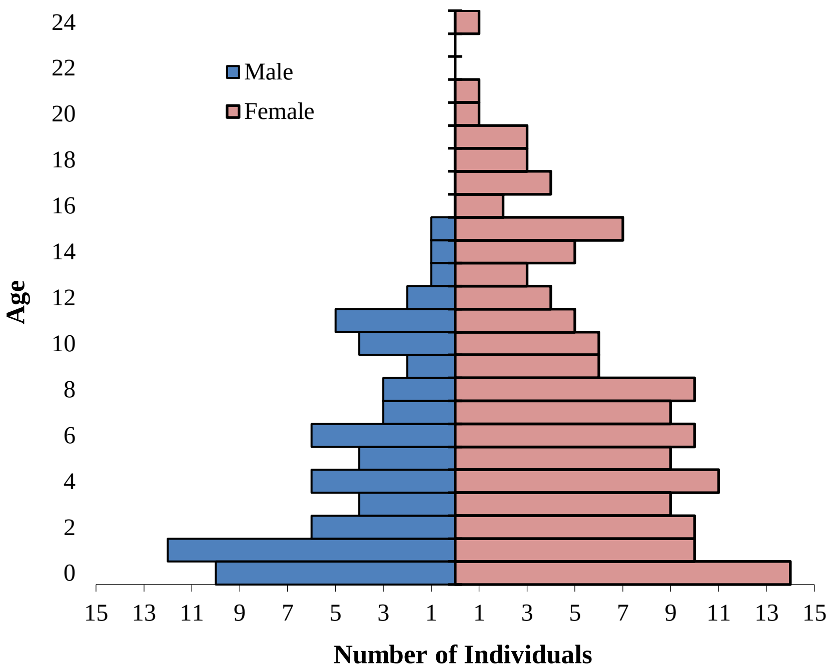


Figure 3.2: Age structure of the current global population of banteng in Indonesian, European, and North American facilities (current to June 6, 2022).

Indonesia

The earliest records of the *ex situ* Indonesian population trace to a pair of animals that entered Taman Margasatwa Ragunan (JAKARTA) in the 1930s. Based on studbook records, this single pair produced the first known captive births in Indonesia and no other animals have entered this facility since that time. Descendants of this pair at JAKARTA likely founded at least part of the population at Kebun Binatang Surabaya (SURABAYA) based on studbook notes indicating early imports of animals into SURABAYA as 'exchanged from Batavia Zoo, Jakarta'. There is a large gap in studbook data from the 1950s until 1975, which is likely an artefact of missing historical records. Studbook records for the current Indonesian population began in 1975. Between 1975 and 2019, the *ex situ* Indonesian population grew at an average rate of 7.9% as a result of successful captive breeding and an import of 10 wild caught animals in 2006 (average $\lambda_{1976\text{-}2019}$ = 1.079; Figure 3.3a). The population recently experienced a decline in the last two years at a rate of -6% due to a reduction of births that were unable to compensate for the number of deaths (average $\lambda_{2020\text{-}2021}$ = 1.079; Figure 3.3a). The reduction in births could be due to COVID impacts that delayed the 2021 Master Planning process. There are still five wild-caught animals remaining in the population.

The age structure of the current *ex situ* Indonesian population is roughly columnar with most age classes filled (Figure 3.3b). However, the age structure is tapered at the bottom due to the small number of births in recent years. A consistent number of births each year will support a more demographically robust age structure that exhibits a roughly pyramidal shape. Though the sex ratio is slightly skewed towards females with 1.6 females for every male, this type of age structure is compatible with the breeding and social system of this species and there is still a moderate number of intact males to be of concern (n=27).

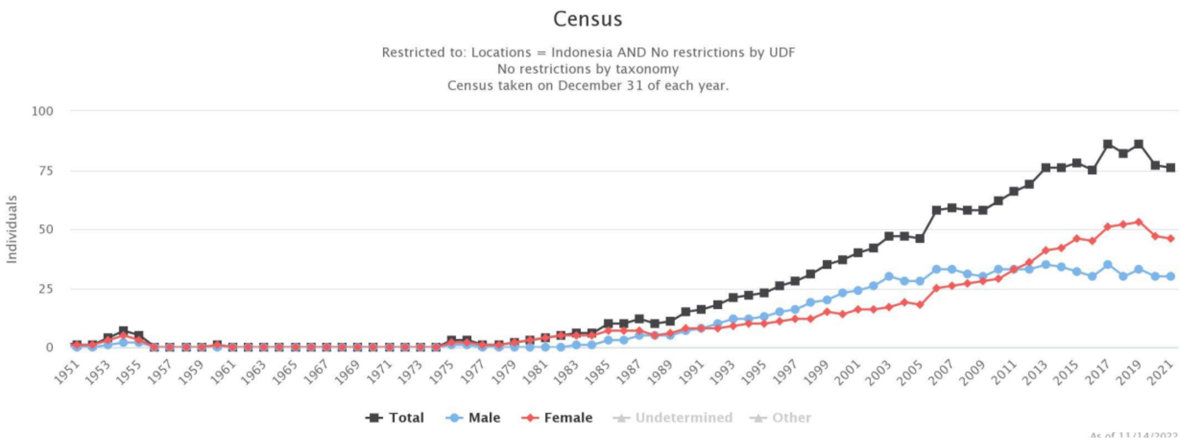


Figure 3.3a: Census of Banteng in Indonesian from 1951 to 2021 (census on 31 December).

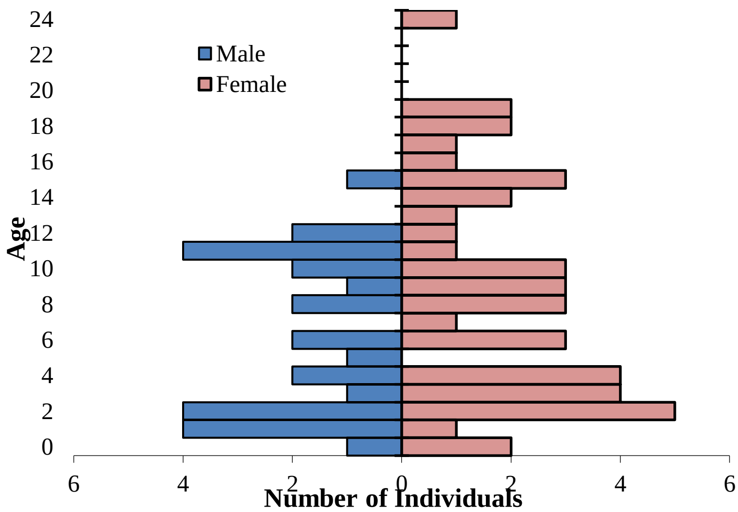


Figure 3.3b: Age distribution of the current potentially breeding banteng population in Indonesia (current to June 6, 2022).

Europe (EAZA)

The current *ex situ* population in Europe traces to imports of captive born animals from Indonesian zoos in the 1950s. In the last 70 years, the *ex situ* European population grew at an average rate of 8.5% mainly due to successful reproduction (average $\lambda_{1950\text{-}2021}$ = 1.085; Figure 3.4a). The population reached a peak of 103 individuals in 1989, but this was followed by a period of slight decline at a rate of -2.1% for roughly two decades due to a combination of reduced reproduction and exports out of the managed population (average $\lambda_{1990\text{-}2012}$ = 0.979; Figure 3.4a). In recent years, the population has grown again as a result of increased rates of reproduction, allowing the current population to reach a peak of 107 animals. There are no wild-caught animals remaining in the population.

The age structure of the current *ex situ* European population is pyramidal with most individuals in the youngest age classes (Figure 3.4b). Most age classes are filled and the population is the largest of all regions, supporting a demographically robust population. Though the sex ratio is skewed towards females with 2.3 females for every male, this type of age structure is compatible with the breeding and social system of this species and there is still a moderate number of intact males to be of concern (n=32).

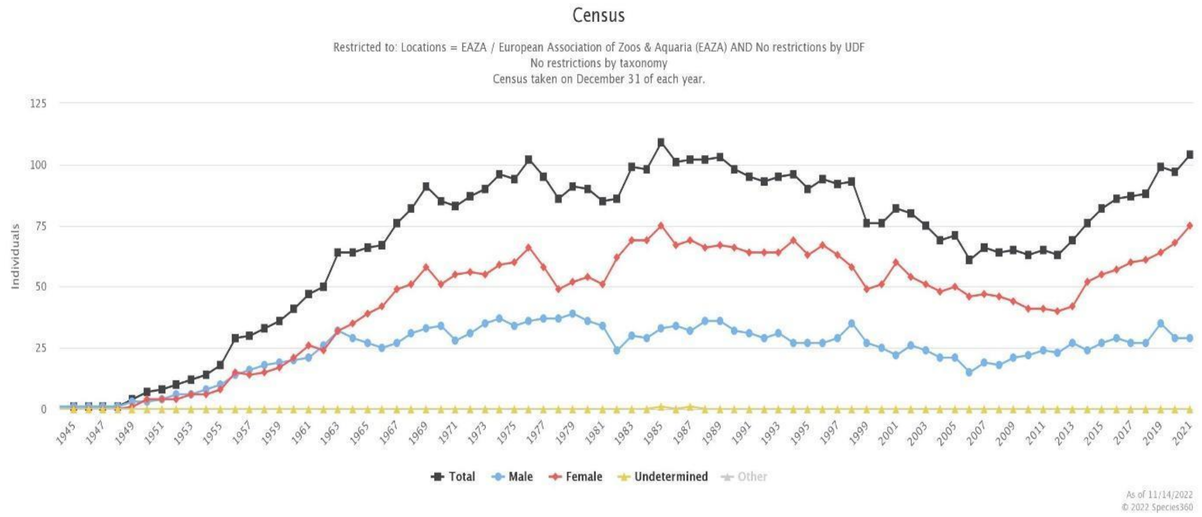


Figure 3.4a: Census of Banteng in Europe from 1945 to 2021 (census on 31 December).

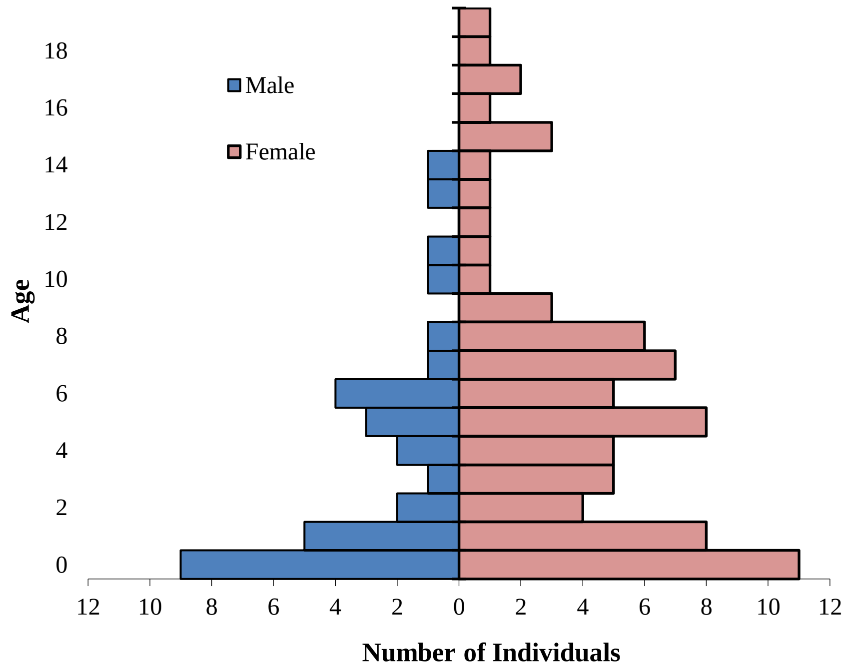


Figure 3.4b: Age distribution of the current potentially breeding banteng population in Europe (current to June 6, 2022).

North America (AZA)

Studbook records indicate that banteng have been consistently held in AZA facilities since 1959, when a captive-born breeding pair was imported from the Netherlands. The population steadily grew in size for the next 30 years at an average rate of 9.8% due to a combination of successful captive breeding and continued imports (average $\lambda_{1960\text{-}1992}$ = 1.098; Figure 3.5a). No wild-caught animals have ever been imported; all imports originated from other regional captive breeding facilities. After an initial period of growth, the population's size fluctuated for about 10 years (1992 – 2003) then experienced a quick decline starting in 2004 when 22 animals were transferred outside of AZA institutions. The population subsequently continued to slowly decline due to a general lack of interest in the species, with an average decline in size of ~4% per year observed from 2005 through 2016 (average $\lambda_{2005\text{-}2016}$ = 0.96). Following the reestablishment of the SSP and the 2018 Breeding and Transfer Plan, the population has begun to again grow in size at a rate of 5.3% in the last five years with births and imports deaths and exports (average $\lambda_{2017\text{-}2021}$ = 1.053).

The age distribution of the population is roughly columnar, although slightly smaller numbers of animals are distributed among the oldest age classes (Figure 3.5b). The sex ratio is skewed towards females with 2.3 females for every male. Although this age structure may be compatible with the breeding and social system of this species, a biased sex ratio can have negative genetic implications if few males breed; a small number of breeding males reduces the effective population size (Ne) and increases the rate at which gene diversity is lost. The North American population is the smallest among the three regions. A larger population size would support more demographic stability.

Figure 3.5a: Census of banteng in North America from 1959 to 2021 (census on 31 December).

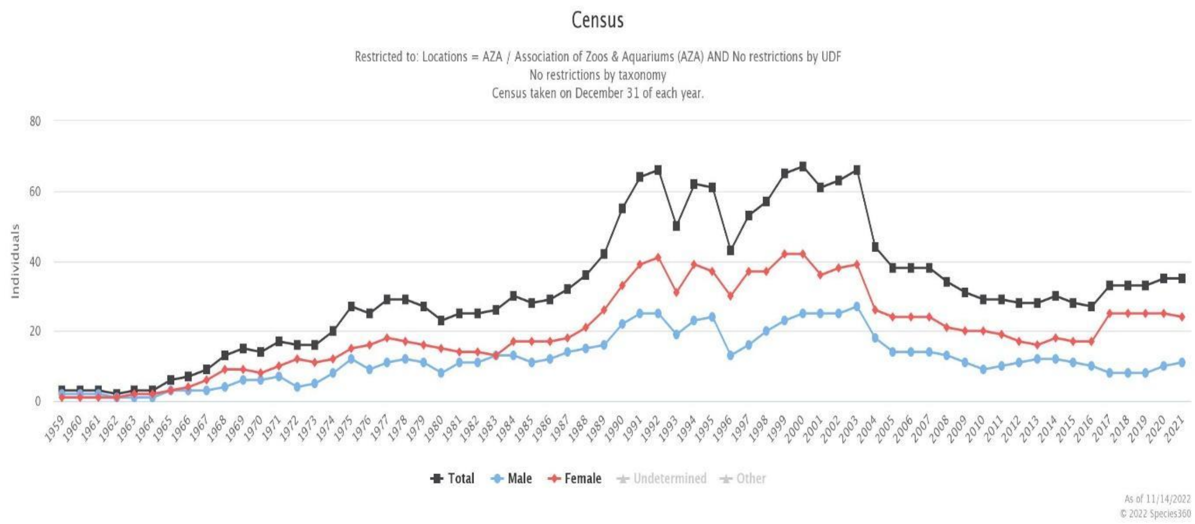
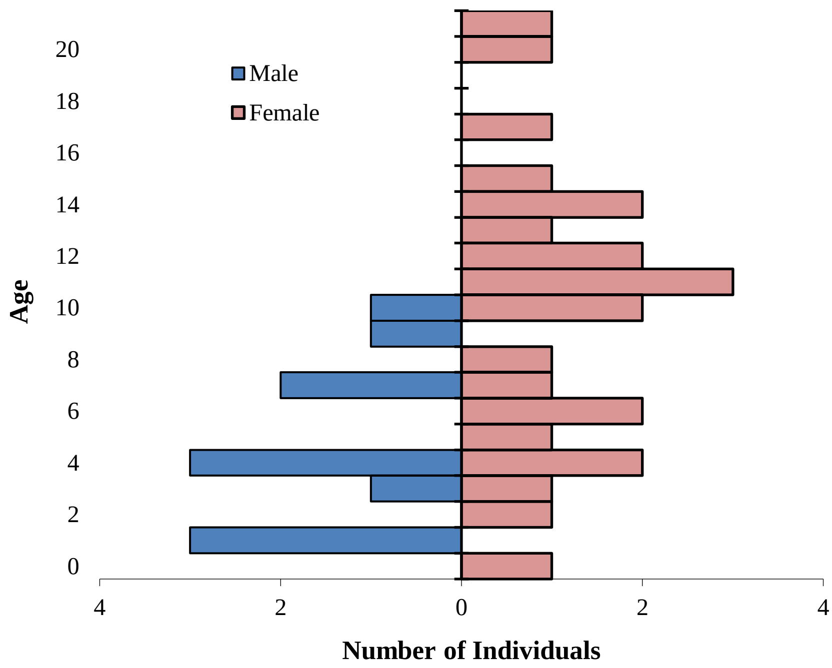


Figure 3.5b: Age distribution of the current potentially breeding banteng population in North America (current to June 6, 2022).



Genetic Status

Genetic analysis of the global population was possible for the first time due to an updated International Studbook. Pedigree assumptions have also been re-evaluated based on the International Studbook where previous assumptions were developed in isolation for each region. The North American and European populations have a notable amount of unknown pedigree prior to pedigree assumptions, however, the Indonesian population has a high level of known pedigree due to known wild caught animals that entered the population. After assumptions and exclusions, the global potentially breeding population had a nearly completely known pedigree (99.8%; Table 4.2).

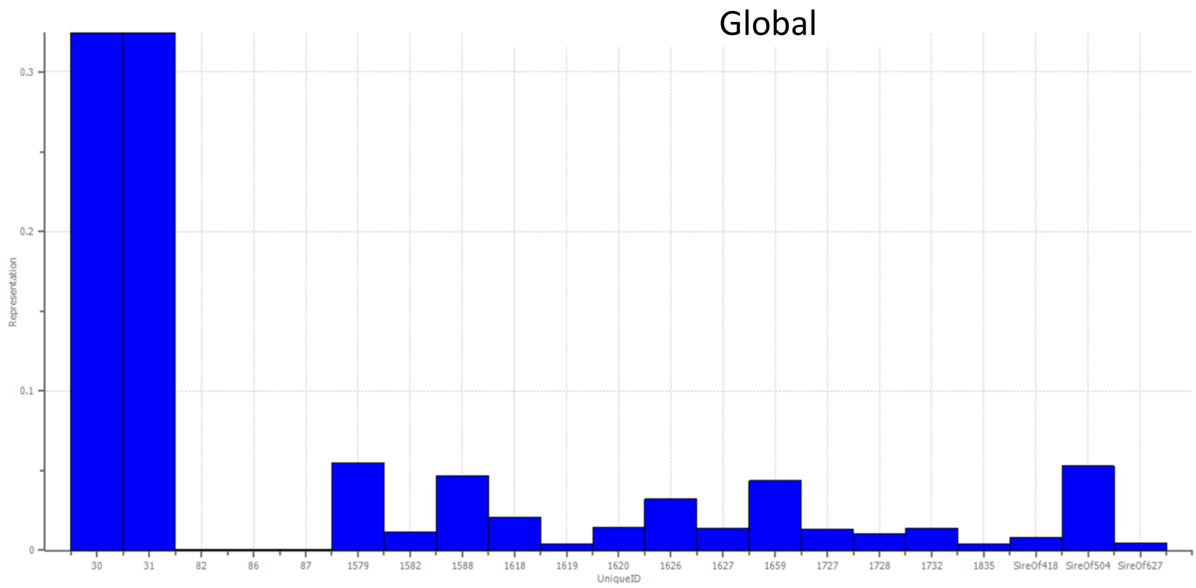
The global population is descended from 21 founders with no potential founders remaining. Founder representations are highly skewed at the global and regional population level; representations that are more equal would retain more gene diversity. Unfortunately, this is effectively impossible to achieve in the European and North American population due to the distribution of founder representations among living individuals, in which the critically under-represented founder lineages represent an insignificant amount of the total representation across the population (Figure 3.6). There is some potential to improve founder representation of hypothetical founder 'SireOf504' in the European and North American populations, but it would be extremely difficult to improve representations of the remaining under-represented founders which have less than 5% representation in any living animal. Founders SB# 30 and 31 are significantly over-represented in the EAZA and AZA populations due to the import of captive born animals at Taman Margasatwa Ragunan (JAKARTA). Breeding pair 30x31 is the only known import into JAKARTA, therefore an assumption was developed for all captive born animals from JAKARTA with unknown parents to be assigned sire and dam 30x31. The North American population has no unique founders, whereas the European population has one unique founder (SireOf418) and the Indonesian population has 13 unique founders (Figure 3.6e). The Indonesia population has the largest number of founders (n=15) due to known, wild caught animals that have entered the population. For this reason, the Indonesia population also has the highest level of gene diversity (93.81%; Table 4.2). It is therefore important for the global population that genetic management of the Indonesia population remains a high priority.

Table 3.2: Genetic summary globally and by zoo region. Genetic statistics are based on the genetically managed population (N).

	Indonesia	**Europe (EAZA)**	**North America (AZA)**	**Global**
Potentially Breeding Population (N)	70(27.43.0)	105(30.75.0)	27(6.21.0)	202(63.139.0)
Excluded Animals	1(0.1.0)	2(2.0.0)	9(5.4.0)	12(7.5.0)
% Known Pedigree				
Before Assumptions and Exclusions	85.9*	11.6*	8.2*	35.7*
After Assumptions and Exclusions	100	99.8	98.9	99.8
Number of Founders	15	8	7	21
Number of Potential Founders	0	0	0	0

Founder Genome Equivalents (FGE)	8.08	1.43	1.24	3.01
Gene Diversity Retained (%)	93.81	65.12	59.72	83.40
Population Mean Kinship	0.0619	0.3488	0.4028	0.1660
Mean Inbreeding (F)	0.0548	0.3295	0.3959	0.2477
N_e/N	0.1943‡	0.33‡	0.4570‡	0.3029‡

*calculated from true (non-analytical) studbook
‡excludes founders



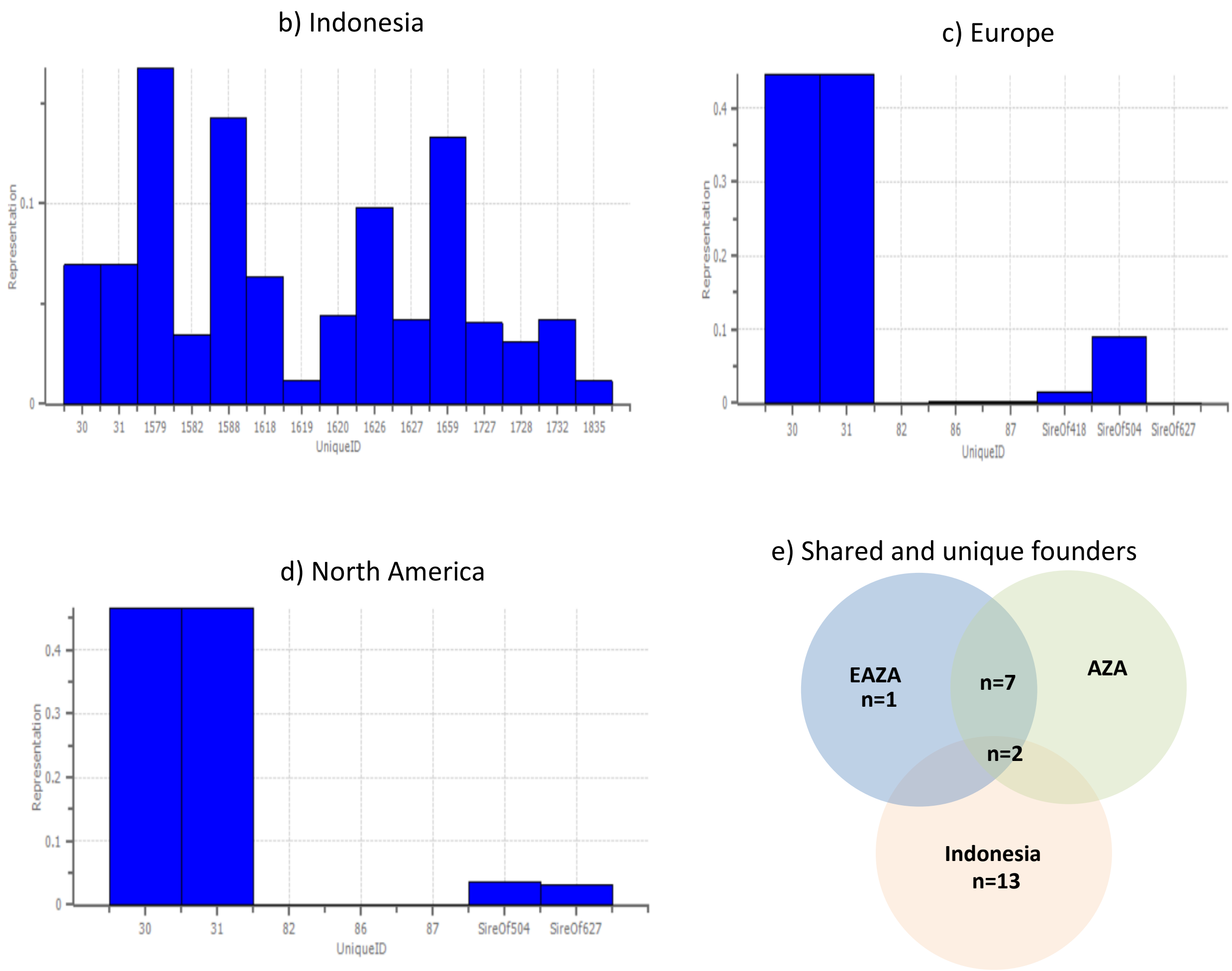


Figure 3.6 a-e: Founder representations for the global population and for each regional population.

3.3 Regional & Global Population Goals

Following the national action plan, the GSMP targets a global *ex situ* population with a minimum of 300 confirmed non-hybridized individuals with 30 founders (animals of wild origin that are not related to any other animal in the population), in order to maintain 90% of genetic diversity of the wild population for 100 years. This population may, in the future, serve as an insurance or supplementation population to back-up the *in situ* population. The pro-active *ex situ* management will be based on a global studbook that uses the information of regionally managed studbooks and will make recommendations for regional and global transfers of individuals.

The initial focus of the GSMP is establishing an effective Indonesian *ex situ* breeding programme (see objectives below). Once this is established and stable, and possibly at the end of this phase (end 2025) an analysis will be conducted in regard to the feasibility of a small number of animal or gamete transfers to other global regions.

3.4 Regional & Global Program Needs

- The identification of which facilities within the three regions will be participating in the GSMP
- Clear schedule for when regional recommendations are expected to be published

3.5 Individuals included in the GSMP Population

The intent of the GSMP is to include all individuals managed through regional programs in Indonesia, Europe, and North America. The most recent studbook data available from those regions suggested the GSMP population currently includes 214 individuals (70 males, 144 females) distributed among 29 institutions.

3.6 Global Ranked Mean Kinship Lists

All mean kinship lists are based on the analytical international studbook and values are subject to change with any birth, death, import, export, inclusion, or exclusion.

Table 4.3: Individual mean kinship values for the global population of banteng. The line in the middle of the male and female lists denotes where the average population mean kinship is (MK = 0.1660). Individuals above the line are the most underrepresented individuals and thus highest priority breeders.

MALES					FEMALES				
SB#	**MK**	**% Known**	**Age**	**Location**	**SB#**	**MK**	**% Known**	**Age**	**Location**
1888	0.0175	100	10	PASURUAN	1582	0.0057	100	19	PASURUAN
1933	0.0180	100	8	PASURUAN	1727	0.0067	100	15	PASURUAN
1938	0.0184	100	8	PASURUAN	1627	0.0070	100	18	PASURUAN
2467	0.0185	100	0	GIANYAR	1732	0.0070	100	15	PASURUAN
2158	0.0192	100	1	GIANYAR	1618	0.0105	100	18	PASURUAN
2468	0.0194	100	1	GIANYAR	1995	0.0131	100	6	BOGOR
2148	0.0197	100	11	GIANYAR	1785	0.0138	100	14	GIANYAR
1857	0.0204	100	11	PASURUAN	1987	0.0148	100	6	GIANYAR
1990	0.0206	100	6	PASURUAN	1939	0.0159	100	8	GIANYAR
2015	0.0218	100	5	BOGOR	1970	0.0159	100	7	GIANYAR
2445	0.0222	100	1	BALURAN	1986	0.0159	100	6	PASURUAN
2437	0.0223	100	2	BALURAN	1916	0.0161	100	9	GIANYAR
1833	0.0227	100	12	BOGOR	1805	0.0165	100	13	GIANYAR
2156	0.0229	100	2	BOGOR	1754	0.0172	100	15	PASURUAN
1860	0.0232	100	11	PASURUAN	2157	0.0185	100	2	GIANYAR
1912	0.0232	100	9	PASURUAN	1940	0.0192	100	8	GIANYAR

MALES					FEMALES				
SB#	**MK**	**% Known**	**Age**	**Location**	**SB#**	**MK**	**% Known**	**Age**	**Location**
1889	0.0237	100	10	PASURUAN	2154	0.0192	100	2	BOGOR
2438	0.0239	100	2	PASURUAN	2469	0.0192	100	0	GIANYAR
2434	0.0252	100	3	PASURUAN	2442	0.0193	100	2	PASURUAN
1861	0.0254	100	11	PASURUAN	1856	0.0199	100	11	BALURAN
2444	0.0266	100	1	PASURUAN	1886	0.0199	100	10	BOGOR
2055	0.0268	100	4	PASURUAN	1926	0.0199	100	9	PASURUAN
2439	0.0268	100	2	PASURUAN	1851	0.0200	100	12	BALURAN
1735	0.0294	100	15	PASURUAN	1762	0.0205	100	14	BOGOR
1843	0.1652	100	12	SURABAYA	1878	0.0211	100	10	PASURUAN
2012	0.1683	100	5	JAKARTA	2433	0.0212	100	3	PASURUAN
2047	0.1683	100	4	JAKARTA	1914	0.0216	100	9	PASURUAN
1895	0.2029	100	10	GARDENCTY	2060	0.0218	100	4	BOGOR
2425	0.2065	97.75	1	SD-WAP	2435	0.0222	100	3	BALURAN
1965	0.2090	95.5	7	SD-WAP	2446	0.0223	100	0	BALURAN
1908	0.2103	100	9	METROZOO	2443	0.0233	100	1	BALURAN
1897	0.2166	98.83	10	MUNICH	2052	0.0252	100	4	PASURUAN
2046	0.2166	100	4	WILDS	2053	0.0259	100	4	PASURUAN
2452	0.2172	99.41	0	MUNICH	2441	0.0259	100	2	PASURUAN
2018	0.2192	100	5	BEWDLEY	2048	0.0266	100	4	PASURUAN
1984	0.2213	100	6	ST LOUIS	2431	0.0266	100	3	PASURUAN
2023	0.2244	100	5	DRESDEN Z	2440	0.0266	100	2	PASURUAN
2022	0.2250	100	5	BEWDLEY	1608	0.1650	100	19	SURABAYA
2061	0.2250	100	4	BEWDLEY	1648	0.1655	100	17	JAKARTA
1867	0.2268	97.66	11	ROMA	1704	0.1655	100	16	JAKARTA
2466	0.2268	99.41	0	MUNICH	1934	0.1666	100	8	JAKARTA
2003	0.2279	100	6	LISIEUX Z	1892	0.1682	100	10	JAKARTA
2455	0.2280	100	0	DRESDEN Z	2432	0.1683	100	3	JAKARTA
1932	0.2300	100	8	TREGOMZOO	1680	0.1939	100	16	BERLINZOO
2379	0.2313	100	1	LE VIGEN	1877	0.1997	100	11	SD-WAP
1972	0.2316	100	7	EDINBURGH	1852	0.2002	100	12	ST LOUIS
2386	0.2318	100	1	LE VIGEN	1823	0.2009	100	13	ST LOUIS
1764	0.2319	100	14	EDINBURGH	2026	0.2021	100	5	METROZOO
2457	0.2330	100	0	MARWELL	1946	0.2025	100	8	SD-WAP
2403	0.2346	100	0	WROCLAW	1968	0.2026	100	7	SD-WAP

MALES

SB#	MK	% Known	Age	Location
2336	0.2347	100	3	WROCLAW
2387	0.2348	100	1	ARNHEM
2393	0.2351	100	1	HILVARENB
2079	0.2357	100	3	HILVARENB
1800	0.2359	100	13	BERLINZOO
2464	0.2362	100	0	LISIEUX Z
2360	0.2365	98.83	2	TREGOMZOO
2458	0.2368	100	0	CHESTER
2401	0.2376	99.41	1	KOLN
2470	0.2376	99.41	0	KOLN
2004	0.2388	98.83	6	KOLN
2450	0.2394	100	0	MARWELL
2359	0.2399	100	2	MARWELL

FEMALES

SB#	MK	% Known	Age	Location
2002	0.2032	100	6	SD-WAP
2409	0.2056	97.75	4	METROZOO
1866	0.2061	95.5	---	ST LOUIS
1844	0.2063	95.41	12	SD-WAP
2411	0.2065	97.75	3	SD-WAP
2419	0.2067	97.75	2	SD-WAP
2472	0.2067	97.75	0	SD-WAP
1865	0.2068	95.5	11	SD-WAP
1763	0.2081	100	14	BEWDLEY
1749	0.2095	100	15	BEWDLEY
1560	0.2099	100	20	GARDENCTY
1854	0.2103	100	11	WILDS
1989	0.2107	100	6	WILDS
2050	0.2108	100	4	WILDS
1514	0.2112	100	21	WILDS
1921	0.2113	100	9	CHESTER
1980	0.2159	100	7	MUNICH
1796	0.2188	100	14	WILDS
1937	0.2195	100	8	BEWDLEY
1906	0.221	100	10	WILDS
1645	0.2239	100	18	MONTPELLI
1675	0.2239	100	17	MONTPELLI
2068	0.2244	100	4	MARWELL
2448	0.2249	99.41	0	MUNICH
1979	0.2254	100	7	HILVARENB
2340	0.2258	99.32	3	WROCLAW
1953	0.2264	100	8	HILVARENB
1925	0.2284	100	9	HILVARENB
1907	0.2291	100	9	CHESTER
2014	0.2292	100	5	TREGOMZOO
1598	0.2298	100	19	DRESDEN Z
1719	0.2299	100	15	MUNICH
2044	0.2301	98.83	5	BEWDLEY
2381	0.2305	100	1	TREGOMZOO

MALES					FEMALES				
SB#	MK	% Known	Age	Location	SB#	MK	% Known	Age	Location
					2402	0.2311	99.66	0	WROCLAW
					2082	0.2313	100	0	HILVARENB
					1705	0.2314	100	16	MUNICH
					2034	0.2316	100	5	BEWDLEY
					2064	0.2320	100	4	HILVARENB
					1960	0.2321	100	7	MUNICH
					2025	0.2324	100	5	HILVARENB
					2451	0.2328	100	0	HILVARENB
					2021	0.2329	100	5	CHESTER
					2066	0.2329	100	4	WROCLAW
					2378	0.2329	100	1	CHESTER
					2400	0.2329	100	1	CHESTER
					2465	0.2329	100	0	CHESTER
					2341	0.2330	100	3	HILVARENB
					2083	0.2331	100	0	LISIEUX Z
					2338	0.2333	100	3	MARWELL
					2028	0.2338	100	5	DRESDEN Z
					1956	0.2346	100	8	KOLN
					2404	0.2346	100	0	HILVARENB
					1999	0.2347	100	6	KOLN
					2447	0.2348	100	0	HILVARENB
					1985	0.2350	100	6	MUNICH
					2380	0.2351	100	1	CHESTER
					2375	0.2354	100	1	MUNICH
					2376	0.2360	100	1	LISIEUX Z
					1954	0.2366	98.83	8	ROMA
					1863	0.2368	100	11	CHESTER
					1977	0.2368	100	7	CHESTER
					2001	0.2368	100	6	CHESTER
					2033	0.2368	100	5	CHESTER
					2392	0.2368	100	1	CHESTER
					2369	0.2369	100	2	MUNICH
					2071	0.2372	100	4	MARWELL
					2395	0.2374	100	1	LISIEUX Z

MALES

SB#	MK	% Known	Age	Location

FEMALES

SB#	MK	% Known	Age	Location
2399	0.2374	100	1	LISIEUX Z
2357	0.2375	100	2	LISIEUX Z
2449	0.2375	100	0	MARWELL
1981	0.2376	98.83	7	BERLINZOO
2035	0.2376	98.83	5	BERLINZOO
2454	0.2376	99.41	0	KOLN
2344	0.2379	100	3	ROTTERDAM
1948	0.2383	98.83	8	ROMA
2073	0.2383	100	4	ARNHEM
2456	0.2385	100	0	TREGOMZOO
1998	0.2386	100	6	ARNHEM
2398	0.2395	100	1	ROTTERDAM
1949	0.2445	100	8	LISIEUX Z
1832	0.2449	100	12	ROMA
1973	0.2450	100	7	LISIEUX Z
2008	0.2451	100	6	TREGOMZOO
1717	0.2453	100	15	ARNHEM
2374	0.2453	100	2	ROTTERDAM
1850	0.2473	100	12	BERLINZOO
1883	0.2484	100	10	ROMA
1961	0.2513	100	7	ROTTERDAM

3.7 Inter-regional Transfer Strategy

The strategy of the Banteng GSMP is focusing on each of the three regions (North America, Europe, and Indonesia), ensuring that all information in their respective regions within the international studbook is accurate and up to date so a full population analysis can be done within each region. This analysis was completed for the North American (AZA) population and an official AZA Breeding and Transfer Plan (BTP) was developed in 2021. An analysis was completed for the European (EAZA) population in the form of a Long-term Management Plan (LTMP) in 2022. The first breeding and transfer plan for the Indonesian region was put together in October 2016 using the Indonesian population database managed through the International Banteng Studbook in Indonesia. This initial analysis only included animals at Taman Safari facilities and Baluran National Park Banteng Breeding Center. The second breeding and transfer plan in 2018 was an expansion of the initial analysis to include all Indonesian holding facilities. Recommendations identified one or two breeding bulls for each facility, with the intent of prioritizing genetically under-represented bulls and minimizing short-term offspring inbreeding. Of the 17 transfer recommendations, six transfers were completed in July 2018.

Of all the regions, the Indonesian *ex situ* population holds the most genetically under-represented animals. Therefore, the initial focus of the GSMP is to establish an effective Indonesian *ex situ* breeding programme. Once this is established and stable, an analysis will be conducted regarding the feasibility of a small number of animal transfers to other global regions.

There are many hurdles in the way of moving a large ruminant like banteng between regions. For this reason, assisted reproductive techniques are being investigated to determine if it may be a more feasible and cost-effective technique for transferring genes between the three regional populations. In addition to the difficulty and expense associated with moving these large animals, there are also a great deal of regional regulations, health requirements, and permissions that will be adhered to and granted. Over the next few years, the Banteng GSMP will be working both on the science of semen collection, cryopreservation of banteng semen, and artificial insemination and on the logistics and permissions needed regarding the transfer of this material and live animals between these three regions.

3.8 Research Needs and Potential Collaborations *Ex Situ*

The following topics were identified as areas needing future research:

- A genetic study is underway to identify the wild populations of origin of the Indonesian, European and North American zoo populations of Banteng. This has progressed for the Indonesian population due to their genetic importance to the global population (see section 6), as well as sampling wild populations. This research will allow for improved management of the genetic diversity of the *ex situ* population, as described in section 3.3.

- Daily data collection on animal condition is important to inform design of animal husbandry and breeding training. This would allow the development of protocols and guidelines to improve husbandry provided and also the success rate of natural breeding attempts.
- It was felt that certain challenges relating to nutrition and reproduction may impact on providing the best husbandry for banteng. So, these topics should be discussed by regional representatives of the *ex situ* community to try to problem solve and potentially develop research activities if a more thorough understanding was required.
- Artificial reproduction: Work to further develop artificial reproductive methods (without risking compromising reproductive potential of the most important individuals). This would include the development of protocols to collect, preserve and use gametes. This is of secondary importance, while the focus should be on natural reproduction.

- Stay vigilant for transferrable diseases (e.g. Foot & Mouth disease) in domestic cattle holdings in countries and regions with zoos holding banteng and practise effective biosecurity.

- Contraception research (Masters Project in place): Research to explore the use of contraception as a management tool for banteng in European zoos to assess both its effectiveness and reversibility. This study will focus on three contraceptives which are currently employed in ex-situ populations in order to evaluate efficacy and reversibility of the contraceptive treatment. Behavioural data and observations of physical changes will be collect to ascertain whether or not the contraception affects behaviour and the dynamics of the herd. The outcome of this work will be increased knowledge of the effectiveness and reversibility of contraceptive use in banteng, which will help inform future guidelines and recommendations for contraception use in cattle.

As the GSMP activities are implemented the specific research questions linked to these topics will be identified and the research set up with partners. No doubt further research questions will be identified during the coming years that can be addressed in the future.

4. Anoa Ex situ Management

4.1 Ex situ Anoa Population Origin

The Anoa International Studbook database has the first recorded Anoa entering zoos in 1844 through Paris, France. The modern day populations among the EAZA and AZA regions originated from three importations from Indonesia to Europe between 1969 and 1977 (Figure 4.1). Eleven animals (six males, five females) were brought in during this time and nine were recruited as founders for the current populations in EAZA and AZA. Detailed geographical origins of all founders are unknown.

The North American AZA population has data starting in the early 1900s, likely from private collectors no longer represented. The currently managed AZA population, however, was started from importations from Europe and Japan in the 1980's (Figure 4.1). For this reason, the AZA and EAZA populations share several founder lineage relations (Figures 4.2a, b).

The PKBSI managed population has not been intensively tracked until more recently with the regional studbook only recording animals in zoos there as far back as 1970. The majority of the animals in Indonesian zoos are originally from wild animals recently brought into captivity and are likely either non-releasable or confiscated animals. Some of these animals have bred, but there are still many potential founder animals yet to breed, representing potentially unique lineages to current managed populations in other regions (Figure 4.2c).

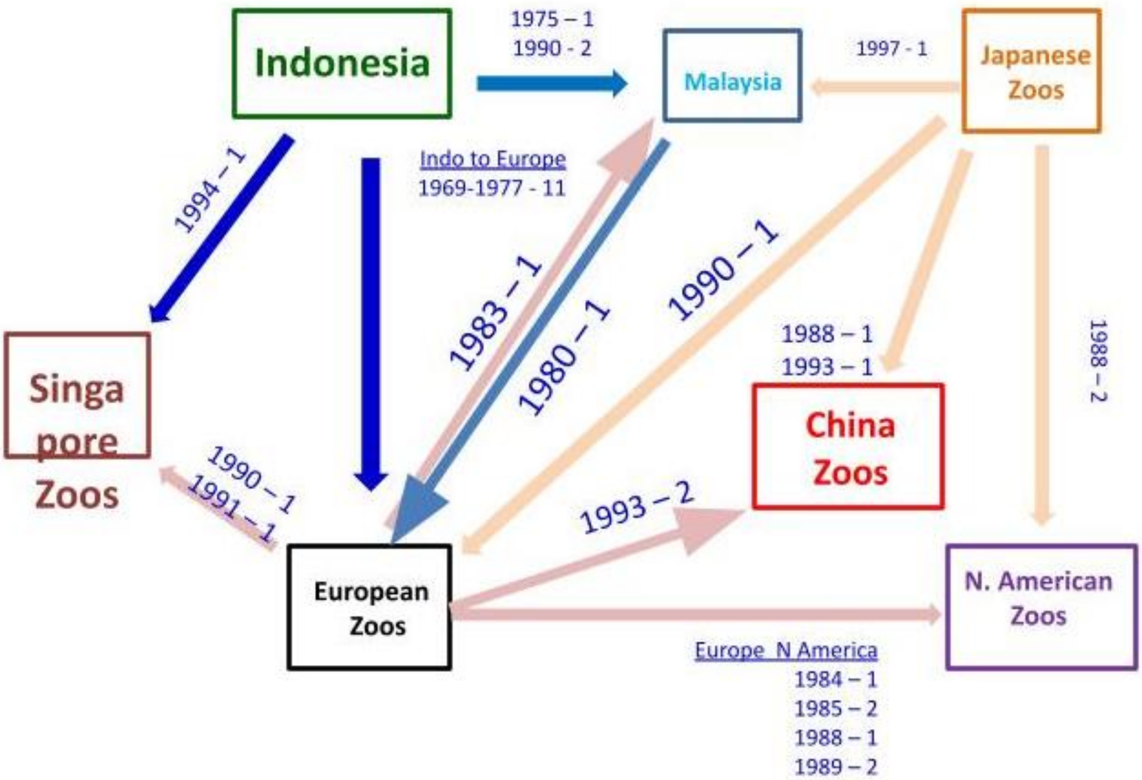


Figure 4.1: Flow chart of international transfers recorded in the Anoa International Studbook from 1970 to present showing the year different transfers occurred along with a number of animals transferred (e.g. Year - # of animals transferred).

4.2 Ex Situ Population Management Strategy

The GSMP population analysis includes three regionally managed *ex situ* populations of Anoa. The European population managed by EAZA as a European Endangered Species Program (EEP). The North American population managed in AZA formerly as a Species Survival Plan® (SSP) but is now managed as an AZA Studbook only. The Indonesian *ex situ* population is managed by PKBSI.

Each regional population is small and has experienced some decline in recent years. Thus, the short-term strategies for the Anoa GSMP will focus on stabilizing or increasing populations within regions. More global strategies will be possible once regional populations stabilize and improve management. To assist in establishing regional populations and to allow for future global management, each regional studbook should be updated as best as possible each year and communicated to the international studbook. Data not recorded in Species360's ZIMS for Husbandry online database by non-ZIMS facility must be manually passed on to the International Studbook Keeper to then allow for the international studbook to be updated annually.

Movements of animals or genetic materials (e.g. gametes) between regions is not likely to be a strategy used for anoa in the near future for management. The primary focus is stabilizing of the different regions and focused management to maintain demographic and genetically stable populations. For the next 3-5 years, the focus of the Anoa GSMP will be to work on regular data updating, work on regulations and processes for transfer of animals in PKBSI and increasing interest in the AZA and EAZA regions of holding anoa.

Each region is expected to adopt management strategies to support demographic stability and genetic variation among anoa *ex situ* populations. The number of recommendations made in each region should meet regional population goals and prioritize under-represented genetic pairs for breeding when possible.

4.3 Demographic & Genetic status of Ex situ Populations

Analysis Notes

Analyses were carried out using the International Anoa Studbook in ZIMS for Studbooks, which combines studbook data from all three managed regions. However, some facilities included in the Indonesian population are not currently represented in the international database. Thus, the most recent PMx analyses from the breeding and transfer recommendations in 2022, were used to summarize the Indonesian population. Software for Indonesian data analyses were SPARKS and PopLink2.5.2. All data for Europe (EAZA) and North America (AZA) populations were obtained from ZIMS for Studbooks or Husbandry. Data for the Indonesian population was compiled By Dr. Yohana Tri Hastuti (Taman Safari, Indonesia). Studbook data filters described below were used to analyse the demographic and genetic status of the global population of anoa. Each region was analysed separately using the PMx project for the global population. No pedigree assumptions were used in these analyses. Life table data were obtained from the global population. A total of 15 individuals were excluded from potentially breeding population (i.e. genetic analyses) due to reasons like sterility or advanced age.

PMx Software Settings

PMx Project: Anoa_Global2023
Created: 2023-02-04 by PMx version 1.6.4.20220303

File: C:\PMxProjects\Anoa_Global2023.pmxproj
Primary data file
Data File Name: zims.zims
Common Name: Anoa
Scientific Name: Bubalus depressicornis
Data Source: ZIMS for Studbooks
Studbook Name: Anoa (Bubalus depressicornis) ISB, EEP
Exported On: 2023-02-04
Software version: ZIMS for Studbooks 3.0
Current Through: 2020-09-04
Compiled By: Gerd Nötzold, Marcel Alaze
Scope: WAZA
Dates: 1988-01-01 to 2023-02-04
Location:
Association: AZA / Association of Zoos & Aquariums (AZA), PKBSI / Perhimpunan Kebun Binatang - Indonesian Zoo & Aquarium Association (PKBSI), EAZA / European Association of Zoos & Aquaria (EAZA)
Other Filters: Status = Living
User: John Andrews

Moves data file
Data File Name: genetic.csv
Common Name: Anoa
Scientific Name: Bubalus depressicornis
Data Source: ZIMS for Studbooks
Studbook Name: Anoa (Bubalus depressicornis) ISB, EEP
Exported On: 2023-02-04
Software version: ZIMS for Studbooks 3.0
Current Through: 2020-09-04
Compiled By: Gerd Nötzold, Marcel Alaze
Scope: WAZA
Dates: 1988-01-01 to 2023-02-04
Location:
Association: AZA / Association of Zoos & Aquariums (AZA), PKBSI / Perhimpunan Kebun Binatang - Indonesian Zoo & Aquarium Association (PKBSI), EAZA / European Association of Zoos & Aquaria (EAZA)
Other Filters: Status = None
User: John Andrews

Moves data file
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Common Name: Anoa
Scientific Name: Bubalus depressicornis
Data Source: ZIMS for Studbooks
Studbook Name: Anoa (Bubalus depressicornis) ISB, EEP
Exported On: 2023-02-04
Software version: ZIMS for Studbooks 3.0
Current Through: 2020-09-04
Compiled By: Gerd Nötzold, Marcel Alaze
Scope: WAZA
Dates: 1988-01-01 to 2023-02-04
Location:
Association: AZA / Association of Zoos & Aquariums (AZA), PKBSI / Perhimpunan Kebun Binatang - Indonesian Zoo & Aquarium Association (PKBSI), EAZA / European Association of Zoos & Aquaria (EAZA)
Other Filters: Status = None
User: John Andrews

Demographic input files
Census1 file: Exchcens.txt

Raw Qx day age class 10767 modified from 1.0 to 0.67
8 births to parents with unknown ages have been added in proportion to known aged parents.
This is 3% of TOTAL births (N=303)

PKBSI PMx Project
PMx Project: Anoa_PKBSI
Created: 2023-02-04 by PMx version 1.6.4.20220303
File: C:\PMxProjects\Anoa_PKBSI.pmxproj

Primary data file
Data File Name: Anoa_July2022.ped
Common Name: ANOA DATARAN RENDAH
Scientific Name: BUBALUS DEPRESSICORNIS
Data Source: PopLink
Studbook Name: Anoa_July2022
Exported On: 2023-02-04
Software version: PopLink 2.5.2
Current through: 2021-11-20
Compiled by: Yohana Tri Hastuti_____
Scope: National Indonesia
Dates: 2023-02-04
Locations:
Association:
Other Filters: Status = Living
User: JAndrews

Moves data file
Data File Name: Anoa_July2022genetics.csv
Common Name: ANOA DATARAN RENDAH
Scientific Name: BUBALUS DEPRESSICORNIS
Data Source: PopLink
Studbook Name: Anoa_July2022
Exported On: 2023-02-04
Software version: PopLink 2.5.2
Current through: 2021-11-20
Compiled by: Yohana Tri Hastuti_____
Scope: National Indonesia
Dates: 2023-02-04
Locations:
Association:
Other Filters: Status = Living
User: JAndrews

Moves data file
Data File Name: Anoa_July2022demog.csv
Common Name: ANOA DATARAN RENDAH
Scientific Name: BUBALUS DEPRESSICORNIS
Data Source: PopLink
Studbook Name: Anoa_July2022
Exported On: 2023-02-04
Software version: PopLink 2.5.2
Current through: 2021-11-20
Compiled by: Yohana Tri Hastuti_____
Scope: National Indonesia
Dates: 1980-01-01 to 2023-02-04
Locations:
Association:
Other Filters: Status = Living
User: JAndrews
Locations data file
Data File Name: location.txt
Demographic input files
Census1 file: Exchcens.txt

Demographic Status

Global

The International Studbook for Anoa includes a total of 161 animal records (77.80.4) among 42 institutions globally. Analysis of the global population combining the three regions was not possible for this reporting, due to some facilities not being represented in the international data that currently cooperate with the PKBSI managed population and data quality for some non-AZA North American holders. Currently, the combined globally managed anoa population consists of 79 animals (40.39) among 31 facilities in the three zoo regions (Table 4.1). A global census is not possible at this time, thus demographic census and age structures are presented separately for each population.

Table 4.1: Population demographics of anoa held in Indonesian, European (EAZA) and North American (AZA) institutions.

	Indonesia	**Europe (EAZA)**	**North America (AZA)***	**Global**
Total Population Size	36	39	9	79
Males.Females.Unknowns	16.20.0	22.19.0	5.4.0	40.39
Number of Institutions	7	22	5	31

*Considerably more anoa are present in North America but held at facilities not participating actively with AZA or the GSMP and thus not included in these analyses.

Indonesia (PKBSI)

The first record of animals in the Indonesian zoo population occurred in 1972 with a wild captured animal from Sulawesi entering into Ragunan Zoo. Based on studbook records the population did not begin growing until the 1990's when more animals were brought into the zoo population from the wild followed shortly after with the first birth event in zoos occurring in 1995 at Taman Safari, Indonesia (Figure 4.2). Between 1988 to 2022, the population grew at an average growth rate of 10.8%. The population recently experiences some declines due to challenges from the COVID pandemic combined with challenges to space and breeding.

The current age structure of the *ex situ* Indonesian population does not approximate a stable population. With few animals in the lowest age classes reflecting the lack of recent breeding, the population can be expected to continue declining in size if breeding cannot be increased (Figure 4.3). While the population is not currently stable, there are a number of animals in reproductive age classes, suggesting that with directed recommendations toward breeding anoa in these age classes. A consistent number of annual births are needed to begin stabilizing and growing this population in the future.

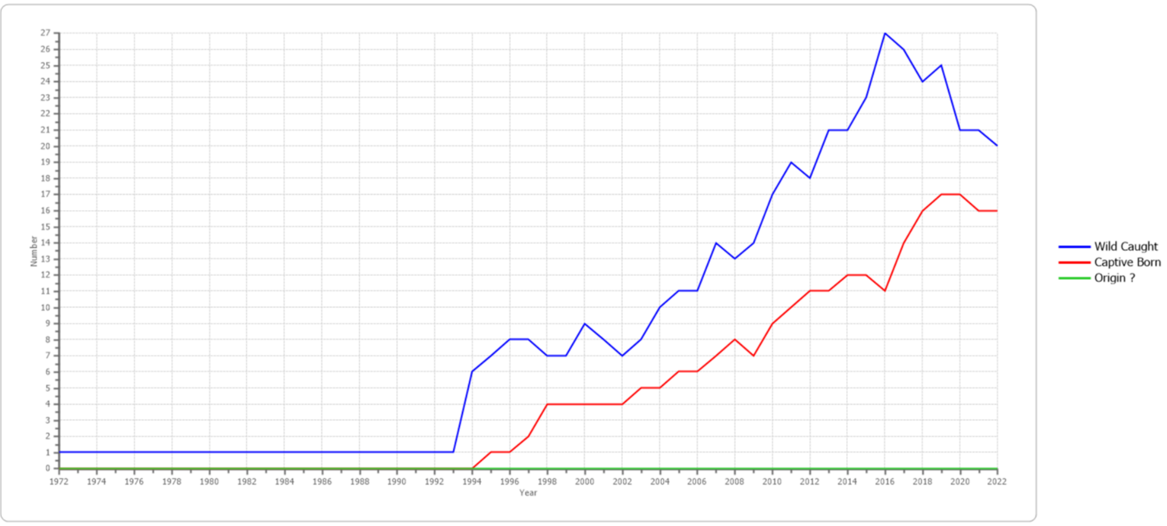


Figure 4.2: Census of the Indonesian Anoa Population from 1972 - 2022.

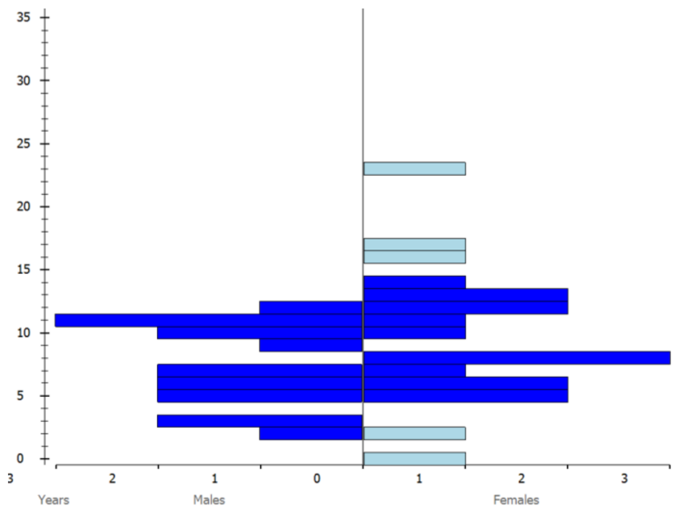


Figure 4.3: Age structure of the current PKBSI population**.**

Europe (EAZA)

The earliest records of anoa in EAZA go back as far as 1844 with at least a small number of anoa continually recorded in European zoos since then. The earliest captive birth was recorded in 1901 at Hamburg Zoo. The population numbers declined close to zero and resurged in the late 1960's when captive births began to be more frequent and consistent peaking at a maximum population size of 71 animals in 2002 (Figure 4.4). Since then, the population has had a slow but steady decline in size. The average growth rate for the population from 1988 to 2022 is 0.2% (lambda = 1.002). Recent five year growth rate is declining at a rate of 5.9% (lambda = 0.941) from 2018 – 2022. There are currently no anoa wild wild origin remaining in the current European population.

The age structure of the European population is somewhat columnar and not stable. Few animals are in the lowest age classes suggesting lack of breeding recently and many age class gaps appear indicating inconsistent breeding through time (Figure 4.5). There are more males than females with many of these aging into older classes where chances of reproduction can become less likely. The population should focus on increasing available space and breeding to stabilize the population as much as possible.

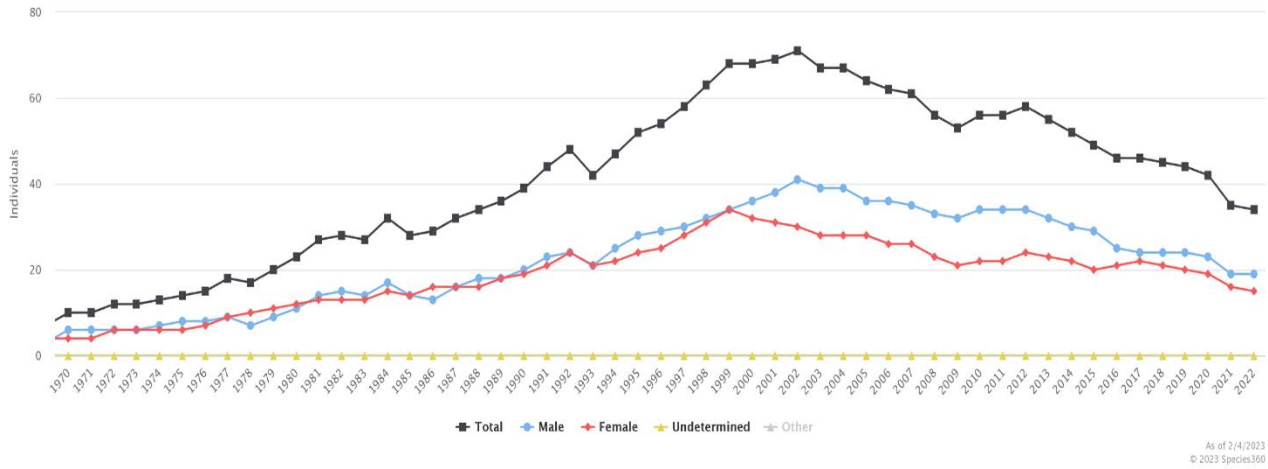


Figure 4.4: Census of the Anoa EEP population from 1970 to 2022.

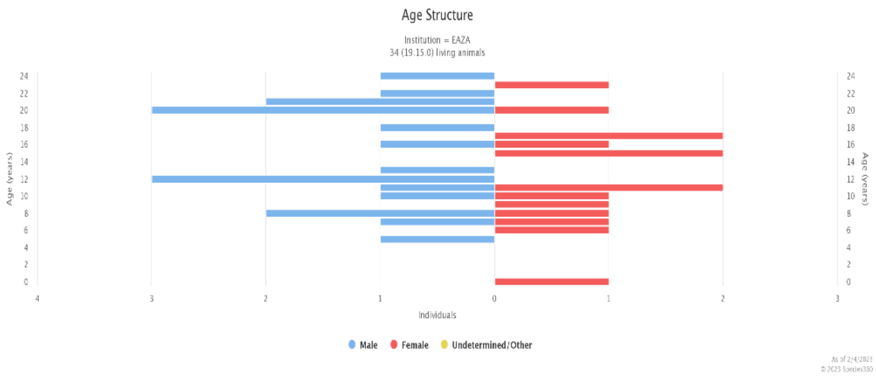


Figure 4.5: Age structure of the current EEP population.

North America (AZA)

The earliest record of anoa in AZA is from 1901 with a transfer of an anoa from Indonesia to Bronx Zoo. Numbers of anoa in North America remained low throughout the census of AZA holders and the first recorded birth in AZA occurred in 1923 at the St Louis Zoo. After 1988, annual births were consistently greater than 10 per year with the population growing to a peak size of 33 animals in 1999 (Figure 4.6). Of special note, there are many private holders in North America with rather large holdings of anoa. It is estimated that one such facility, the Centre for Conservation of Tropical Ungulates (CCTU), currently has 36 anoa, though data from this facility are not reliable and animals are not clearly identifiable. Currently there are only nine anoa in AZA facilities and they are no longer managed as a formal SSP, however, holding zoos and other AZA supporters of the GSMP continue to support management of anoa in the GSMP.

The populations average five year declining growth rate is 9.5% (lambda = 0.915) and the demographic projections suggest the AZA holdings could go extinct in as early as 7 years if declines increase.

The age structure demonstrates the sparse number of animals in the AZA population with more than half in upper age classes that are potentially non-reproductive (Figure 4.7). Without more anoa entering the AZA population, the population may not persist in AZA facilities.

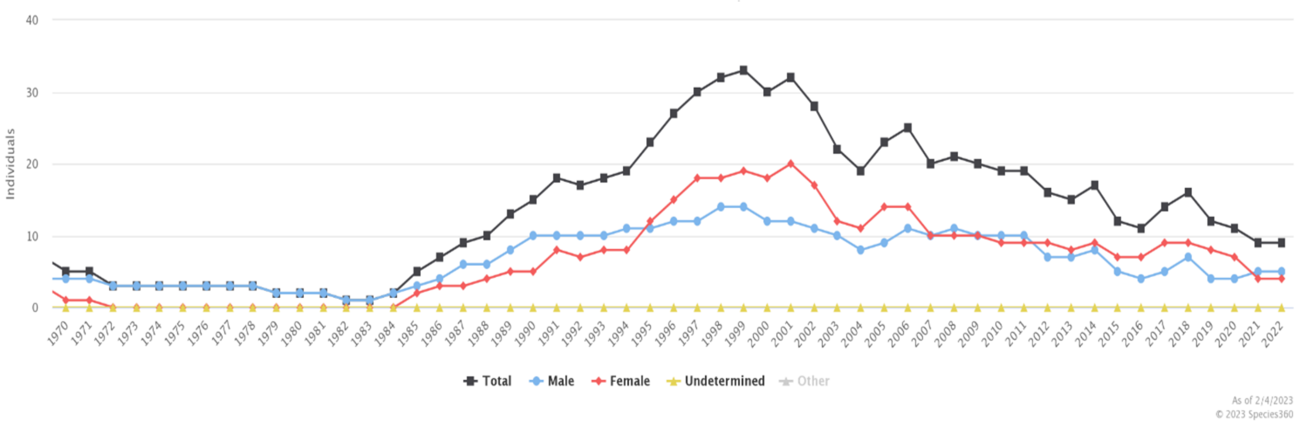


Figure 4.6: Census of anoa in AZA zoos from 1970 to 2022.

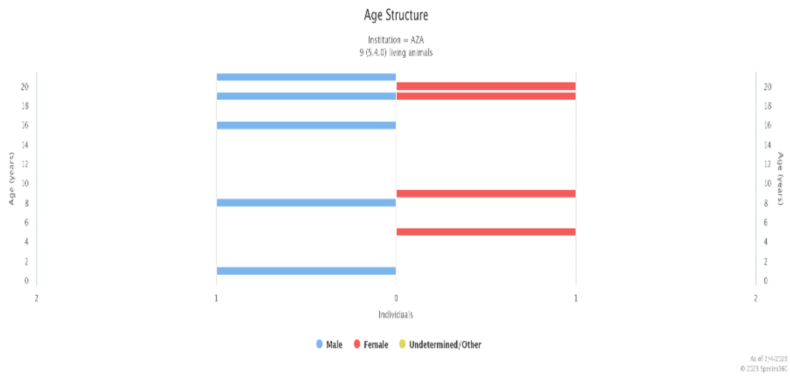


Figure 4.7: Age structure of the current population of anoa in AZA**.**

Genetic Status

Genetic status of the global population is not available at this time due to ongoing challenges with data and the need to update data across regions. No pedigree assumptions were utilized for this analysis to resolve any unknown pedigree as most pedigree is highly known. Animals of advanced age (≥20yo) were excluded from genetic analysis and considered post reproductive. Following exclusions, the total potentially breeding population of anoa across the three zoo regions is 64 animals (Table 2).

Data work needed to allow for global analysis requires resolution of data for holders in North America and Indonesia. Some participating institutions in the PKBSI population are not included in the international studbook currently. Additionally, some North American holders not currently members of AZA have historically provided rough estimates of holdings but not individual data of enough quality to include in the studbooks. Future work should aim to work with the PKBSI studbook keeper to incorporate all known living animals currently into the international database. This effort was greatly delayed due to the COVID pandemic but plans to resume this work are underway. Similarly, representatives in North America are working to forge partnerships and gain updated data on non-AZA facilities with anoa.

Table 4.2: Genetic summary globally and by zoo region. Genetic statistics are based on the genetically managed population (N).

	Indonesia	**Europe (EAZA)**	**North America (AZA)**	**Global**
Potentially Breeding Population (N)	34	25	5	64
Excluded Animals	2 (0.2)	9 (7.2)	4 (0.4)	15 (7.8)
% Known Pedigree				
Before Assumptions and Exclusions	100		100	-
After Assumptions and Exclusions	100	96	100	-
Number of Founders	12	7	7	-
Number of Potential Founders	14	0	0	-
Founder Genome Equivalents (FGE)	5	2.76	1.62	-
Gene Diversity Retained (%)	90	81.89	0.69.2	-
Population Mean Kinship	0.0430	0.1811	0.3080	-
Mean Inbreeding (F)	0.0430	0.1142	0.1525	-
N_e/N	0.1667	0.4615	0.4000	-

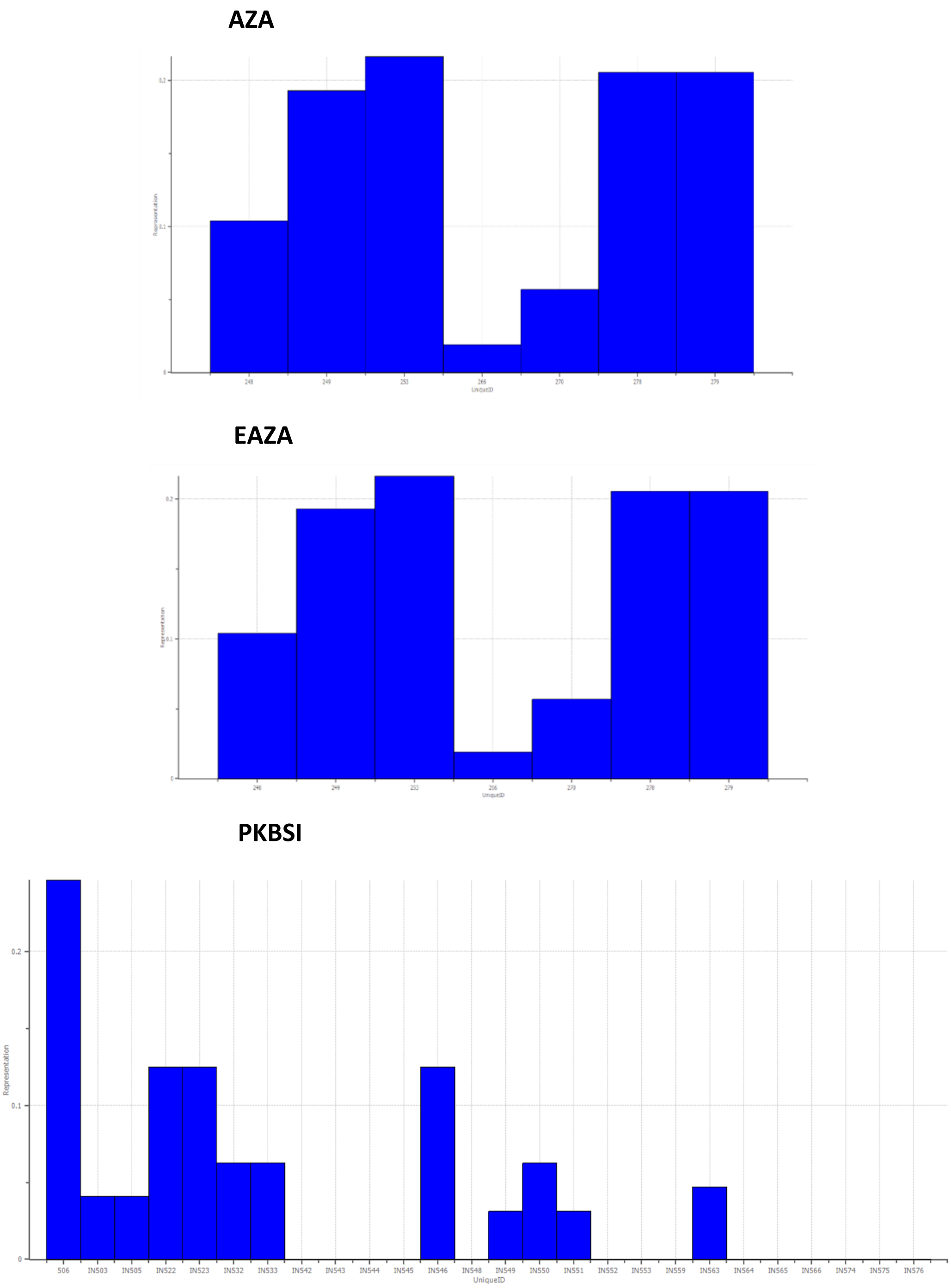


Figure 4.8: Founder representation graphs for the AZA (Top), EAZA (Mid) and PKBSI (Bottom) populations.

4.4 Regional & Global Population Goals

Regional goals are to stabilize each population through increased and consistent breeding and to increase gene diversity by region and globally above 90%. Anoa *ex situ* populations could serve as insurance populations in the future if stable *ex situ* populations can be maintained.

Initial goals in this masterplan are to implement strategies to combine data efficiently and allow for global analysis. Once international data are properly updated, global analysis will help to improve future management and guide potential global management further.

4.5 Regional & Program Needs

- Resolution of Anoa International Studbook to more accurately incorporate PKBSI and AZA holdings.
- Clear schedule of agreed upon updates to the International studbook among all regions.
- Global analysis to assess gene diversity.

4.6 Individuals included in the GSMP Population

The intent of the GSMP is to include all individuals managed through regional programs in Indonesia, Europe, and North America. The best available data currently suggest that a total of 79 anoa (40 males, 39 females) among 31 member facilities. However, additional living animals outside of regional management are managed also with a total of 161 anoa (77.80.4) currently shown as living in the International Studbook among 42 facilities.

4.7 Mean Kinship Explanation

No global mean kinship list is available at this time due to reasons outlined in materials above. The current International database is not currently usable for global analysis. Therefore, showing mean kinships for regional populations is not helpful for this report and thus are not included.

4.8 Inter-regional Transfer Strategy

The strategy of the Anoa GSMP will be to focus primarily on improving international data across the three regions. Informed recommendations on global management, including inter-regional transfers, is not feasible until this is possible. A breeding and transfer plan (BTP) was last produced for the Anoa SSP in 2021. The EEP produces annual transfer and breeding recommendations within the EAZA population. The first set of recommendations for anoa in PKBSI was produced in 2016 using the Indonesian population database. A second set of recommendations were produced in 2018, and included more efforts to collect input from Indonesian zoos resulting in successful fulfilment of several breeding recs and only a handful of transfers. Regionally, transferring animals is difficult in Indonesia and perhaps the most important area where transfers need to occur to allow for continued maintenance of *ex situ* anoa.

Indonesia has the most potential gene diversity due to the availability of founders from the wild via confiscations. Therefore, the initial focus of the GSMP was to establish effective Indonesian *ex situ* breeding programs. After some success mentioned above, the next main goal to allow for continued management of anoa is to facilitate more regular transfers to avoid inbreeding and continue successful breeding.

Assisted reproductive management may be a viable option in the future as a solution to the difficulties of moving a large aggressive ungulate in Indonesia. Little is known about assisted reproductive measures in this species but more research would benefit this population on this topic. The first collection and storage of sperm has begun within the EEP collection.

Ideally, if regional populations stabilize demographically and produce more offspring, inter-regional transfers would benefit the global population. Recruiting unique potential gene diversity in the Indonesian *ex situ* population and spreading it among AZA and EAZA will improve the overall genetic health of the global population as a whole.

5. Babirusa *(Babyrousa celebensis)* Ex situ Management

5.1 Source of the Global Ex situ Population

A global as well as regional studbook databases are used to maintain the population data for all three regional participants in the GSMP. Babirusa have been kept in captivity in private and zoological collections in Indonesia as early as the period 1500-1900 (Macdonald, 2018). The first Babirusa in captivity outside of Indonesia was a pair of Sulawesi Babirusa (*Babyrousa celebensis*) that arrived at the Paris Menagerie du Jardin des Plantes in 1829 and that successfully produced a male offspring in 1830 (Quoy & Gaimard 1830). In North America it was the Bronx Zoo that first obtained a Babirusa in 1929 and in Australia Adelaid Zoo in 1937. Between 1829 and 1973 the international studbook records 68 Babirusa being kept in zoos outside of Indonesia, all of which are thought to have been Sulawesi Babirusa, apart from three Hairy Babirusa (*Babyrousa babyrussa*) that were living in Amsterdam Zoo between 1915 and 1925 (Anonymous 1916; Mohr 1960). None of these individuals have living descendants.

Figure 5.1 illustrates the origin of the current living population of Babirusa in zoos worldwide, as well as the history of intercontinental Babirusa transfers from 1974 until the present. At unknown times prior to 1974 an unknown number of individuals was transferred from the wild (allegedly from Sulawesi) into Surabaya Zoo. Molecular genetic analysis shows that there were at least 5 founders. The precise number remains unknown but oral communication with staff in Surabaya Zoo suggested the number is small. Descendants from this first founder period were transferred to all the other subpopulations at multiple moments in time. There are good pedigree records for the individuals once they left Indonesia, but the basis of the pedigree (the historical generations in Surabaya Zoo and other Indonesian zoos) remains unknown. In 1998, seven individuals (5.2) were confiscated from the illegal trade on Sulawesi and transferred to Surabaya Zoo. Of these, 2.2 individuals were clearly very young, whereas 3 males were clearly older adult males. One of the female individuals that arrived at young age (studbook number 420) died in 2018 without ever having bred. Descendants from the remaining 6 founders from 1998 are living in Indonesian zoos only and interbred with descendants of the first founder event. One of these 6 founders only has living descendants that are post-breeding age (see Genetic status) and is thus functionally lost.

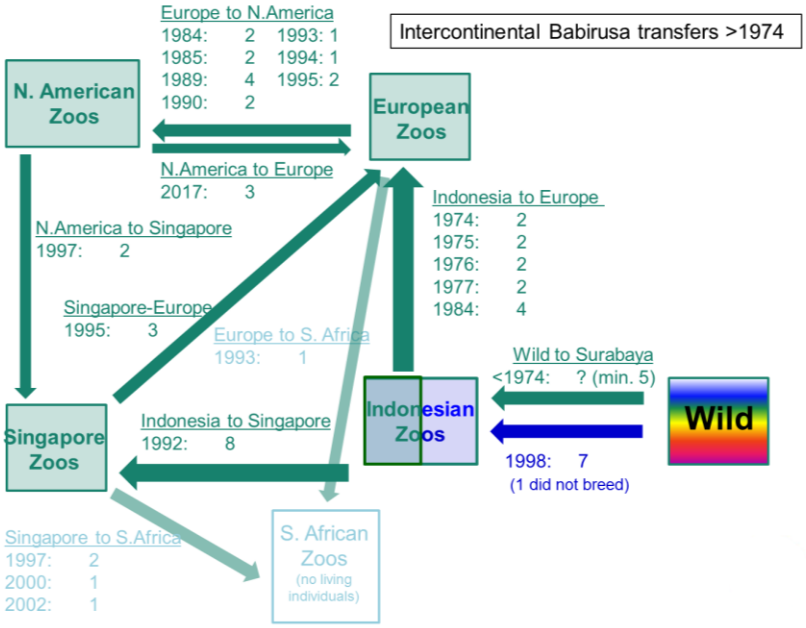


Figure 5.1: Flow chart of international transfers recorded in the Babirusa International Studbook from 1974 to the present showing the year different transfers occurred along with the number of animals transferred (e.g. Year - # of animals transferred).

5.2 Ex situ Population Management Strategy

Given that:

- The wild Babirusa population on Sulawesi continues to experience a considerable level of poaching and illegal trade;
- Habitat loss and degradation is still ongoing;
- It is a difficult and likely lengthy task to bring these primary threats under control;
- There is taxonomic uncertainty and that there is a research project working to clarify these, but that at this moment we cannot yet conclude whether the genetic and morphological differences found point to different populations, subspecies or species
- The current *ex situ* population is derived from uncertain geographic origins on Sulawesi

It was decided that:

- The role of the world zoo population of Babirusa would ideally be to provide a genetically and demographically sustainable and behaviourally competent insurance population for the wild population on Sulawesi, that holds the potential to supply individuals for genetic or demographic supplementation or reintroduction, should this become necessary in the future.
- In view of the current taxonomic uncertainty, the goal of the global Babirusa zoo population for the foreseeable future is:
  - to manage the current population to the best of our abilities so that it is as demographically stable and genetically diverse as is possible under the circumstances
  - to continue to increase capacity in husbandry and breeding/transfer management in all participating Indonesian zoos

- to ensure husbandry experience and interest in the keeping of Babirusa is maintained in the other zoo associations
    - for the non-Indonesian regions to help each other with intercontinental transfers when possible, to address any demographic problems
    - at the appropriate time, to investigate if a small number of PKBSI animals can be shared with other regions on the condition it does not cause harm to the genetic and demographic health of the Indonesian population.
- Until taxonomic issues and management capacities have been sufficiently addressed, it is recommended that no new *ex situ* breeding programmes are set up with wild caught Babirusa from one particular geographic origin (from either Sulawesi, the Togian islands or Buru and the Sula islands).

5.3 Demographic & Genetic Status of Ex situ Populations

All analyses were carried out using the international studbook dataset in ZIMS for Studbooks. The regional studbook keepers maintain their own regional datasets and, for institutions that are not members of Species360, provide their data to the international studbook keeper for inclusion in the international dataset. Table 5.1 shows the studbook keepers/coordinators for each region. Information on date span and geographic filters used for analysis, as well as individuals excluded from genetic analysis can be found in Appendix 5.1. Information on the ZIMS for Studbooks pedigree overlay used to deal with pedigree gaps can be found in Appendix 5.2. The date span used for analysis was 1 January 1974 till 20 July 2022.

Table 5.1: Studbook keepers/Coordinators for the regional and international (global) *ex situ* babirusa populations.

Region	**Studbook keeper/Coordinator**
PKBSI	Sri Pentawati (Surabaya Zoo – Indonesia)
EAZA (Incl. Singapore Zoo)	Jörg Beckmann (Nürnberg Zoo – Germany)
AZA	Joe Forys (Audubon Nature Institute – USA)
WAZA	Jörg Beckmann (Nürnberg Zoo – Germany)

Demographic Status

On the 20th July 2022, the world captive population of Babirusa counted a total of 214 individuals living in 37 institutions, distributed over the different regions as presented in Table 5.2. PKBSI, EAZA and AZA each hold populations of similar sizes. One third of the EAZA population is housed by EAZA (and SEAZA) member Singapore Zoo. The global population slightly increased since the previous masterplan. At a regional level, the European population more than doubled, the AZA population increased slightly, and the PKBSI and Singapore populations both decreased slightly since 2018.

Table 5.2: Babirusa population in different regional and national zoo associations across the world – at the time of the previous (2018) and current (2022) masterplan analyses.

		3 Jan 2018		20 July 2022	
	Region	# Individuals	#Zoos	# Individuals	#Zoos
	PKBSI	32. 48. 0 (80)	8	31. 39. 0 (70)	6
EAZA	Europe	7. 17. 0 (24)	5	22. 27. 0 (49)	11
EAZA	Singapore Zoo	11. 19. 0 (30)	1	11. 14. 0 (25)	1
	AZA	30. 31. 0 (61)	20	30. 40. 0 (70)	19
	TOTAL	80.115. 0 (195)	34	**94.120. 0 (214)**	**37**

Figure 5.2 illustrates how the size and sex ratio of the world and regional populations has evolved over time. There are good studbook records for the individuals once they left Indonesia, but there are no truly reliable historical records for Indonesian zoos predating the start of the PKBSI studbook, with the exception of Surabaya Zoo that started with detailed record keeping for Babirusa in 1998 when new founders arrived. Hence, since the PKBSI studbook was only started in ~2011, data received on the Indonesian population before this date was infrequent and imprecise. The spike in the world and PKBSI census graph is therefore due to data collection inconsistencies rather than a truly observed phenomenon. As such, data for the world and PKBSI population before ~2011 are not very informative. Census information on the EAZA, AZA and Singapore populations is precise for the whole period. The census graphs start in 1974, when the individuals at the basis of the current population outside of Indonesia started to arrive in Europe. Europe, North America and Singapore have housed Babirusa in small numbers before this period but there is no genetic link to the current living population and therefore this more historical part of keeping Babirusa in zoos was ignored for the current analysis. For more details on the history of the world captive population and intercontinental transfers since 1974 see section 5.1 and Figure 5.1). Figure 5.3 shows the age pyramids for the world and regional zoo populations of Babirusa.

Global

The world zoo population of Babirusa has grown only slightly since the start of the GSMP, and this growth is largely explained by the growth in the European population. The global age pyramid is in good condition.

PKBSI

The PKBSI population has slowly but steadily declined since ~2011 due to slightly more deaths than births having occurred in that period. Nevertheless, the age pyramid still shows a relatively healthy number of individuals in juvenile and prime breeding ages, though it will be important to keep breeding with the individuals in the older reproductive age classes for both demographic (achieving a sufficient birth rate) and genetic reasons (some of the most genetically important individuals are getting older – see ‘Genetic status’). This has guided the breeding recommendations for PKBSI. It will be very important to try and follow all breeding recommendations to ensure a reversal of the decline.

AZA

The population in AZA’s Species Survival Plan (SSP) for Babirusa briefly declined after 1996 but then stabilized around ~40 individuals, and from about 2005 started to grow again till it reached 66 individuals in 2016. In 2017 three 3 individuals were exported to Europe and the population briefly dipped to 58 individuals in 2019 to then rapidly grow again to the current 70 individuals. The population has a healthy age structure. AZA is not experiencing any notable problems with its population and is actively recruiting new holders. The covid pandemic may affect the latter, with the financial crisis possibly putting new enclosures on hold. The carrying capacity was set for 80 individuals in the short term future.

EAZA

Mandai Wildlife Reserve became an Associate Member of EAZA and the babirusa population in Singapore zoo is now managed under EAZA’s EEP (EAZA *Ex situ* programme) for Babirusa. Because the European and Singapore populations show a very different demographic development, and transfers between them are not frequent, they are discussed separately below.

Europe

In the 20 years from 1977 to 1996, the European population experienced a census based average growth rate of 8% per year. Since in that period only 2 individuals were imported in 1977 and 4 in 1984, and breeding was not restricted, this growth rate gives a good indication of what a Babirusa population can achieve in a growth phase. The realization that the founder base of the current world population was very small (see ‘Genetic status’ below), and that new founders (from confiscation of illegal trade) arrived in Surabaya Zoo in 1998, lead to a deliberate slowing of breeding in Europe in the hope of being able to import descendants of the new founders from Indonesia. The importation was never realized and the slowing of breeding lead to a population crash in the EAZA. Thanks to fervent efforts by the EEP coordinator and the participating institutions (e.g. by bringing all remaining Babirusa together in 5 institutions to optimize breeding chances), as well as an important demographic boost from the AZA population in the form of the transfer of three individuals to Europe in 2017, the European population has seen a rapid growth from 21 individuals at the end of 2016, to 49 currently. The combination of births and imports has also led to an improvement in the age pyramid structure, but most of the offspring born in the last two years have been males.

Singapore

Due to the challenges associated with transferring Babirusa in or out of Singapore, the population size of Singapore Zoo is largely determined by its own carrying capacity. Singapore suffers from the fact that when breeding occurs, its carrying capacity is immediately reached, resulting in a pulse pattern of breeding and thus empty cohorts in the age pyramid. At the request of EAZA, the population was increased from about 2008 onwards in the hope of exporting animals from Singapore to Europe for demographic rescue, but these exports could not be realised and the population size declined back to a more comfortable level in terms of space capacity. However, from 2013 onwards no breeding has occurred and all individuals are now at the upper end of the reproductive window. Singapore would urgently need to produce several litters to maintain its population into the future through births rather than importation.

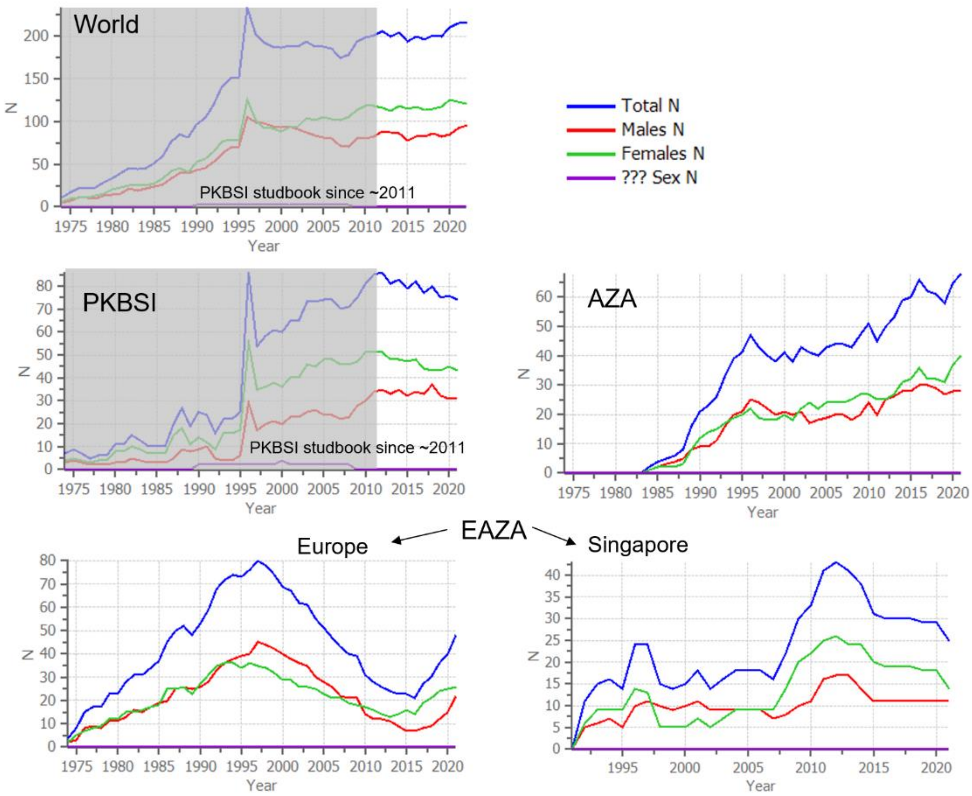


Figure 5.2: Census graphs by sex for the world and regional zoo populations of Babirusa. The PKBSI studbook was started ~2011. Data received on the Indonesia population before this date was infrequent and imprecise, among others leading to the spike in the world and PKBSI census graph, which is due to data collection inconsistencies rather than a truly observed phenomenon. Census data for the world and PKBSI population is therefore not informative before ~2011. Census information on the EAZA, AZA and Singapore populations is precise from 1974 onwards

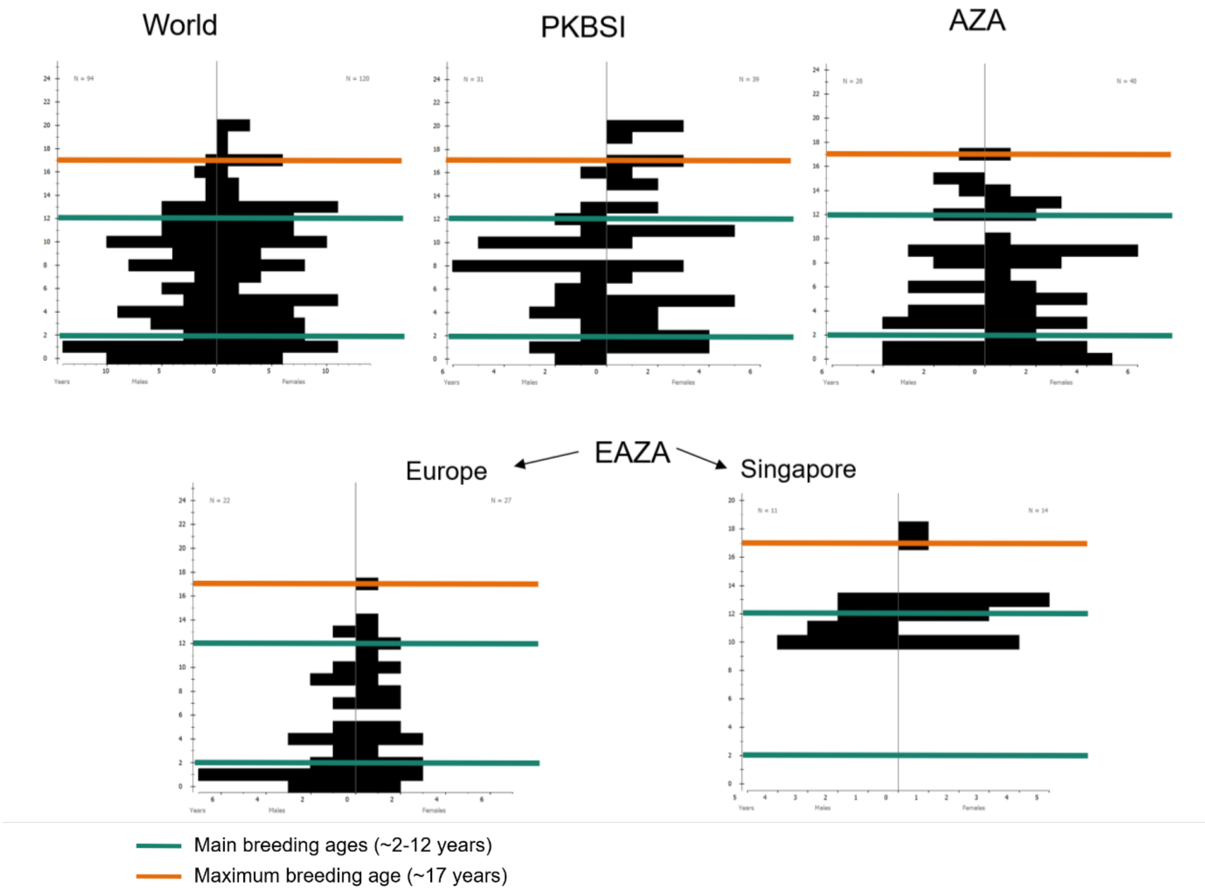


Figure 5.3 Age pyramids for the world and regional zoo populations of Babirusa. Males on the left, females on the right. Notice the different scales on the axes.

Fecundity and mortality

Only the EAZA and AZA populations have sufficient data to build reliable life tables. Figure 5.4 shows the age specific fecundity (Mx) for the EAZA and AZA populations together for the period 1 Jan 1974 to 1 Jan 2018. Reproduction can start at the age of 1 but is mostly from age 2 onwards. Fecundity starts to significantly decline from about the age of 12 onwards and the maximum age of reproduction was 16 for males and 17 for females. Figure 5.5 shows the age specific mortality (Qx) for the EAZA and AZA populations together. Total first year mortality is 34%, and this is very similar for males and females. Total 30-day mortality was 31%, again similar for males and females. Mortality remained low in the adult age classes until aging sets in at the age of about 14 onwards. Maximum longevity was 20 for males and 23 for females.

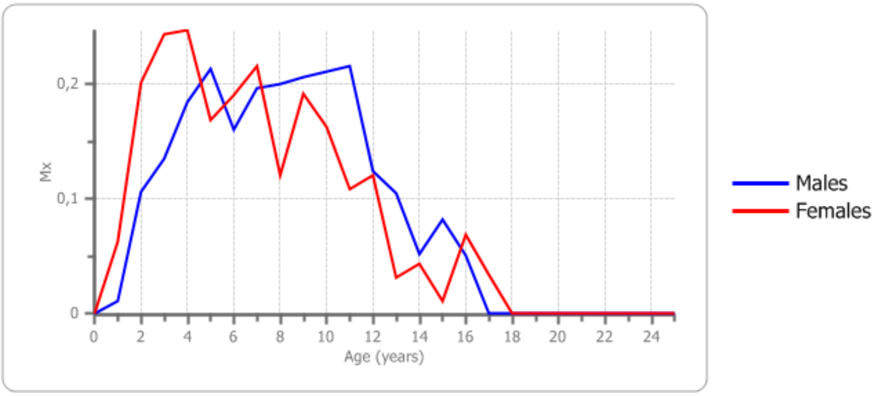


Figure 5.4: Age specific fecundity (Mx) (the average number of same-sexed young born to animals in that age class) for the EAZA and AZA population together (1 Jan 1974 till 01 Jan 2018 - unsmoothed data).

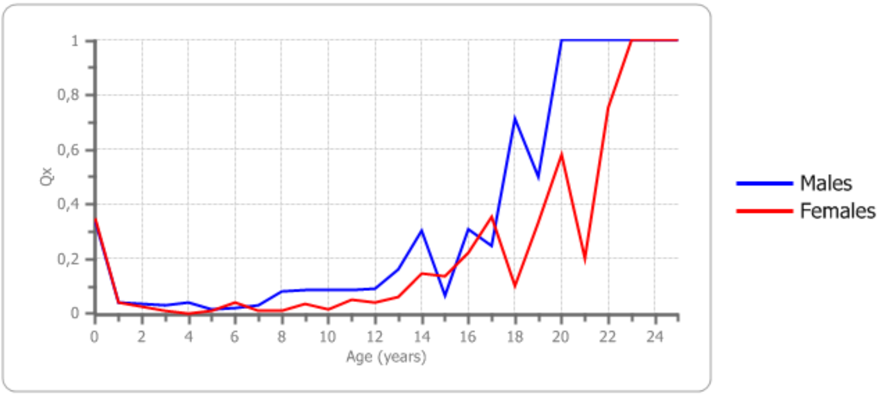


Figure 5.5: Age specific mortality (Qx) (probability that an individual of age x dies during that age class) for the EAZA and AZA population together (1 Jan 1974 till 08 Jan 2018 - unsmoothed data).

Analysis of the international studbook dataset up to 20th July 2022 shows that out of 546 total litters, the mean litter size is 1.44, the median is 1, and the litter size frequency is distributed as follows:

Litter size	Number of litters (Percentage)
1	321 (58.8%)
2	210 (38.5%)
3	15 (2.7%)

Genetic Status

Analytical pedigree

Without analytical assumptions, very little of the pedigree is known in Indonesia and none of the descendants in Europe, North America and Singapore can be traced back to founders (Table 5.3). Therefore an analytical pedigree overlay was developed and applied in ZIMS for Studbooks, details of which can be found in Appendix 5.2. In essence, molecular genetic analysis by the Sulawesi Ungulate Project showed that the pre-1974 founder event contained at least five founders (one microsatellite locus showed 9 alleles). All founders came into Surabaya Zoo. Because there are no studbook records from that time, it was assumed that all five founders contributed as equally as possible. Early exports from Surabaya were given MULT parents with WILD1 and WILD2 as potential sires (50% each) and WILD4, WILD5 and WILD6 as potential dams (33.3% each). For later exports, or later births in Surabaya, another generation was created by establishing Hypothetical6, Hypothetical7 and Hypothetical8, whereby each has the other five WILDs as multiple parents.

Table 5.3: Percent pedigree known, number of founders and number of potential founders in the true versus the analytical studbook (before exclusion of individuals not able to breed (again)) for the world and regional Babirusa zoo populations.

Region	True studbook			Analytical Studbook (before exclusion of living individuals not able to breed (again))		
	%Known pedigree	#Founders	#Potential Founders	%Known pedigree	#Founders	#Potential Founders
PKBSI	38.3	6	10	91.4	11	0
EAZA	0	0	0	100	5	0
AZA	0	0	0	100	5	0
Singapore	0	0	0	86.5	5	0
TOTAL	12.8	6	0	95.6	11	0

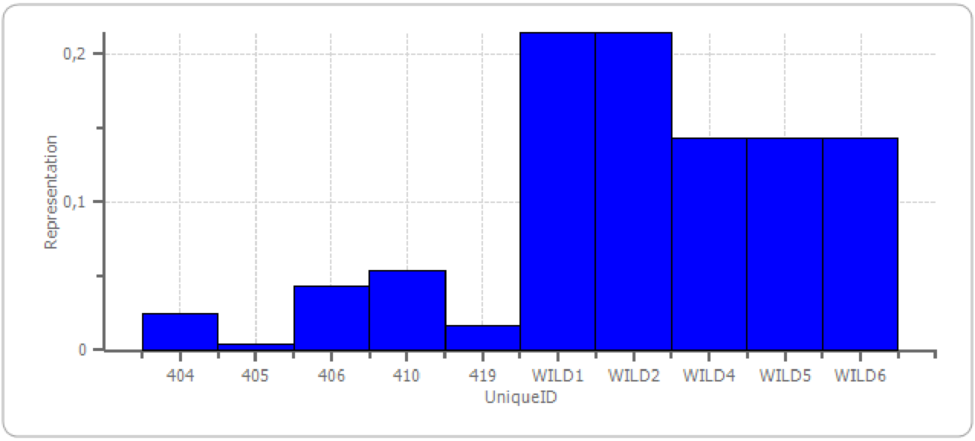
Potentially breeding population

In addition, 14 individuals were excluded from the genetic analysis because they were thought never to be able to breed (again) (PKBSI 8; Europe 1; Singapore 2; AZA 3) (see Appendix 5.1). Because these individuals can no longer pass on their genes to the next generation, they are so to speak “genetically dead”. If these individuals are genetically very important, including them in the analysis might overestimate the genetic health of the population (they may have rare genetic material, but if they cannot breed, this will disappear from the population when they die). The opposite is also true, if they are genetically overrepresented, including them might give an overly pessimistic view of the genetic health of the population.

Founder analysis

The pedigree overlay essentially makes all of the descendants from the pre-1974 founder event related to each other and gives each of the hypothetical founders (WILD1, WILD2, WILD4, WILD5, WILD6) an equal number of descendants and a fixed proportion of representation (Figure 5.6 a,b). In this way, inbreeding events can be identified, and future inbreeding can be minimized. Although an official PKBSI studbook for Babirusa was not created until 2011, Surabaya Zoo has been keeping detailed studbook records on their institutional population from the moment the 1998 founders arrived, and thus the spread of the genes from these founders can be tracked through the pedigree. Descendants from these founders are only present in the Indonesian population (Figure 5.7 a,b). Five from the seven 1998 founders (studbook numbers 404, 405, 406, 410, and 419) have living descendants that can potentially breed and all of these only live in the PKBSI population (Figures 5.6b and 5.7b). Since the previous masterplan, founder line 411 has been lost. While this founder still has one living descendant (studbook number T72), this is now of post-reproductive age (and was thus removed from the genetical analyses). Also, the 7^{th} wild origin individual (studbook number 420) has died at the age of 20 years without ever having bred. Founder 405 has only two living descendants of breeding age (studbook numbers T178 and T492), making these descendants very valuable for breeding in the Indonesian population. This is reflected in the breeding and transfer recommendations for PKBSI.

a)



b)

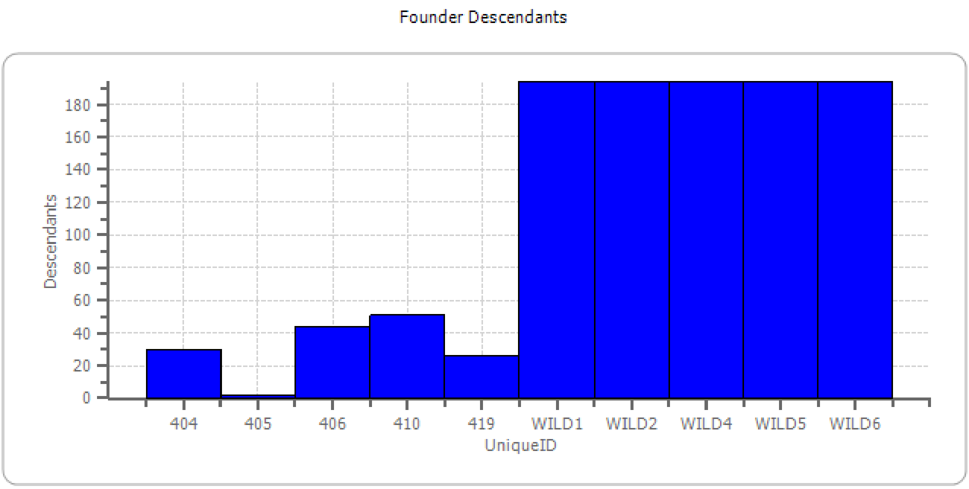
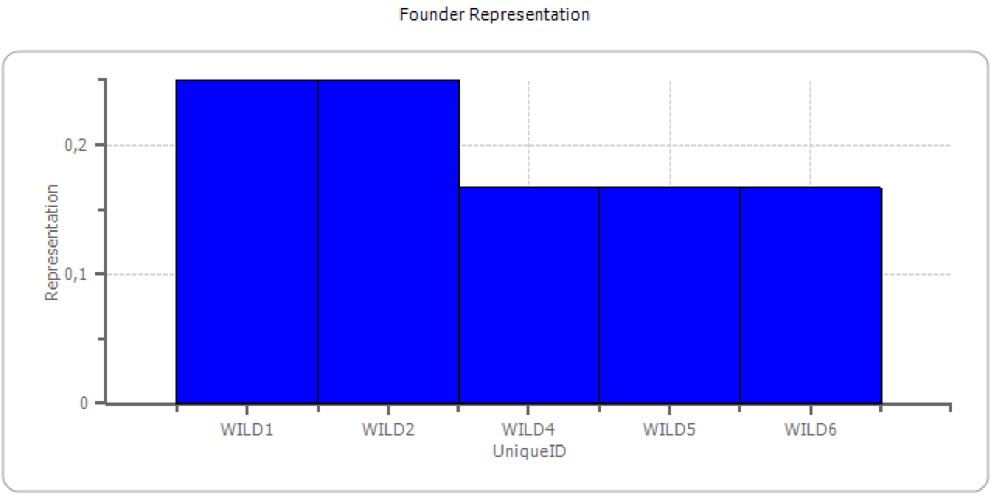


Figure 5.6: a) Founder representation and b) number of founder descendants for the world Babirusa population *[please note that the representation and number of descendants of the hypothetical founders is determined by the assumptions in the analytical pedigree]***.**

a) Non-Indonesian population



b) Indonesian population

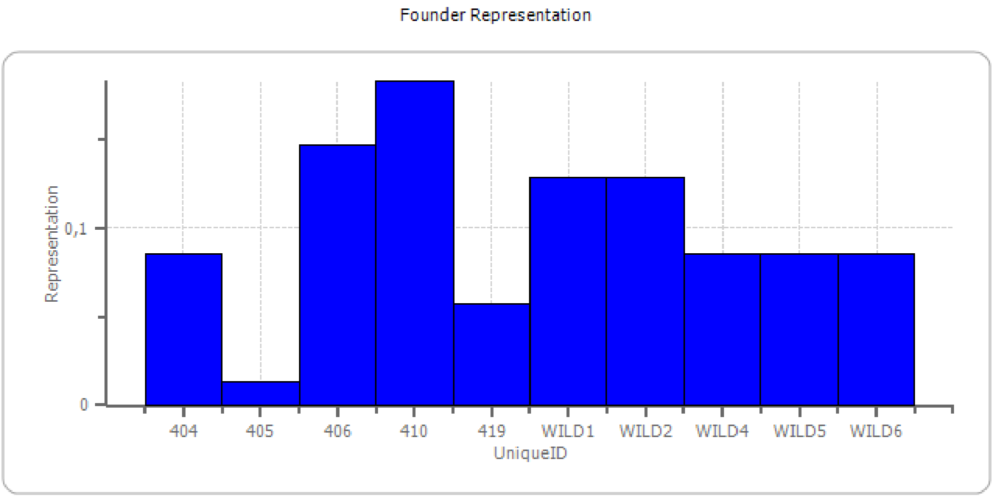


Figure 5.7: a) Founder representation in the non-Indonesian Babirusa populations (EAZA [Europe+Singapore] and AZA) and b) Founder representation in the Indonesian Babirusa population (PKBSI) *[please note that the representation and number of descendants of the hypothetical founders is determined by the assumptions in the analytical pedigree]***.**

Genetic analysis

The genetic summary statistics for the world and regional populations can be found in Table 5.4. Because of the lack of pedigree data for the initial founding period, rather than the absolute values of the parameters, it is their relative value across different populations that is most informative. Only the PKBSI population has descendants of the 1998 founder event and thus has higher levels of gene diversity retained and, with the exception of Singapore, lower levels of inbreeding compared to the other subpopulations. Under current assumptions, there are only 10 founders for the world population and therefore the proportion of the wild source gene diversity retained in the global zoo population is already below 90% of the wild source gene diversity. Moving a few individuals from PKBSI to the other subpopulations would allow reduction in the inbreeding levels in these populations, especially in Europe and North America. Because the non-Indonesian populations are derived from the same founders, transferring individuals between these subpopulations will under the current pedigree assumptions have little genetic benefit – but may bring demographic benefit. Ultimately, the only way to improve the gene diversity of the global *ex situ* population so that it is able to maintain 90% of the wild gene diversity for 100 years, is to add new founders – see 'Regional and Global Programme Goals'.

Table 5.4: Genetic summary statistics for the world and regional zoo Babirusa populations, based on the analytical studbook data and after exclusion of individuals that can never breed (again).

			EAZA		
	World	**PKBSI**	**Europe**	**Singapore**	**AZA**
N (total)	214	70	49	25	70
N (potentially breeding population)*	200	62	48	23	67
% Pedigree known	95.6	90.3	100	87.5	100
% Pedigree certain	11.0	35.6	0	0	0
Founders	10	10	5	5	5
Potential Founders	0	0	0	0	0

Founder Genome Equivalents (FGE)	3.56	2.86	1.72	1.89	1.78
Potential FGE	7.79	5.04	3.06	2.63	2.78
Gene diversity retained	0.86	0.83	0.71	0.74	0.72
Potential gene diversity retained	0.94	0.90	0.84	0.81	0.82
Mean inbreeding coefficient	0.2120	0.1692	0.2704	0.1498	0.2242
Population mean kinship	0.1406	0.1750	0.2899	0.2642	0.2817
Ne/N	0.37	0.40	0.38	0**	0.41

* Fourteen individuals excluded from genetic analysis because they are assumed never to be able to breed (again) (8 PKBSI, 1 Europe, 2 Singapore, 3 AZA – see Appendix 5.1. for details)

** Based on 2.7 breeding females and 0 breeding males (none of the males currently alive have living offspring or have produced offspring)

5.4 Regional and Global Programme Goals

Global

The role of the world zoo population of Babirusa is to provide a long term, genetically and demographically sustainable and behaviourally competent insurance population for the wild population on Sulawesi, that holds the potential to supply individuals for genetic or demographic supplementation or reintroduction, should this become necessary in the future.

This translates to the following long-term population goals:

- Maintain 90% of the wild source gene diversity in the captive population for 100 years
- Grow the population to ~400 individuals. The long-term capacity per region is shown in Table 5.5. This requires identifying additional participating institutions in each region (in pace with population growth). If no extra space can be identified, another region may have to be brought into the partnership in the longer term.
- Add, gradually, over time, ~20 extra founders (see important comments under “PKBSI” below)

Table 5.5: Current global and regional population size and long-term capacity (as determined during the 1st masterplanning meeting in 2016) for the zoo populations of Babirusa.

	Region	# Ind.	GSMP target	Long term target/ capacity
	PKBSI	70		100
EAZA	Europe	49		100
EAZA	Singapore	25		30
	AZA	70		125
	TOTAL	**214**	400	355

And sporadically add new founders as they become available from confiscations/ centres on Sulawesi

To achieve this it is necessary to:

- Grow the subpopulations towards their target sizes, adding new holding institutions as required and possible;
- Slow the loss of gene diversity as much as possible by basing breeding recommendations on mean kinship;
- Keep inbreeding levels as low as possible (without new founders, inbreeding can no longer be avoided in any of the subpopulations);
- should wild origin individuals become available to the zoo population through confiscations by law enforcement and/or from centres on Sulawesi, include these in the PKBSI population (see important comments under "PKBSI" below);
- When the time is appropriate and breeding has been successful, investigate if a small number of PKBSI animals can be shared with other regions on the condition it does not cause harm to the genetic and demographic health of the Indonesian population. This would be important to reduce inbreeding in the other subpopulations and achieve the target of a healthy global insurance population for conservation;
- Carry out intercontinental transfers between the non-Indonesian subpopulations as required and possible, for example to improve demographic structure.
- ensure husbandry experience and interest in the keeping of Babirusa is maintained/increased in all subpopulations.
- Stay vigilant for transferrable diseases (e.g. African Swine Fever) in domestic pig holdings and wild boar populations in countries and regions with zoos holding babirusa. Practise effective biosecurity.

PKBSI

Over the last 10 years there has been a slow decline in population size (Figure 5.8).

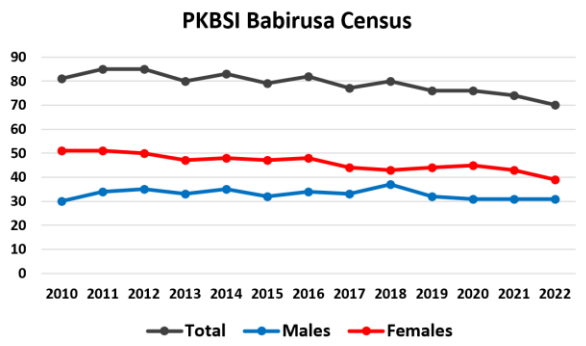


Figure 5.8: Census of the PKBSI Babirusa population from 2010 till the present.

In order to reverse the decline and grow by 3% per year towards the intended target size for PKBSI, 9 piglets need to be born per year. From 2018 till 2021, only an average of 6 piglets were born per year and it is therefore essential that breeding efforts are increased compared to previous years.

With an average litter size of ~1.5 piglets, ~6 females need to give birth in order to produce 9 piglets. But not every recommended breeding pair will produce offspring. For that reason, 12 breeding pairs were recommended for the next breeding cycle. If we assume a success rate of 50% (of bringing breeding pairs together and them producing piglets) this would result in 6 pairs producing piglets.

One founder line was lost during the previous masterplan period, and there is high risk of losing another during this masterplan period because founder 405 has only two living descendants of breeding age (studbook numbers T178 and T492). These two individuals have therefore received breeding recommendations and every effort should be made to produce piglets from them. The other recommended pair combinations have as much as possible been based on:

- the mean kinship values of the animals (giving priority to animals with lower mean kinship values and combining males and females with similar mean kinship values),
- limiting inbreeding,
- giving priority to genetically important individuals that are nearing the maximum ages for reproduction,
- the needs and requests of the participating zoos, and
- practical considerations (e.g. distance of transport etc.).

Relatively few breeding recommendations from the previous masterplan period resulted in breeding and a high proportion of the piglets born had at least one incorrect parent. It is therefore important that breeding recommendations that are agreed to are really attempted, and that the correct individuals are paired with each other (according to the recommendations).

Three transfers were recommended to help optimise the breeding opportunities. In addition, it would be wise to start the process to find an extra zoo to hold Babirusa, so that there is sufficient space to hold the piglets produced during this and the next breeding cycle.

Should any wild origin individuals arrive into the PKBSI population through confiscations and/or from centres on Sulawesi, breeding with these new individuals has in the short term a higher priority than breeding with existing stock (if space is limited). Wild origin individuals would ideally be paired with proven breeders of good breeding age and relatively high genetic importance. The PKBSI studbook keeper and the Babirusa GSMP population biologist should be consulted to advise on breeding recommendations for such individuals.

Both from a genetic point of view, and in terms of the viability of the wild populations, it is better to very occasionally add a founder to the *ex situ* population than to add a larger number all at one time. It is also important that the *ex situ* programme does not unintentionally stimulate trade in Babirusa from the wild. Therefore, it is not recommended to pro-actively organise the capture of wild Babirusa. This approach also allows for working in a conservative manner until the taxonomic status has been clarified further.

EAZA

Europe

The European Babirusa population has seen a much needed, steady improvement, from the critical situation it was in at the start of the first masterplan session, to a more comfortable state now. However, a population of 49 individuals is still very vulnerable to demographic stochasticity. It therefore remains important to focus on continued growth of the population towards its target size of 100 at which point it would be safer from random demographic events.

The gene diversity of this population is already very low and inbreeding unavoidably continues to increase. Without additional founders the only option is to slow the loss of gene diversity as much possible. There are no (partially) unrelated individuals in non-Indonesian populations.

Some European holders have been inspired by their PKBSI colleagues to start holding babirusa in small social groups, rather than in pairs. For the first time an all-male group has been established due to the male biased sex ratio in younger individuals.

Recommendations are to:

- Continue breeding every female of breeding age
- In consultation with the SSP coordinator, investigate options to import females from AZA to address the imbalance in sex ratio among young and breeding age animals.
- Identify more holders
- Implement transfers recommended by the EEP coordinator as soon as possible in case transfer restrictions start to apply due to African Swine fever. Where necessary, institutions to liaise with their government authorities to request exemptions from any cull requirements during potential outbreaks in the vicinity of zoos
    - Ensure that husbandry experience and interest in the keeping of Babirusa is maintained and learn from experiences with holding different social group structures

Singapore

If Singapore wishes to keep holding babirusa it is critical that a number of litters are born within the next year or two because all individuals of breeding age are nearing the maximum ages of reproduction. Import of individuals from PKBSI in a short time frame will not happen and the most cost effective way to maintain a small population in Singapore is to breed again with the current stock, despite the inbreeding. As is the case for the AZA and European populations, there are no (partially) unrelated individuals in non-Indonesian populations.

Recommendations are:

- The EEP coordinator and Singapore Zoo institutional representative to urgently confer regarding:
  - Singapore Zoo's intended plans for the species (keep holding? carrying capacity?)
  - the best way forward to add young individuals to the population; if this is through breeding this should be attempted urgently due to the increasing age of all the animals
- Depending on Singapore Zoo's plans with Babirusa in the institutional collection plan, ensure husbandry experience and interest in the keeping of Babirusa is maintained

AZA

The AZA babirusa population is demographically in good shape and is also able to produce offspring 'on demand' for export to other regions, e.g. EAZA. As is the case for the EAZA population, the gene diversity of this population is already very low and inbreeding unavoidably continues to increase. Without additional founders the only option is to slow the loss of gene diversity as much possible. There are no (partially) unrelated individuals in non-Indonesian populations.

Recommendations are:

- Grow the population to its estimated short-term capacity of 80 individuals
- Try to identify new holders, to be able to reach the short-term target for 80 individuals; and investigate options to go beyond this size in the future, towards the GSMP regional target.
- In consultation with the EEP coordinator, investigate option to export a few individuals (preferably females) from AZA to EAZA, to improve the sex ratio among breeding age individuals in the EEP
- Ensure husbandry experience and interest in the keeping of Babirusa is maintained

6. Sumatran Tiger *Ex situ* Management

6.1 Source of the Global Ex situ Population

The International Tiger Studbook has been maintained and published annually since 1975 (Peter Müller, Zoo Leipzig, ISB Keeper). These records document 99 wild-caught Sumatran tigers, 59 of which reproduced and 35 of which have left descendants in today's global living population (i.e., founders).

According to studbook records, Sumatran tigers were exported from Indonesia in the 1940s to early 1970s primarily to European zoos, including 12 wild-caught founders that represent about 50% of today's global gene diversity, along with one pair of founders exported to the US in 1939 that left numerous descendants. The North American zoo population of Sumatran tigers began in earnest in the late 1980s with importations from Indonesia, Europe and Australia, which included 5 new founder lines from tigers captured in the 1970s. Today's Sumatran tiger populations in Japan and Australia basically represent the same founders as those in Europe and North America. Since 1990, only a few (and related) Sumatran tigers (<10) have been exported from Indonesia to other regions. Numerous tiger exchanges among the four regional programs outside of Indonesia (AZA in North America, EAZA in Europe, JAZA in Japan, ZAA in Australasia) occurred both before and after establishment of the WAZA Sumatran GSMP in 2008. This non-PKBSI Sumatran tiger population is genetically well mixed across regions and is derived primarily from 18 founders captured from 1940s to 1980s.

In contrast, little tiger reproduction is documented in Indonesian zoos prior to 1980, with no living descendants of tigers before that time. Today's PKBSI Sumatran tiger population is derived from 22 founders, with about 70% of its genetics coming from tigers captured since 1990. Thus, while there is overlap in the genetics among all GSMP regions, Sumatran tigers *outside* of PKBSI primarily hold *historical* gene diversity from tigers living in the wild many decades ago (and with up to 8 generations in captivity), while the PKBSI tiger population represents *more recent* gene diversity after the wild population because more fragmented and with less time in captivity.

All Sumatran tigers held in these five managed *ex situ* populations are traceable back to wild-caught tigers from Sumatra. While occasional crosses with other tiger subspecies have occurred, both within and outside of Indonesia, only Sumatran tigers that can be traced back to wild ancestors are included in the GSMP population**.**

6.2 Ex situ Population Management Strategy

According to the Sumatran Tiger GSMP Vision Statement, *the Sumatran Tiger Global Species Management Plan (GSMP) brings together all zoo partners managing Sumatran tigers to promote international collaboration for ensuring the long-term survival of the Sumatran tiger*. To achieve this vision, the Sumatran Tiger GSMP supports activities that:

- Promote the maintenance of a demographically and genetically healthy global *ex situ* population;
- Support the needs and goals of the regional tiger *ex situ* programs through collaboration and cooperation, including transfer of tigers, information and expertise; and
- Encourage international collaboration in support of *in situ* tiger conservation.

(from *WAZA Sumatran Tiger GSMP 2012 Report*).

The GSMP population includes five regionally managed *ex situ* populations of Sumatran tigers:

- *Ex situ* population in Indonesia is managed by PKBSI within institutions on the islands of Sumatra, Java and Bali.
- Europe: managed by EAZA as a European Endangered Species Program (EEP)
- North America: managed by AZA as a Species Survival Plan® (SSP®)
- Australasia: managed by ZAA as a Species Management Program (SMP)
- Japan: managed by JAZA as a Japanese Species Management Program (JSMP)

<u>Coordinators</u>

GSMP: Malcolm Fitzpatrick, Convenor; Ligaya Tumbelaka, co-Convenor
PKBSI: Ligaya Tumbelaka, Coordinator
EAZA: Teague Stubbington, Coordinator
AZA: Karen Goodrowe, Coordinator
ZAA: James Biggs, Coordinator
JAZA: Kazunori Yoshizumi
ISB: Peter Müller, International Studbook Keeper
Population biologist: Kathy Traylor-Holzer

This global meta-population is managed essentially as two sub-populations – tigers held in facilities within the range country of Indonesia (primary population), and tigers held in zoos in Europe, North America, Australasia and Japan (secondary population). While the Sumatran tiger population outside of Indonesia collectively is large and well managed on a regional level, the level of relatedness is high within and among these four populations, leading to poor long-term viability in the absence of new genetic founders from Indonesia. As described above, this secondary population has received very little genetic input for over 30 years (~4 generations). Therefore, the Indonesian tiger population is the key to the viability of the management programs outside of Indonesia and to the global GSMP population.

As the range country *ex situ* population, the PKBSI Sumatran tiger population has the potential to serve as an effective genetic insurance population and to support the entire global *ex situ* population through occasion exports to the other GSMP partners. Good genetic management combined with effective reproduction, especially from any new wild-caught tigers that opportunistically come into the population, will be key to the long-term viability of the PKBSI population and, ultimately, for the GSMP population.

To move toward this achievable goal of increasing the genetic viability of the regional and global *ex situ* populations, and thus their value as insurance populations, it will be important to:

1) Effectively incorporate the genetic lines of any wild-caught tigers into the *ex situ* Indonesian tiger population;
2) Intensively manage the Indonesian *ex situ tiger* population so that it is demographically stable and retains high genetic diversity; and
3) Periodically distribute new genetic founder lines from Indonesia to the rest of the regional *ex situ* tiger populations in the GSMP.

In addition, reproductive success should be improved in all regional populations to stabilize age structure and promote population growth.

6.3 Demographic & Genetic Status of Ex Situ Populations

All analyses were carried out using the WAZA Sumatran Tiger International Studbook (ISB) maintained by Peter Müller (Zoo Leipzig, retired) in ZIMS for Studbooks, which includes the studbook data for all five managed regions. The data span for analysis was 1 January 1990 to 4 January 2023 and restricted to the five regional associations (AZA, EAZA, JAZA, PKBSI, ZAA, plus any partner institutions). Data for the non-Indonesian regional populations was reviewed previously by the regional species coordinators to verify institutional members and identify any permanent non-breeding tigers (e.g., sterilized, post reproductive). Data for the Indonesian population were compiled by Ligaya Tumbelaka (Bogor Agriculture University; GSMP co-Convenor & PKBSI Sumatran tiger studbook keeper) and provided to Peter Müller for inclusion into the ISB. A total of 42 tigers were excluded from the potentially breeding population (i.e. genetic analyses) – 1 neutered male (AZA) and 41 post-reproductive females (PKBSI - 18; AZA - 7; EAZA - 12; JAZA - 2; ZAA - 2) (see Appendix for full list of excluded tigers).

Demographic Status

Global

The global population of Sumatran tigers showed steady growth from 1990 to the mid-2010s; it then plateaued at ~385 tigers and is now in decline (Figure 6.1). As of 4 January 2023, the global population of Sumatran tigers was 329 individuals in 121 institutions in North America, Europe, Japan, Australasia and Indonesia (Table 6.1). Most regional populations are in decline, resulting in ~3% decline per year in the global GSMP population. The global population has declined by 14% since the 2018 masterplan, with the majority of this drop in tiger numbers due to decline in the PKBSI population.

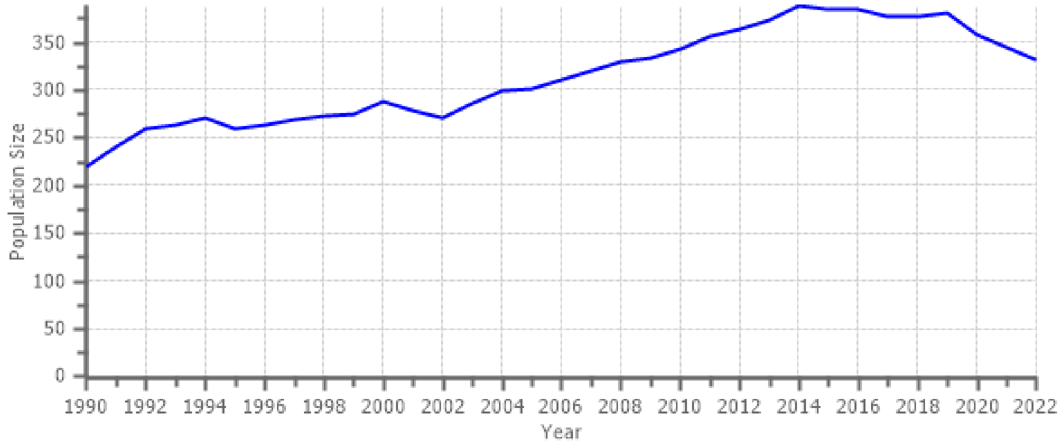


Figure 6.1: Census of Sumatran tigers in the GSMP (AZA, EAZA, JAZA, ZAA and PKBSI populations) from 1990 to 2022 (census on 31 December).

Table 6.1: Sumatran tiger population in each of five regional managed populations of the GSMP at the time of masterplan analysis (February 2018 and January 2023).

Program	Population size- 2018 (M.F.U)	Population size - 2023 (M.F.U)	Change in size in 5 years (annual λ)	Permanent non-breeders (% of pop)	Potential breeders - 2023 (M.F.U)
Indonesia (PKBSI)	119 (54.65)	85 (40.45)	***28% decline (λ=0.935)***	**18 (21%)**	67 (40.27)
Europe (EEP)	119 (56.62.1)	116 (49.67)	*2.5% decline (λ=0.995)*	12 (10%)	104 (49.55)
North America (SSP)	80 (41.39)	69 (31.38)	*14% decline (λ=0.97)*	8 (12%)	61 (30.31)
Australasia (ZAA)	47 (25.22)	41 (20.21)	*13% decline (λ=0.973)*	2 (5%)	39 (20.19)
Japan (JAZA)	16 (7.9)	18 (8.10)	13% increase (λ=1.024)	2 (11%)	16 (8.8)
Global (GSMP)	381 (183.197.1)	329 (148.181)	*14% decline (λ=0.969)*	42 (13%)	287 (147.140)

Low reproductive rates (small number of cubs) in recent years is the primary factor leading to population decline. This not only affects immediate population size, but it means that there are fewer future breeders coming into the population. Sumatran tiger *ex situ* populations are aging (Figure 6.2), and the number of females of prime reproductive age in these populations is proportionately low. Female reproductive success declines after about age 8, and female tigers have not reproduced past age 15 (Figure 6.3). Even if reproductive rates improve to those historically observed since 1990, the global population is likely to decline for about 10 years due to this older age structure until a healthier age pyramid is established (Figure 6.4). Encouragingly, some recent improvement in birth rates in EAZA and AZA populations is helping to rebuild demographic stability, but increased efforts to produce more cubs is still needed.

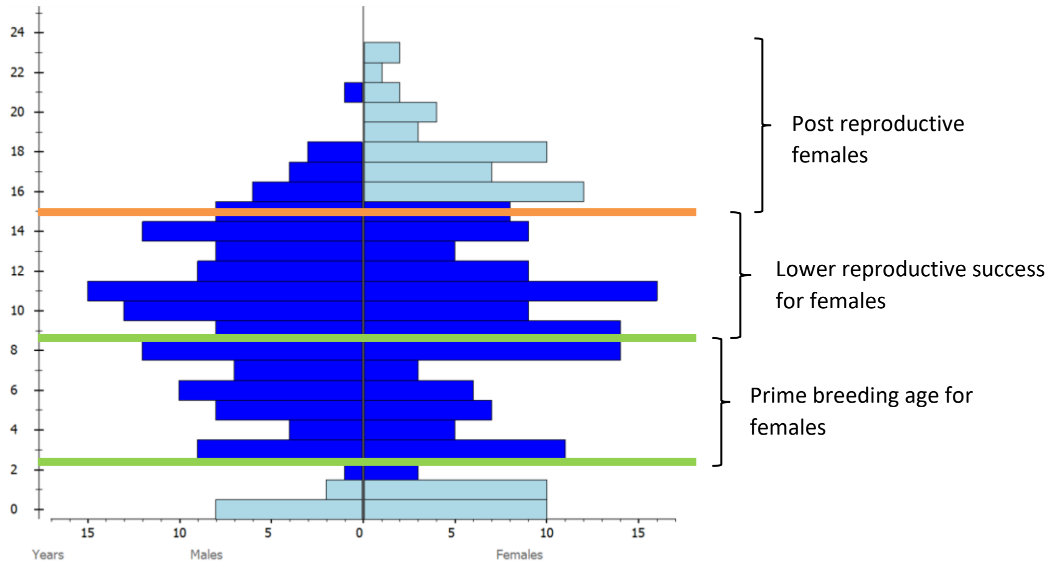


Figure 6.2: Age structure of the current global GSMP population of Sumatran tigers (as of 4 January 2023). Light blue bars represent pre- and post-reproductive individuals.

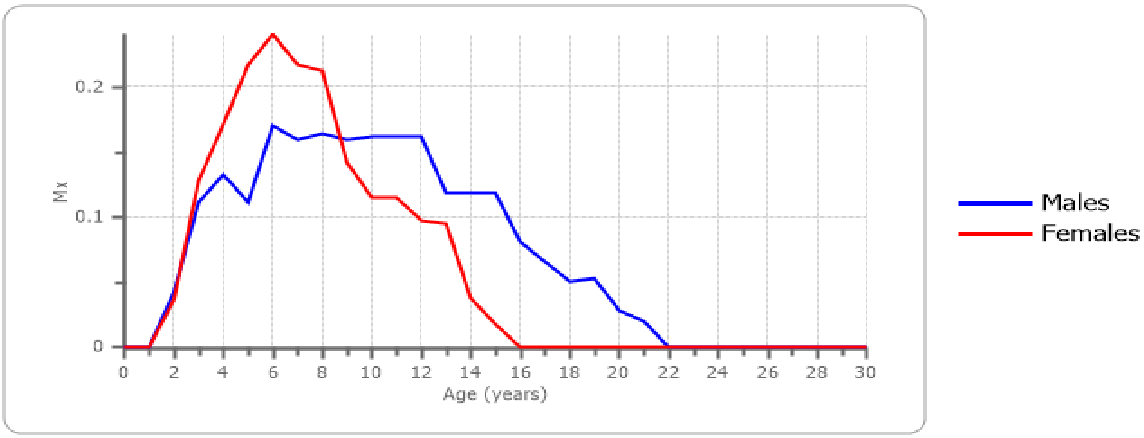


Figure 6.3: Age-specific fecundity (Mx) (average number of same-sexed young born to tigers in that age class) for the GSMP (1 Jan 1900 to 4 Jan 2023); smoothed.

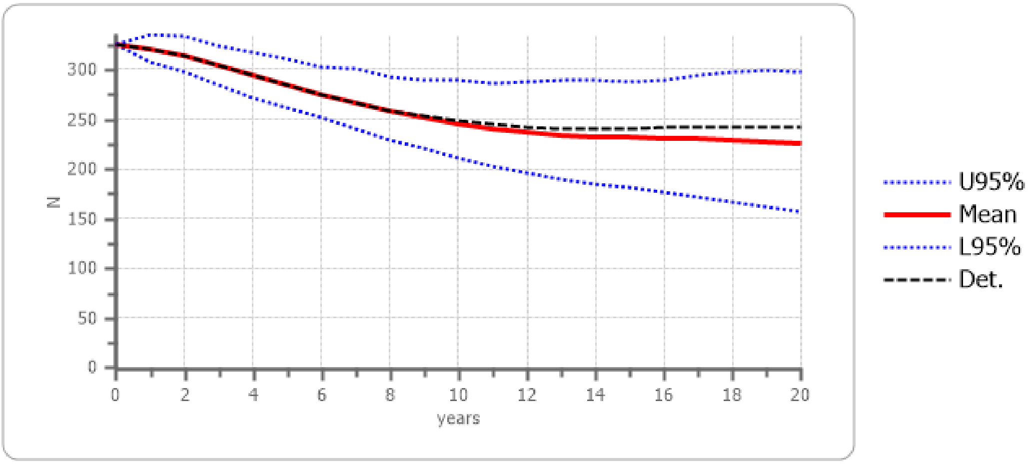


Figure 6.4: Projected global (GSMP) Sumatran tiger population based on current age structure and historical demographic rates (Jan 1990 to Jan 2023). Dashed black line = deterministic projection. Other lines = stochastic projection (red line = mean; dotted blue lines = 95% of stochastic runs, upper and lower limits).

Indonesia (PKBSI)

The rate of decline in PKBSI Sumatran tiger population (6.5% annually) is more than twice that of the global population, resulting in a 28% decline in the number of Sumatran tigers in PKBSI zoos in the last five years (Figure 6.5; Table 6.1). Almost half of the adult females are now too old to reproduce, and many others are past prime breeding age and will soon be too old (Figure 6.6). If reproduction remains low, the population is likely to continue to decline significantly (Figure 6.7). The PKBSI tiger population will need to produce about 5 litters of cubs, *each year*, for the next 8-10 years to keep the population stable at about 85 tigers, and about 7 litters of cubs each year will be needed to grow the population back to about 100 tigers in the next 5 years.

There are only 12 female Sumatran tigers of prime breeding age in PKBSI zoos, and only one of these females has reproduced so far. Females that have reproduced before (proven breeders) have much higher breeding success than females that have never produced cubs, and this difference becomes more important as females get older (Saunders *et al*. 2014).

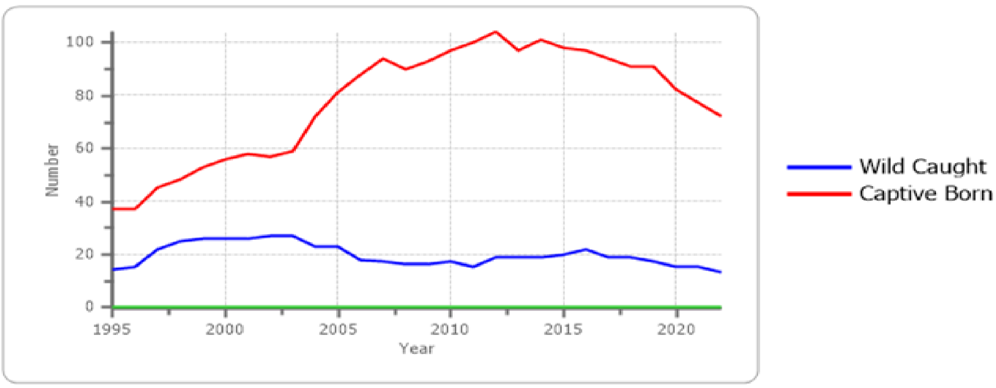


Figure 6.5: Census of Sumatran tigers in PKBSI zoo from 1995 to 2022 (census on 31 December).

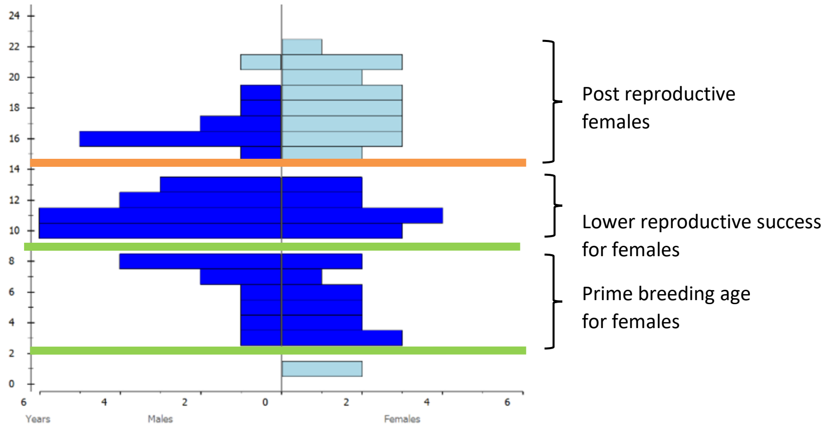


Figure 6.6: Age structure of the current PKBSI population for Sumatran tigers (as of 4 January 2023). Light blue bars represent pre- and post-reproductive individuals.

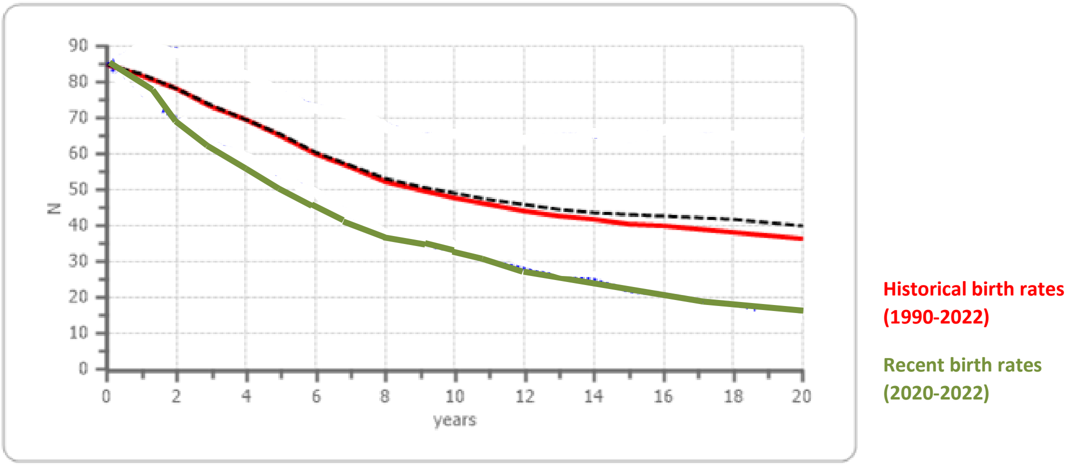


Figure 6.7: Projected PKBSI Sumatran tiger population based on current age structure and historical reproductive rates in red (1990-2022) and recent reproduction rates in green (2020-2022). Dashed black line = deterministic projection. Lines for upper and lower stochastic limits were removed for clarity

It is critical for the demographic health of the PKBSI tiger population to breed as many reproductive females as possible, each year, to stabilize the population, provide new future breeders, and increase the future reproductive success of the current female tigers as they age. Therefore, it is important that each female has a suitable male for breeding at same zoo, as much as this is feasible. Also, it will be important to investigate any challenges that PKBSI zoos are facing in breeding their tigers and to provide mentoring support to improve breeding success.

About 20-35 tigers in PKBSI zoos are expected to die in the next 5-6 years. As these older tigers die, this will provide more space for new young tigers produced through increased reproduction. However, this may require the transfer of some tigers to different PKBSI zoos to take advantage of this available space.

Outside of Indonesia (AZA, EAZA, JAZA and ZAA)

There are 244 (108.136) Sumatran tigers in the four regional populations outside of Indonesia, with almost half of these in Europe and rest spread across the other regions (Table 6.1). Taken together, this secondary population has shown modest decline in the past few years, primarily in North America and Australasia. All regions are experiencing lower reproductive success, which may or may not be related to the increasing levels of inbreeding in these population (see *Genetic Status* section). While the age structure is out of balance, there are proportionately fewer post-reproductive tigers, and recent births in the past two years are starting to rebuild the population base to produce future breeders (Figure 6.9). The status of the age-sex structure varies among the four regions and is generally correlated with size (Figure 6.10). Populations in Japan and Australasia have a limited number of reproductive females, which limits options if there are health or behavior issues.

When considered as a single population, the number of tigers outside of Indonesia is projected to decline over the next 10-15 years to about 200 tigers due to the aging population structure (Figure 6.11). However, this assumes higher reproductive rates than have been observed in recent years (i.e., 1990-2022 rates), no inbreeding depression impacts, and no regional issues with skewed sex ratios or mate availability.

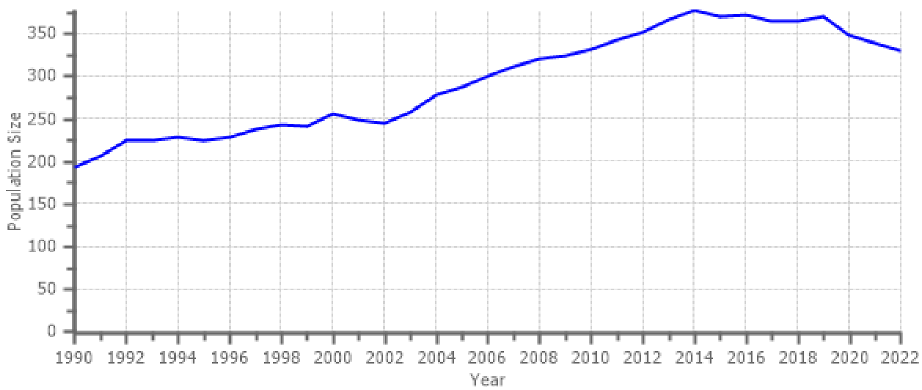


Figure 6.8: Census of Sumatran tigers in zoos outside of Indonesia (AZA, EAZA, JAZA, ZAA) from 1990 to 2022 (census on 31 December)

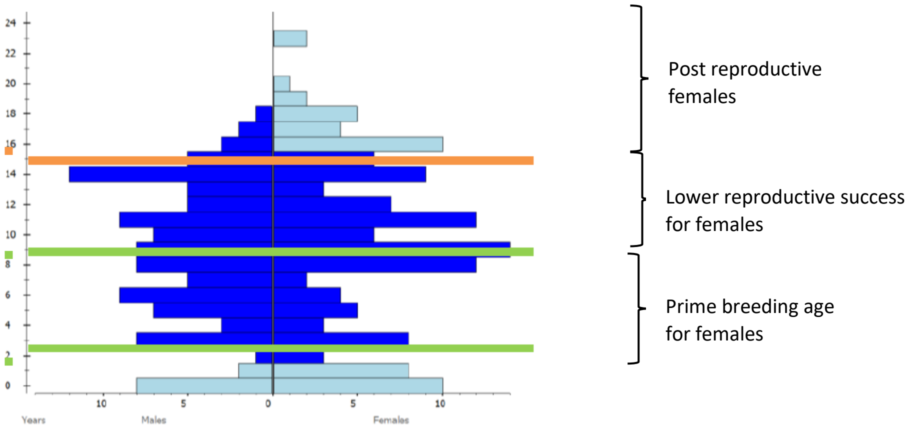


Figure 6.9: Age structure of the current Sumatran tiger populations outside of Indonesia (as of 4 January 2023). Light blue bars represent pre- and post-reproductive individuals.

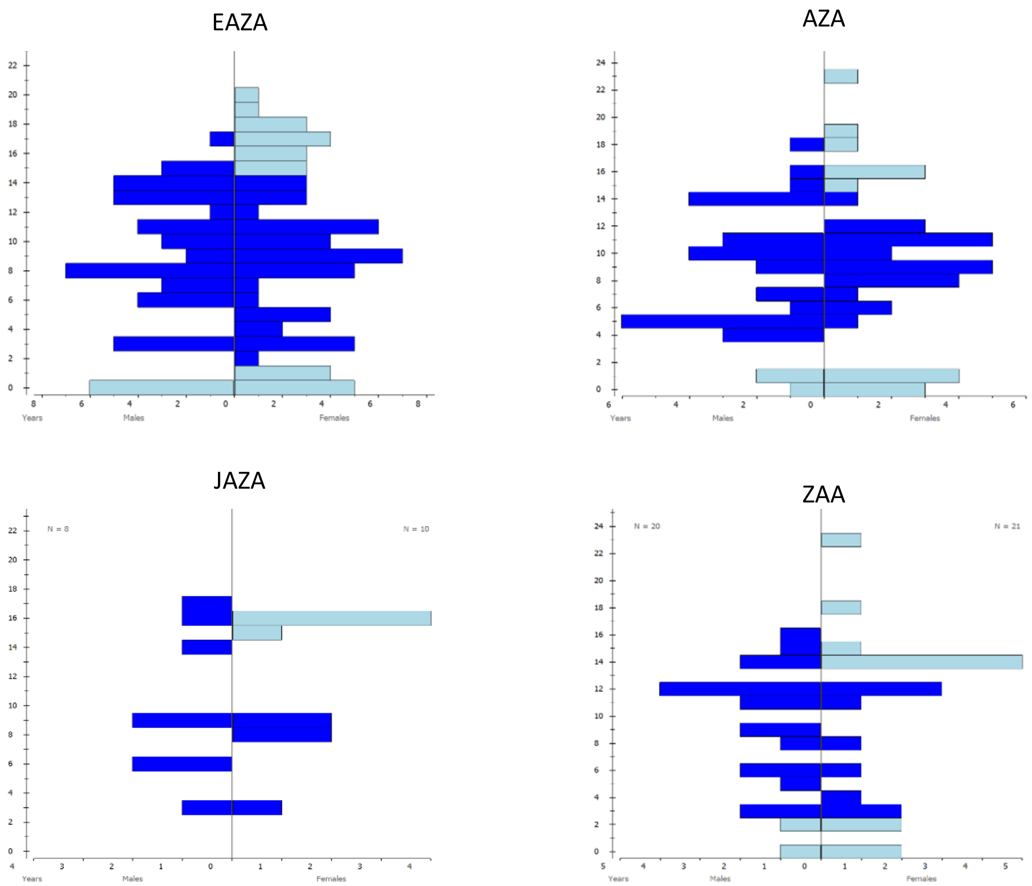


Figure 6.10: Age structure of the current Sumatran tiger populations in Europe, North America, Australasia and Japan (as of 4 January 2023). Light blue bars represent pre- and post-reproductive individuals

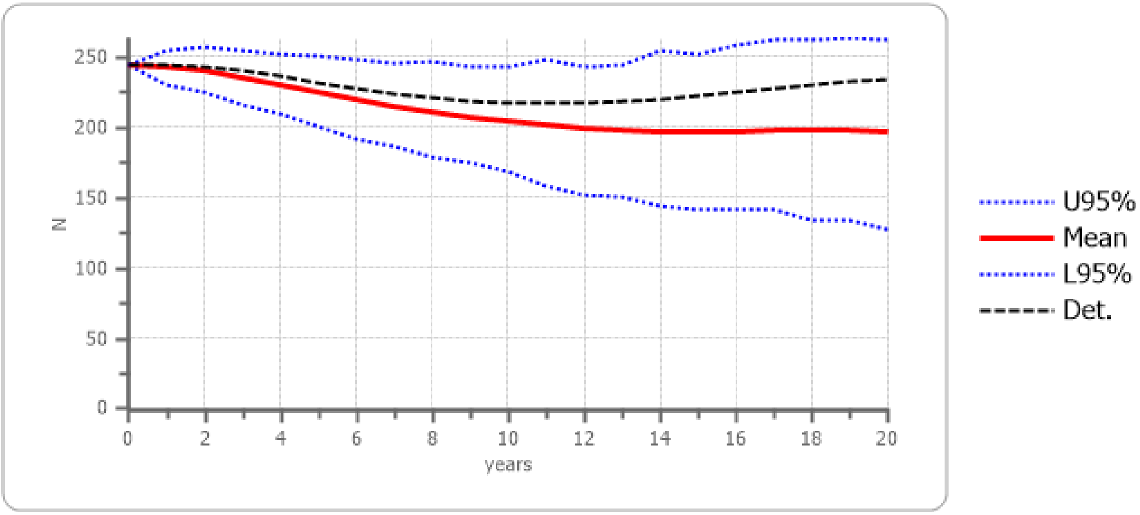


Figure 6.11: Projected global (GSMP) Sumatran tiger population based on current age structure and historical demographic rates (Jan 1990 to Jan 2023). Dashed black line = deterministic projection. Other lines = stochastic projection (red line = mean; dotted blue lines = 95% of stochastic runs, upper and lower limits.

Genetic Status

Global

The global *ex situ* population of Sumatran tigers is genetically diverse (GD = 0.9434), derived from 35 founders captured from the wild over the past 80 years based on a 100% known/certain pedigree (Table 6.2). Mean inbreeding is slightly higher than the first-cousin level. Current effective population size (Ne) based on breeding males and females is 80, with an Ne/N = 0.2888.

Table 6.2: Genetic information for the regional and global Sumatran tiger *ex situ* populations (as of 4 Jan 2023).

	GSMP	PKBSI	Outside PKBSI	AZA	EAZA	JAZA	ZAA
N (total)	329	85	244	69	116	18	41
Potential breeders	287	67	220	61	104	16	39
% pedigree known	100%	100%	100%	100%	100%	100%	100%
Founders	35	22	22	16	18	20	20
Potential founders	5	5	--	--	--	--	--
Founder Genome Equivalents	8.84	7.53	6.16	4.24	4.16	2.64	4.15
Potential FGE	30.20	21.14	13.10	6.48	7.79	4.44	7.50
Gene diversity (GD)	0.9434	0.9336	0.9189	0.8821	0.8797	0.8109	0.8794
Potential GD	0.9834	0.9763	0.9618	0.9228	0.9358	0.8874	0.9333

Mean inbreeding coefficient	0.0728	0.0589	0.0764		0.0588	0.0946	0.0591	0.0625
Population mean kinship	0.0566	0.0664	0.0811		0.1179	0.1203	0.1891	0.1206
Ne/N (current)	0.2888	0.1684	0.3179		0.2700	0.4114	0.2500	0.1368

Global
The global *ex situ* population of Sumatran tigers is genetically diverse (gene diversity (GD) = 0.9434), derived from 35 founders captured from the wild over the past 80 years based on a 100% known/certain pedigree (Table 6.2). Mean inbreeding is slightly higher than the first-cousin level. Current effective population size (Ne) based on breeding males and females is 80, with an Ne/N = 0.2888. There are several genetic differences, however, among the regional tiger populations.

PKBSI
The Indonesian zoo tiger population is based on 22 founders (wild-caught tigers that have left descendants). Five of these founders (2 males, 3 females) are still alive and may be able to produce more offspring. Additionally, there are another 5 wild-caught tigers (4 males, 1 female) that have not yet reproduced but are potential founders and may still be able to contribute to the *ex situ* population. Immediate reproduction by these 10 living wild-caught tigers at 4 PKBSI institutions is a high genetic priority for the PKBSI and the entire GSMP.

Current gene diversity is good in the PKBSI but additional founders and genetic management will be required to maintain a genetically healthy population. Inbreeding is just below the first-cousin level but will surpass that in the next generation without genetic management. There is significant potential to increase gene diversity through breeding wild-caught tigers and other under-represented genetic lines. Ne/N is low, indicating that a significant portion of adults have not reproduced, and may lead to population decline and faster loss of gene diversity. Since it will be important to breed as many females as possible to prevent further population decline, genetic management can be accomplished by breeding wild-caught males and other genetically valuable males as much as is possible.

Outside of Indonesia (AZA, EAZA, JAZA and ZAA)
The *ex situ* tiger breeding population outside of Indonesia is almost three times as large as the PKBSI population and is derived from the same number of founders (n=22). However, gene diversity is lower (GD = 0.9189) due to the loss of some of the original genetic diversity of the founders over time. Figure 6.12 shows the relative contribution of founders to the PKBSI and non-PKBSI populations. There are several more generations in captivity for most founders of the non-PKBSI population. Genetic management has slowed this loss (Ne/N = 0.3179), but inevitably inbreeding is building with almost no new genetic lines since the 1980s. Except for four older tigers that were imported from Indonesia in 2008 and 2013, all Sumatran tigers outside of Indonesia are related to each other and so all breeding involves inbreeding. While these regional programs have done a good job of retaining gene diversity, their viability is critically dependent upon new genetic lines from PKBSI.

An interesting consideration is that there is limited overlap between founder lines within and outside of Indonesia. In addition, earlier founder lines came from the wild tiger population when it may have been larger and less fragmented. This situation opens up possibilities to consider eventually returning some of these older genetic lines to the PKBSI population. In the short term, however, there are sufficient new wild-caught tigers in Indonesia that are high priority for breeding to capture their genetic lines in the global *ex situ* insurance population.

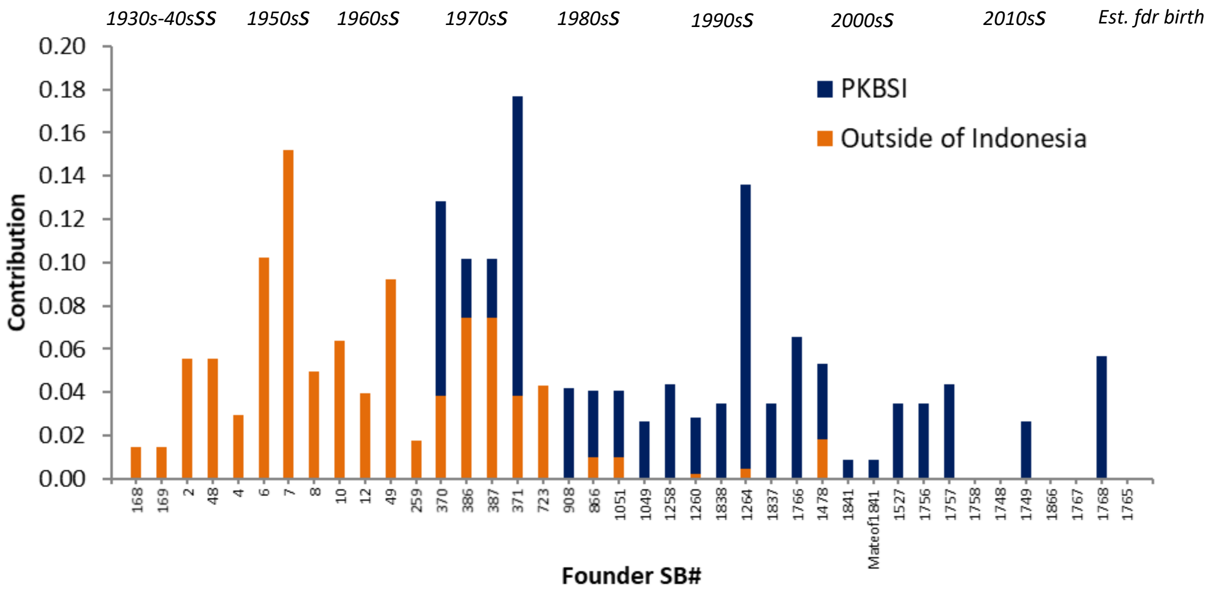


Figure 6.12: Relative contributions for 35 founders (bars) and 5 potential founders (no bars) in PKBSI and in the four regional programs outside of Indonesia (AZA, EAZA, JAZA, ZAA). Founders are listed in order of estimated birth date, from 1937 to 2016. Approximate timeline is provided at the top.

There are some genetic differences among the four regional populations outside of Indonesia (Table 6.2). All are mostly based on the same founders but in slightly different proportions, so this limits the genetic value of inter-regional exchanges outside of PBKSI. The EAZA population is notable as the largest regional population; it also has the highest Ne/N ratio (highest proportion of breeders) and also the highest mean inbreeding. Cub mortality (to 30 days) is 3-4x higher in the EAZA population than in the other three regions; this may or may not be due in part to inbreeding impacts. JAZA manages a small population that has significantly lower gene diversity but has a comparable mean inbreeding coefficient and Ne/N as other larger populations. There is still significant potential gene diversity in JAZA that can be gained through reproduction of current tigers, but this small population will need supplementation more often. JAZA may be able to benefit from imports from other non-PKBSI regions, while AZA, EAZA and ZAA will require new founder lines from Indonesia for long-term genetic health.

6.4 Regional & Global Population Goals & Needs

A primary purpose of the Sumatran tiger *ex situ* population is to serve as a genetically diversity insurance population against further decline in the wild. All five Sumatran Tiger GSMP regional programs have a regional program goal of maintaining 90% gene diversity for 100 years; however, all four regional programs outside of Indonesia are currently below this target. Additional founders and genetic management based on mean kinship values will be required in order for any regional population to meet this goal.

The GSMP provides a meta-population management framework to enable the retention of a high level of gene diversity and sustainability on a global level through periodic exchanges (Lacy *et al*. 2013). The GSMP has set a genetic goal of *at least* 90% gene diversity for 100 years, with each region to maintain ≥ 87% gene diversity. This would limit inbreeding to about the half sib level in regional programs.

Meeting these genetic goals will require that current regional populations increase in size rather than decline. Table 6.3 outlines the 2022 genetic goals and target population size for the GSMP and its regional programs, as well as identified needs to achieve these goals. In addition, improving reproduction success of attempted breeding pairs will be important for the necessary population growth and effective genetic management.

Table 6.3: Regional and global tiger program genetic and demographic goals and needs.

Program	Genetic goal	Target population size	Needs (to achieve goals)
Indonesia (PKBSI)	90% GD for 100 yrs	100	Population management assistance
Europe (EEP)	90% GD for 100 yrs	130 (150 with new holders)	New genetic founders needed
North America (SSP)	90% GD for 100 yrs	100 (may not be feasible)	New genetic founders needed
Australasia (ZAA)	90% GD for 100 yrs	60-70 (possibly higher in future)	Periodic inter-regional transfers, as needed and feasible
Japan (JAZA)	90% GD for 100 yrs	50	New young tigers for breeding
Global (GSMP)	At least 90% GD for 100 yrs; Each region to maintain ≥ 87% GD	At least 400?	

6.5 Global Ranked Mean Kinship List

Mean kinship values represent the relatedness of a tiger to the rest of the GSMP population. These values change with any birth, death, or other changes to the population.

Table 6.4: Ranked mean kinship values for the global population of Sumatran tigers. The line in the male and female lists denotes the population mean kinship is (MK = 0.0566). Individuals are listed in descending order of priority for breeding for the GSMP population. PKBSI tigers are listed **in bold**. Wild-caught tigers are **in red.**

MALE				FEMALE			
Stbk#	MK	Location	Age	Stbk#	MK	Location	Age
1748	**0.0000**	**LAMONGAN**	**11**	**1758**	**0.0000**	**BOGOR**	**12**
1765	**0.0000**	**BOGOR**	**7**	**1749**	**0.0027**	**LAMONGAN**	**11**
1767	**0.0000**	**BUKITTING**	**10**	**1757**	**0.0045**	**BOGOR**	**12**
1866	**0.0000**	**LEMBAHHIJ**	**10**	**1762**	**0.0045**	**BOGOR**	**7**
1856	**0.0018**	**BOGOR**	**11**	**1832**	**0.0054**	**BOGOR**	**4**
1756	**0.0036**	**BOGOR**	**13**	**1833**	**0.0054**	**BOGOR**	**4**
1761	**0.0045**	**BOGOR**	**7**	**1768**	**0.0058**	**BUKITTING**	**10**
1849	**0.0045**	**MEDAN**	**18**	**1764**	**0.0063**	**PASURUAN**	**6**
1760	**0.0054**	**PASURUAN**	**8**	**1887**	**0.0067**	**PASURUAN**	**1**
1763	**0.0054**	**BOGOR**	**6**	**1888**	**0.0067**	**PASURUAN**	**1**
1766	**0.0067**	**BUKITTING**	**21**	1500	0.0072	TOKYOUENO	15
1491	**0.0072**	**BOGOR**	**16**	**1770**	**0.0072**	**BUKITTING**	**8**
1521	**0.0072**	**SURABAYA**	**13**	**1774**	**0.0072**	**SAWAHLUNT**	**5**
1652	**0.0072**	**BOGOR**	**12**	**1775**	**0.0072**	**SAWAHLUNT**	**5**
1773	**0.0072**	**BUKITTING**	**5**	**1507**	**0.0126**	**BOGOR**	**15**
1834	**0.0072**	**BUKITTING**	**4**	**1865**	**0.0151**	**MEDAN**	**8**
1769	**0.0076**	**BALI ZOO**	**8**	1510	0.0175	BEERWAH	15
1495	**0.0126**	**BOGOR**	**16**	**1813**	**0.0179**	**LAMONGAN**	**3**
1501	**0.0126**	**BOGOR**	**15**	**1814**	**0.0179**	**LAMONGAN**	**3**
1503	**0.0126**	**BOGOR**	**15**	**1772**	**0.0202**	**BUKITTING**	**6**
1508	0.0126	WELLINGTN	15	**1831**	**0.0207**	**BALI ZOO**	**3**
1858	**0.0151**	**MEDAN**	**11**	1613	0.0321	BERLIN TP	11
1859	**0.0151**	**MEDAN**	**11**	**1616**	**0.0321**	**BALI ZOO**	**10**
1860	**0.0151**	**MEDAN**	**10**	**1467**	**0.0352**	**JAKARTA**	**13**
1862	**0.0151**	**JAKARTA**	**8**	**1604**	**0.0352**	**JAKARTA**	**11**
1864	**0.0151**	**JAKARTA**	**8**	**1605**	**0.0352**	**JAKARTA**	**11**
1812	**0.0179**	**LAMONGAN**	**3**	**1606**	**0.0352**	**JAKARTA**	**11**
1353	**0.0312**	**LAMONGAN**	**16**	**1463**	**0.0377**	**JAKARTA**	**15**
1321	**0.0316**	**SURAKARTA**	**17**	**1466**	**0.0381**	**JAKARTA**	**13**
1743	**0.0349**	**YOGYAKART**	**12**	**1611**	**0.0389**	**JAKARTA**	**10**
1747	**0.0349**	**BATUSECRE**	**10**	1816	0.0464	BEERWAH	2
1607	**0.0355**	**JAKARTA**	**11**	1817	0.0464	BEERWAH	2
1608	**0.0355**	**JAKARTA**	**11**	1720	0.0476	ADELAIDE	6
1346	**0.0368**	**JAKARTA**	**18**	1899	0.0478	BERLIN TP	0
1462	**0.0368**	**JAKARTA**	**15**	1900	0.0478	BERLIN TP	0

1471	**0.0368**	**JAKARTA**	**12**
1472	**0.0368**	**JAKARTA**	**12**
1465	**0.0381**	**JAKARTA**	**13**
1350	**0.0385**	**JAKARTA**	**17**
1609	**0.0389**	**JAKARTA**	**10**
1610	**0.0389**	**JAKARTA**	**10**
1722	0.0424	ORANA	6
1688	0.0430	BEERWAH	9
1689	0.0443	SYDNEY	9
1803	0.0452	BEERWAH	3
1721	0.0464	ORANA	6
1815	0.0464	BEERWAH	2
1639	0.0509	LOSANGELE	9
1320	0.0518	OCEANJRNY	18
1407	0.0540	ESKILSTUN	14
1337	0.0541	ZOORASIA	16
1559	0.0546	SD-WAP	10
1741	0.0557	GREEN NSC	5
1742	0.0557	NASHV ZOO	5
1405	0.0558	SENDAISHI	14
1783	0.0569	OKLAHOMA	4
1784	0.0569	PHOENIX	4
1785	0.0569	KANSASCTY	4
1734	0.0578	SAN ANTON	5
1876	0.0579	OCEANJRNY	1
1737	0.0579	SD-WAP	5
1571	0.0585	TACOMA	11
1702	0.0585	LINCOLN C	7
1712	0.0585	LINCOLN C	6
1556	0.0585	BATONROUG	10
1793	0.0588	SYDNEY	3
1703	0.0589	WACO	7
1403	0.0590	TORONTO	14
1554	0.0590	DISNEY AK	10
1555	0.0590	TOPEKA	10
1399	0.0592	METROZOO	14
1332	0.0599	BLOOMINGT	16
1371	0.0601	HONOLULU	15
1728	0.0602	AKRON	5
1729	0.0602	AUCKLAND	5
1730	0.0602	MEMPHIS	5
1894	0.0602	OKLAHOMA	0
1401	0.0605	LOUISVILL	14
1913	0.0606	ADELAIDE	0
1619	0.0614	DALLAS	11
1402	0.0617	WACO	14
1635	0.0619	BUSCH TAM	9
1400	0.0620	BERLIN TP	14

1640	0.0529	TACOMA	9
1682	0.0529	MEMPHIS	8
1684	0.0529	TACOMA	8
1638	0.0529	SD-WAP	9
1448	0.0536	LOUISVILL	12
1707	0.0557	JACKSONVL	7
1786	0.0569	AUCKLAND	4
1532	0.0569	METROZOO	11
1533	0.0574	JACKSONVL	11
1572	0.0576	DISNEY AK	11
1670	0.0576	GREEN NSC	8
1671	0.0576	NASHV ZOO	8
1735	0.0578	HONOLULU	5
1877	0.0579	WINSTON	1
1905	0.0579	WINSTON	0
1906	0.0579	WINSTON	0
1534	0.0582	OKLAHOMA	11
1713	0.0585	NASHV ZOO	6
1714	0.0585	AKRON	6
1545	0.0585	FT WAYNE	11
1794	0.0588	SYDNEY	3
1795	0.0588	SYDNEY	3
1868	0.0589	METROZOO	1
1458	0.0590	SD-WAP	12
1557	0.0594	WINSTON	10
1558	0.0594	WINSTON	10
1895	0.0602	OKLAHOMA	0
1914	0.0606	ADELAIDE	0
1915	0.0606	ADELAIDE	0
1457	0.0608	PHOENIX	12
1404	0.0610	NZP-WASH	14
1658	0.0612	SD-WAP	9
1659	0.0612	SAN ANTON	9
1879	0.0632	DALLAS	1
1882	0.0632	DALLAS	1
1636	0.0632	DALLAS	9
1875	0.0644	ESKILSTUN	1
1382	0.0661	NYIREGYHA	14
1676	0.0676	TOKYOUEN O	8
1677	0.0676	SENDAISHI	8
1808	0.0676	ZOORASIA	3
1664	0.0680	FRANKFURT	8
1629	0.0685	KOBEANIMK	9
1630	0.0685	ZOORASIA	9
1719	0.0692	HEIDELBRG	6
1380	0.0697	LE PAL	15
1444	0.0702	MELBOURN E	12
1446	0.0702	CLIFTONAU	12

1883	0.0632	OCEANJRNY	1
1723	0.0676	MIYAZAK	6
1725	0.0676	KOBEANIMK	6
1663	0.0680	BEWDLEY	8
1665	0.0680	COLWYNBAY	8
1718	0.0680	BEKESBRNE	6
1452	0.0683	NYIREGYHA	12
1627	0.0685	KOCHI	9
1628	0.0685	TOKYOUENO	9
1809	0.0685	NAGOYA	3
1308	0.0691	LISBON	17
1311	0.0692	NAGOYA	17
1411	0.0693	LISIEUX Z	14
1341	0.0702	DUBBO	16
1443	0.0702	YARRALUML	12
1445	0.0702	MELBOURNE	12
1567	0.0702	MOGO	12
1568	0.0702	MOGO	12
1805	0.0703	ATTICAZOO	3
1599	0.0703	SYDNEY	11
1601	0.0703	DUBBO	11
1428	0.0704	PERTH	14
1396	0.0704	TASMANZOO	14
1643	0.0706	AUGSBURG	9
1416	0.0709	FRANKFURT	13
1644	0.0710	AMIENS	9
1357	0.0710	LA FLECHE	15
1692	0.0719	ADELAIDE	8
1413	0.0719	FONTAINE	13
1564	0.0721	FOTA	10
1563	0.0725	BRNO	10
1807	0.0725	CHESTER	3
1366	0.0726	BARCELONA	15
1528	0.0727	LE PAL	11
1560	0.0728	DUDLEY	10
1412	0.0732	ARNHEM	13
1717	0.0739	EDINBURGH	6
1903	0.0740	AMIENS	0
1409	0.0741	WROCLAW	13
1553	0.0742	YARMOUTH	11
1368	0.0747	PRAHA	15
1552	0.0751	OBTERRE	11
1529	0.0753	LONDON RP	11
1660	0.0754	BOISSIERE	8
1408	0.0754	HEIDELBRG	13
1394	0.0755	MALTON	14
1395	0.0755	BEAUVAL	14

1569	0.0702	WELLINGTN	12
1806	0.0703	JERUSALEM	3
1397	0.0704	TASMANZO O	14
1693	0.0707	HAMILTON	8
1417	0.0709	LA FLECHE	13
1359	0.0710	BARCELONA	15
1459	0.0711	DUDLEY	12
1632	0.0711	AUGSBURG	9
1657	0.0712	LISBON	9
1565	0.0713	OSNABRUC K	10
1547	0.0713	BEWDLEY	11
1600	0.0716	SYDNEY	11
1424	0.0718	HAMILTON	14
1908	0.0720	LE PAL	0
1755	0.0725	EDINBURGH	5
1414	0.0728	MALTON	13
1561	0.0728	COLWYNBA Y	10
1602	0.0729	FOTA	10
1871	0.0731	HEIDELBRG	1
1872	0.0731	HEIDELBRG	1
1873	0.0731	HEIDELBRG	1
1562	0.0732	ESKILSTUN	10
1438	0.0733	RHEINE	13
1421	0.0738	COOMERA	14
1422	0.0738	YARRALUML	14
1423	0.0738	COOMERA	14
1378	0.0741	BEAUVAL	14
1631	0.0742	JIHLAVA	9
1779	0.0742	JIHLAVA	4
1633	0.0742	HALLE	9
1634	0.0742	RAMAT GAN	9
1678	0.0742	MAUBEUGE	8
1679	0.0742	MAUBEUGE	8
1778	0.0750	KREFELD	4
1367	0.0750	CHAMPREP	15
1726	0.0752	TWYCROSS	5
1736	0.0754	AMIENS	5
1544	0.0755	TAMWORTH	11
1668	0.0756	MANOR HS	8
1538	0.0758	ROMA	11
1642	0.0758	WROCLAW	9
1694	0.0758	CHESTER	8
1870	0.0763	PRAHA	2
1641	0.0766	OBTERRE	9
1537	0.0768	LE VIGEN	11
1796	0.0768	BEKESBRNE	3
1797	0.0768	LISIEUX Z	3

1697	0.0756	FUENGIROL	7
1667	0.0756	ROMA	8
1669	0.0756	FOTA	8
1695	0.0758	LE VIGEN	8
1696	0.0758	MANOR HS	8
1711	0.0760	CHAMPREP	7
1753	0.0766	OSNABRUCK	6
1754	0.0766	TWYCROSS	6
1907	0.0768	RHEINE	0
1912	0.0771	KREFELD	0
1798	0.0776	KREFELD	3
1708	0.0782	RAMAT GAN	7
1891	0.0782	LONDON RP	0
1893	0.0782	LONDON RP	0
1799	0.0794	LA TESTE	3
1800	0.0803	AALBORG	3
1889	0.0811	AALBORG	0

1911	0.0771	KREFELD	0
1393	0.0774	SHEPRETH	14
1732	0.0782	FUENGIROL	5
1824	0.0782	PAIGNTON	3
1825	0.0782	PAIGNTON	3
1543	0.0794	LONDON RP	11
1363	0.0795	ZOORASIA	16
1364	0.0795	SENDAISHI	16
1709	0.0803	AALBORG	7
1890	0.0811	AALBORG	0

6.6 PKBSI Ranked Mean Kinship List

Mean kinship values represent the relatedness of a tiger to the rest of the PKBSI population. These values change with any birth, death, or other changes to the population.

Table 6.5: Ranked mean kinship values for the PKBSI Sumatran tiger population. The line in the male and female lists denotes the population mean kinship is (MK = 0.0664). Individuals are listed in descending order of priority for breeding for the PKBSI population. Wild-caught tigers are **in red.**

MALE

Stbk#	MK	Location	Age
1748	0.0000	LAMONGAN	11
1765	0.0000	BOGOR	7
1767	0.0000	BUKITTING	10
1866	0.0000	LEMBAHHIJ	10
1856	0.0088	BOGOR	11
1756	0.0175	BOGOR	13
1491	0.0219	BOGOR	16
1521	0.0219	SURABAYA	13
1652	0.0219	BOGOR	12
1761	0.0219	BOGOR	7
1849	0.0219	MEDAN	18
1495	0.0252	BOGOR	16
1501	0.0252	BOGOR	15
1503	0.0252	BOGOR	15
1760	0.0263	PASURUAN	8
1763	0.0263	BOGOR	6
1766	0.0329	BUKITTING	21
1773	0.0351	BUKITTING	5
1834	0.0351	BUKITTING	4
1769	0.0373	BALI ZOO	8
1858	0.0458	MEDAN	11
1859	0.0458	MEDAN	11
1860	0.0458	MEDAN	10
1862	0.0458	JAKARTA	8
1864	0.0458	JAKARTA	8
1812	0.0622	LAMONGAN	3
1321	0.0794	SURAKARTA	17
1353	0.1025	LAMONGAN	16
1607	0.1043	JAKARTA	11
1608	0.1043	JAKARTA	11
1743	0.1140	YOGYAKART	12
1747	0.1140	BATUSECRE	10
1346	0.1171	JAKARTA	18
1462	0.1171	JAKARTA	15
1471	0.1171	JAKARTA	12
1472	0.1171	JAKARTA	12
1465	0.1233	JAKARTA	13
1350	0.1254	JAKARTA	17
1609	0.1274	JAKARTA	10
1610	0.1274	JAKARTA	10

FEMALE

Stbk#	MK	Location	Age
1758	0.0000	BOGOR	12
1749	0.0132	LAMONGAN	11
1757	0.0219	BOGOR	12
1762	0.0219	BOGOR	7
1507	0.0252	BOGOR	15
1832	0.0263	BOGOR	4
1833	0.0263	BOGOR	4
1768	0.0285	BUKITTING	10
1764	0.0307	PASURUAN	6
1887	0.0329	PASURUAN	1
1888	0.0329	PASURUAN	1
1770	0.0351	BUKITTING	8
1774	0.0351	SAWAHLUNT	5
1775	0.0351	SAWAHLUNT	5
1865	0.0458	MEDAN	8
1813	0.0622	LAMONGAN	3
1814	0.0622	LAMONGAN	3
1772	0.0711	BUKITTING	6
1831	0.0733	BALI ZOO	3
1616	0.1017	BALI ZOO	10
1467	0.1153	JAKARTA	13
1604	0.1153	JAKARTA	11
1605	0.1153	JAKARTA	11
1606	0.1153	JAKARTA	11
1463	0.1212	JAKARTA	15
1466	0.1233	JAKARTA	13
1611	0.1274	JAKARTA	10

6.7 Inter-regional Transfer Strategy

Inter-regional transfer of tigers falls into two categories: 1) transfers between PKBSI (primary population) and other regions (secondary population); and 2) transfers among non-Indonesian regions. To date, GSMP-recommended inter-regional transfers have focused primarily in the regions outside of Indonesia. Such transfers have provided modest genetic and demographic benefit. For long-term sustainability of the non-PKBSI regional populations, and of the global GSMP population, periodic transfer of new genetic lines from PKBSI to other regions will be critical.

The following considerations have been outlined for GSMP inter-regional transfers:

- Consider the genetic impact on both regions; ideally, any transfers should provide benefit to both the source and destination populations;
- Consider the demographic impact on both regions; transfer may help balance skewed sex ratios;
- Transfer animals that have good breeding potential (i.e., young, healthy, known pedigree);
- Use transfers to improve the receiving regional population's demographic and genetic status, then focus efforts on breeding those new animals to benefit from those transfers; and
- Limit the number of inter-regional transfers due to the resources and risks involved (i.e., limit transfers to those with substantial genetic or demographic benefit).

If a regional program has a tiger that is not needed for its population, it is recommended that the regional coordinator first contact the GSMP before placing a tiger in another region or outside of the GSMP. In this way, the population biologist can explore beneficial options. If a tiger is not needed by any of the GSMP regional partners, then it can be transferred outside of the GSMP program.

6.8 Research Needs and Potential Collaborations *Ex Situ* and *In Situ*

A well-managed, physically, demographically and genetically healthy global *ex situ* population of Sumatran tigers can contribute to the viability of the *in situ* population in a variety of ways, as identified in the 2012 Sumatran Tiger GSMP Report (Figure 6.13). In addition to serving as an insurance population, captive tigers can serve as a potential source population for:

- Demographic and/or genetic supplementation or reintroduction in the event of severe decline in the wild;
- Research that may benefit the conservation of wild tigers, such as refining monitoring or management techniques, as well as research that improves management;
- Training activities that may benefit the management of wild tigers, such as immobilization techniques that can be applied to capturing and transferring conflict tigers;

- Educational programs to increase awareness of human impacts on wildlife and inspire support of conservation activities and actions; and
- Raise funds for *in situ* conservation projects that benefit wild tigers and their habitats.

These potential *ex situ* conservation roles provide opportunities for collaboration either between *ex situ* partners and/or between *in situ* and *ex situ* partners. Past collaborations include working with tiger conflict teams to develop protocols and provide hands-on training in tiger immobilization and health assessment. Many institutions and regions share educational materials in conjunction with International Tiger Day. Some of the regional tiger programs provide financial support to tiger *in situ* conservation activities (e.g., Wildcats Conservation Alliance, Tiger SSP Tiger Conservation Campaign).

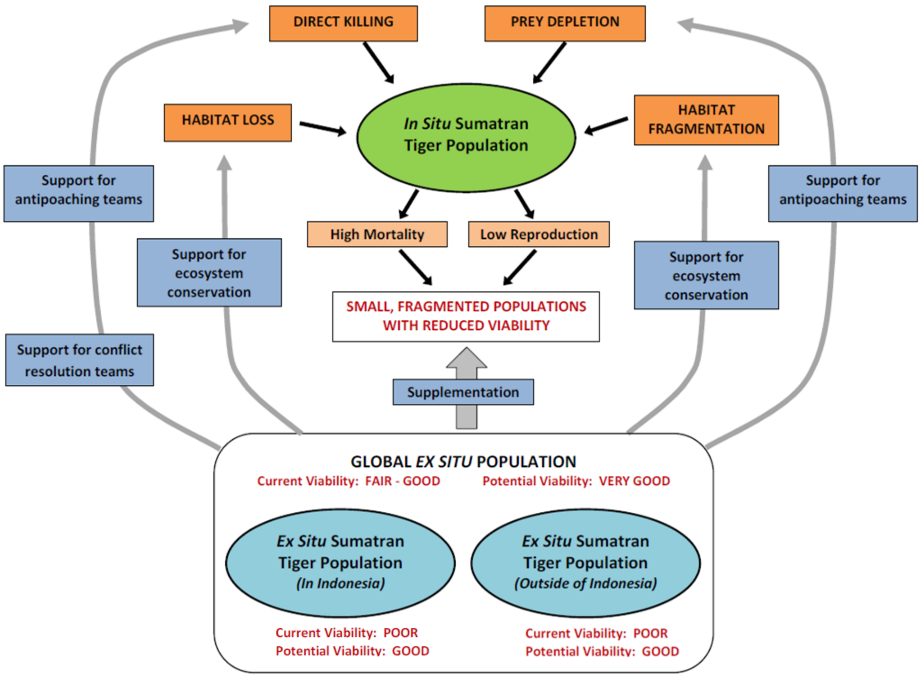


Figure 6.13: Diagram of how Sumatran tiger *ex situ* populations and associated institutions can support the viability of wild Sumatran tigers and/or reduce threats to the wild population (from Sumatran Tiger GSMP 2012).

There are no formal tiger GSMP research projects at this time; however, there are two areas of interest that are being investigated across regions in a collaborative manner:

1) Genetic analysis: Tiger biosamples will be collected and analysed to investigate genetic diversity and inbreeding, kinships and/or potentially genetic differences among regional populations. The GSMP is in the early stages of exploring this project for tigers in PKBSI zoos, see section 7 below..

2) Reproductive viability assessment (RVA): Expanding and updating previous analysis by the Tiger SSP (Saunders *et al.* 2014), data are being gathered to support a regional

and global analysis of factors related to *ex situ* reproductive success in tigers using methods described in Bauman *et al.* 2019. This will help to improve reproductive success in recommended tiger breeding pairs across regions.

Through the GSMP Husbandry Working Group, experienced tiger *ex situ* managers will be working with PKBSI (and potentially other regional programs) to assess tiger breeding and health issues, and to mentor institutions in introducing male-female tigers for breeding. See section 8 below.

Some regions are collecting and storing tiger biosamples (e.g., blood, tissue and/or semen) in cryobanks. These samples may be valuable in the future to genetically supplement the living *ex situ* population.

7. Using Genetics to Improve the Global Conservation Management of Anoa, Babirusa, Banteng and the Sumatran Tiger

7.1 Introduction

One of the most important long-term threats to the survival of the GSMP species stems from a potential lack of genetic diversity, a common issue in large mammal species. Recent work on anoa and Sulawesi babirusa suggest that they have lost a significant amount of genetic diversity in the wild over the last few hundred years (Frantz *et al*. 2018). The level of resolution that was afforded by this previous study, however, does not allow us to make any prediction about their potential long-term survival. Overall, our knowledge of the genetic diversity in these species *in situ* and *ex situ* varies, where some knowledge exist for the Sumatran tiger, anoa and babirusa *in situ* (Figure 7.1), but limited for *ex situ*, or, in the case of banteng, non-existent.

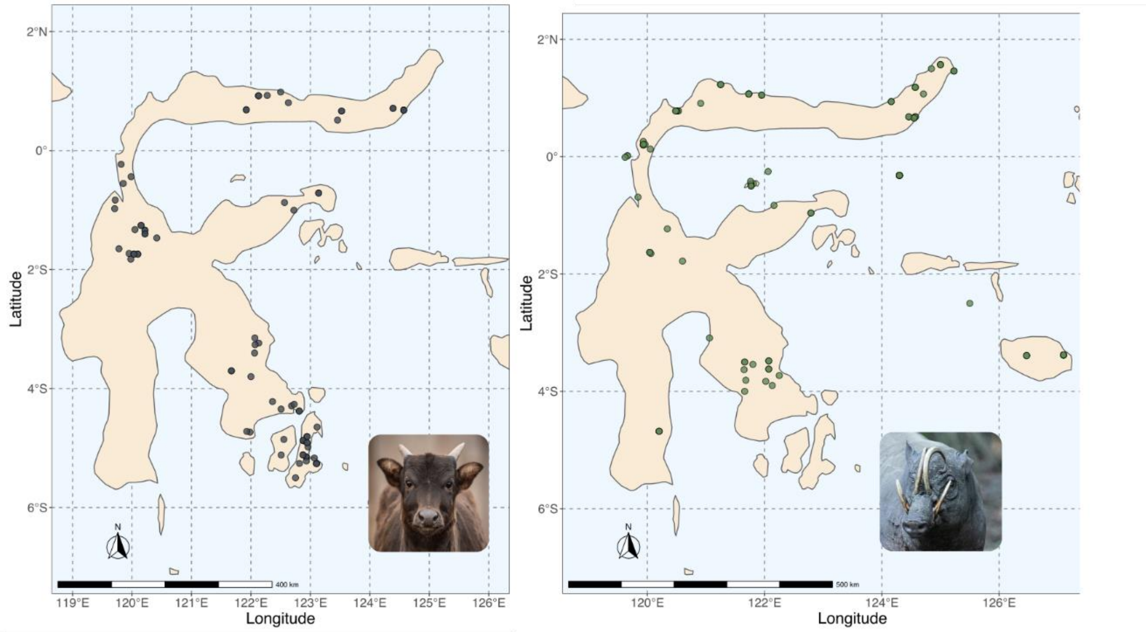


Figure 7.1. Maps of Sulawesi and the surrounding islands, with locations of samples of wild individuals already sequenced for Anoa and Babirusa (Frantz et al 2018). Photo credit Anoa = Chester Zoo, Babirusa = Dr Simon L. Mitchell.

Anoa, babirusa, banteng and Sumatran tigers are widely represented in zoos across Indonesia. These captive populations represent a potential source of important genetic diversity to help improve future conservation efforts for the species. During the last GSMP planning period (2018-2022), samples from individuals representing all founder lines of the anoa, banteng and babirusa PKBSI populations were collected, and genome sequenced. In addition, species sampling drives for anoa, babirusa and banteng have been or are in the process of being initiated in the AZA and EAZA populations. Currently, banteng biopsy sampling is being planned in four national parks (NPs) in Java (Alas Purwo, Baluran, Meru Betiri, Ujung Kulon) and for Sumatran tiger zoo populations and possibly conflict tigers. In addition, reviewing potential with government agencies, HarimauKita and NGOs for hub linking *in situ* and *ex situ* Sumatran tiger DNA sampling. The benefits of this include possible future genetic supplementation of fragmented and isolated wild populations, with low genetic diversity, through to the illegal wild trade. Analysis of DNA samples from confiscated skins, bones and animals could help identify tiger populations most at risk from poaching and track down people and organizations involved in the illegal tiger and wildlife trade.

Assessing the genetic makeup of the zoo populations will 1) enable understanding of the genetic variation in the various zoo populations; 2) allow origin assignment of individuals; and 3) map and compare the level of relatedness and inbreeding in the populations. Understanding these factors will help guide zoo population management to ensure that maximum genetic diversity (e.g. via pedigree reconstruction or kinship matrices) is maintained to maximize their value for long-term conservation goals. Ultimately the aim is to slow or if possible, prevent the loss of important genetic diversity to provide the best possible offset for adapting to future environmental change.

The ongoing genetic work provides a foundation for the conservation management of the zoo populations not only in Indonesia, but also globally. This is important, as these zoo populations are insurance populations, to allow potential reinforcement from zoos should the wild populations move closer towards extinction. It is therefore important to ensure their long-term genetic health and that the genetic diversity of the zoo populations resemble that of the wild populations to the extent possible. Indonesian zoos are critical to this goal, as they receive any individuals that are removed from the wild, including human wildlife conflict, illegal wildlife trade and animals not suitable for release, and hold the key to capturing their genetic variation through effective population management.

7.2 Aims

1. Obtain information about geographical origin, taxonomic purity, genetic variation and relatedness of all anoa, babirusa, banteng and Sumatran tiger zoo populations globally.
2. Assess and compare levels of the genetic diversity in wild and zoo populations.
3. Guide the management of the zoo populations to ensure the long-term survival of genetically healthy self-sustaining populations that resemble their wild counterparts.

7.3 Partners

- Indonesian Zoos and Aquariums Association (PKBSI)
- National Research and Innovation Agency (BRIN)
- Copenhagen Zoo
- Ludwig Maximilians University of Munich (LMU)
- Queen Mary University of London (QMUL)

The results of the proposed project will be used by PKBSI and other regional and national zoo associations in the GSMPs (i.e., EAZA, AZA, ZAA (Australasia), JAZA) to maintain the greatest level of genetic diversity in the insurance populations for those species. For banteng, the results will provide the foundation for a metapopulation management of the banteng in four NPs in Java, through active collaboration with KKHSG, Alas Purwo, Baluran, Meru Betiri and Ujung Kulon. For Sumatran tigers, collaboration with HarimauKita and NGOs will be explored, as well as discussions with the Indonesian Government in terms of conflict tigers.

This will help reach the GSMP goal of "demographically and genetically healthy global population across the *ex situ* - *in situ* continuum".

7.4 Methods

Ex situ sampling: In Indonesia, samples have been collected from selected individuals from the PKBSI populations of anoa, babirusa and banteng (Table 7.1). In the 2023-2025 Masterplan period, a sampling drive on the PKBSI population of Sumatran tigers will be conducted, pending approval by KKHSG.

In line with the GSMP framework and aim, samples from regional zoo associations, e.g. AZA, EAZA, ZAA for Sumatran tigers, and EAZA and AZA for anoa, babirusa and banteng will be obtained. Individuals are selected for sampling to ensure full representation of all founder lines, where possible. These samples will be used to reconstruct pedigrees of the zoo populations, fill gaps, assess genetic health (e.g inbreeding and genetic diversity), identify the origins of the zoo populations and determine ancestry. For EAZA, anoa and banteng sampling has already been initiated. Within AZA, banteng sampling is underway and for anoa and babirusa a sample request will be initiated. In addition, the Conservation Centres for Species Survival (C2S2) network is an important source of *ex situ* anoa individuals who already engage in a breeding program between the C2S2 partners. We will explore sampling within the C2S2, to include this population to gain understanding of the health of the global population within the goals and framework of the GSMP. In order to ensure the best quality and quantity of genomic DNA for sequencing, fresh or already collected blood or tissue samples will be collected from the European and North American zoo populations.

Supporting *in situ* samples will match the *ex situ* sampling, and consist of ~60 wild anoa and ~40 wild babirusa samples already stored in Europe, from previous research.

Table 7.1. List of banteng, anoa and babirusa selected for sampling, in order to capture the founder lines of the PKBSI populations. During 2021-2022, blood samples from all selected individuals were collected from PKBSI zoos for genetic analysis (total number of individuals and sex ratio (M, F).

	Banteng	Babirusa	Anoa
Taman Safari Cisarua Bogor	6 (3, 3)	7 (4, 3)	7 (3, 4)
Taman Safari Prigen	13 (5, 8)	2 (1, 1)	-
Bali Safari Park	3 (0, 3)	1 (1, 0)	2 (1, 1)
Taman Margasatwa Ragunan Zoo	6 (2, 4)	4 (1, 3)	3 (2, 1)
Bandung Zoo	1 (0, 1)	-	-
Batu Secret Zoo	-	1 (1, 0)	-
Kebun Binatang Surabaya Zoo	2 (1, 1)	14 (2, 12)	5 (1, 4)
Gowa Discovery Park	-	-	1 (1, 0)
Citra Satwa Celebes	-	-	6 (3, 3)
Total Individuals	**31 (11, 20)**	**29 (10, 19)**	**24 (11, 13)**

Table 7.2. Wild samples to be collected from anoa, babirusa and banteng for the 2023-2025 GSMP Masterplan period. Sumatran tiger samples will be collected from *ex situ* populations.

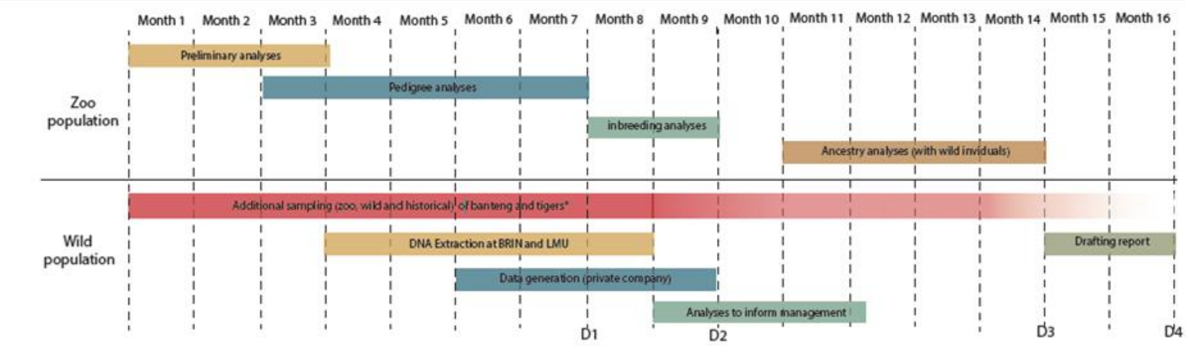
Species	Specimen	Location	Number
Banteng	Tissue (biopsy)	Alas Purwo, Meru Betiri, Baluran, Ujung Kulon	20 individuals sampled from each national park
	Skull fractions/bone	Museums in Indonesia and in museum collections outside the country, as well as more recent skulls collected and stored in the four national parks	approx. 30
Anoa	Tissue (biopsy)/blood	Sulawesi (4 provinces)	approx. 15 from each province
	Skull fractions/bone	Sulawesi (4 provinces)	approx. 15 from each province
Babirusa	Tissue (biopsy).blood	Sulawesi (4 provinces)	approx. 15 from each province
	Skull fractions/bone	Sulawesi (4 provinces)	approx. 15 from each province
Sumatran tiger*	Hair with opportunistic Tissue (biopsy)/blood	PKBSI holders	approx. 22 (details may change)

In situ sampling: In the 2023-2025 Masterplan period, the aim is to collect and sequence 20 wild banteng samples from each of the four Javan NPs: Alas Purwo, Meru Betiri, Baluran and Ujung Kulon. For the wild banteng populations, skin biopsy samples have already been secured for six individuals (8 samples) in Baluran NP, which are stored within the NP. The remaining 14 individuals to be sampled from Baluran and 20 from each of the three other NPs will be collected using a Dan-Inject Dart Gun (Model J.M.S.T.R, Dan-Inject ApS, Børkop, Denmark) under the training of and curated by Baluran National Park staff. An SOP has been developed for the biopsy sampling and shared with the NP staff in Alas Purwo, Ujung Kulon and Meru Betiri. For anoa and babirusa sampling will be explored from the four Sulawesi provinces (Table 7.2). Lastly, the partnership will explore sampling from conflict tigers when available and permitted.

Following the same setup as for PKBSI anoa, babirusa and banteng samples, additional samples from the wild as well as zoos in Indonesia will be sent to BRIN. BRIN will perform DNA extraction of all samples and make use of a commercial company to genome sequence the samples. In addition to the wild and zoo samples of anoa, banteng and babirusa, we are gathering a large dataset of historical samples from museums ranging from the 1890s through to the late 1940s. By comparing the current standing genetic variation in contemporary populations (wild/captive) to the genetic diversity from museum specimens, we can build up a temporal picture of genetic diversity changes through time and before major anthropogenic impact. As these historic samples span major development acceleration across Indonesia, this might provide a more accurate "baseline" to be aiming for when establishing the minimum genetic diversity required for the zoo populations. To achieve this, we will sequence the whole-genomes from museum specimens in a dedicated ancient DNA lab in LMU, Munich. Ancient DNA techniques target the degraded, fragmented DNA which results from old museum specimens. Based on previous work we are aiming for a genome coverage of between 5-10X.

The wealth of information provided by these methods allows us to 1) retrieve relatedness between individuals in a population with great precision; 2) obtain precise estimates of genetic diversity and inbreeding levels; and 3) establish where, in the wild, the individuals from a zoo population came from, but only if samples are available from the natural distribution range of the species. This greatly enhances the value of molecular based methods for maximising genetic diversity in captive populations and improving the genetic outcomes of future release. For this work, the GSMP partnership has already sequenced the genomes of PKBSI zoo samples of anoa, babirusa and banteng, and GSMP partners have sequenced and published results from wild samples of anoa and babirusa. Preliminary analyses of the sequencing results from the PKBSI zoo populations of anoa, babirusa and banteng are being conducted by Indonesian (BRIN) and European zoo scientists (Copenhagen Zoo, QMUL/LMU). Data will be used to inform the 4th set of breeding and transfer recommendations for Indonesian zoos, starting in February 2024. Data will be equally shared, analyzed and published jointly with all the partners. Besides the conservation angle, the project also aims to provide capacity building and knowledge transfer related to data analysis of NGS data. Partner laboratories at Copenhagen Zoo and QMUL/LMU will provide training and knowledge transfer of highly specialized expertise in bioinformatics, genome science and population genetics, which are being planned to Indonesian scientists.

7.5 Timeline



D1: Deliverable 1: Pedigree reconstruction of world-wide captive population.
D2: Deliverable 2: Inbreeding coefficient, at individual, zoo, and country level.
D3: Deliverable 3: Geographic origin of each individual.
D4: Deliverable 4: Report from the genetic WG with recommendation for breeding.
*Banteng wild sampling will be conducted during May-November 2023 timeframe - other species will be sampled opportunistically beyond this.

Figure 7.2: Timeline of the sampling of wild and zoo populations to meet the stated deliverables D1-D4

7.6 Outcomes

The main species conservation outcome will be that this collaborative project will provide vital information to give more effective recommendations for breeding to PKBSI and other GSMP regional zoo associations (EAZA, AZA,ZAA, JAZA) and for enabling meta-population management of wild banteng in Indonesia:

- Reconstruct pedigree of zoo individuals (or incorporation of pairwise kinships) to **minimize inbreeding and strive towards genetically healthy self-sustaining populations**
- Estimate genetic diversity within different zoo populations and kinships between those populations to **maximize the potential of transfers of animal between zoos**
- Establish the geographic origin of zoo individuals (including founders) to **minimize cross-breeding between differentially adapted populations** (for anoa and babirusa)
- **Meta-population management strategy outlined** for banteng across the four NPs in Indonesia to **improve the genetic diversity of the *in situ* population**.

Altogether these analyses will provide the foundation to make informed decisions and help guide the future management of the species, and expertise and analytical knowledge will be shared among all GSMP partners.

8. Husbandry Training and Capacity Building

8.1 General approach for husbandry training

Maintaining a high standard of husbandry and animal care is essential to zoo management and to the success of cooperative breeding efforts and *ex situ* conservation of the GSMP species. Working with PKBSI the Action Indonesia GSMPs aim to optimise general and breeding related husbandry for banteng, babirusa, anoa and Sumatran tiger by providing support, advice and training via our global network of husbandry experts.

The goals for the Husbandry Training Working Group are to reach and maintain demographically and genetically healthy *ex situ* global populations for the four species, and to use expertise from the zoo community to help support *in situ* activities. These goals remain relevant to the Husbandry Training Working Group entering the next phase of master planning, and to help achieve them a number of overarching actions based on the theory of change diagrams were set for each;

Goal - Reaching demographically and genetically healthy *ex situ* global populations:

- Optimise general husbandry
- Optimise breeding related husbandry
- Assist PKBSI in developing a zoo professional training programme

Goal - Use expertise from the zoo community to help *in situ* activities:

- Provide husbandry support for rescue centres run by government agencies
- Training for rescue, care and rehabilitation of wild caught or confiscated animals

8.2 Summary of achievements 2018/2021

Over the course of the previous masterplan period, a number of actions were successfully implemented;

Husbandry guidelines were completed, translated and approved for distribution for banteng and anoa. The first draft of babirusa guidelines have also been completed and are being reviewed.

In a 2018 workshop, 32 participants built their capacity in enclosure design and collection planning. Tailored husbandry advice and guidance has also been delivered through zoo visits to 17 zoos, which have included on-site discussions and follow-ups with keepers, curators, veterinarians and directors. Virtual husbandry training webinar sessions took place in 2020 due to the Covid-19 pandemic, delivered by experts and practitioners from PKBSI and the GSMPs. Virtual training sessions have had high participation, with up to 76 participants from up to 33 institutions attending per session, with pre and post training surveys used to monitor the effectiveness of the training.

A draft of a husbandry training framework has been created and presented to PKBSI for review. The framework includes the main knowledge areas and key skills that keepers need for each level of their career. It has been designed so that the range of husbandry topics taught via Action Indonesia GSMP workshops and training sessions fit into the framework of learning.

8.3 Vision and key aims 2023-2025

Generally speaking, all regions have good husbandry knowledge and are fairly successful in keeping, breeding and rearing banteng, anoa, babirusa and Sumatran tiger. However, in some Indonesian zoos there is still room for improvement in terms of breeding success, particularly for the Sumatran tiger which has seen a significant decline in successful reproduction over the last 3 years. Addressing husbandry issues related to breeding success will be a priority given that many of the genetically important individuals of all four species are held in this region. The Action Indonesia GSMP will work closely with PKBSI to provide materials and training for Indonesian zoo professionals to assist in these areas. This will include but are not limited to:

1. Developing both virtual and in person training and support for husbandry skills in the following topics;
    - Biosecurity
    - Nutrition
    - Body condition scoring
    - Animal training for medical procedures
    - Housing/enclosures
    - Enhancing breeding success

2. Developing an online library of resources to support the above topics that can be accessed and used freely by Indonesian zoo staff, as well as continuing to produce, update and share other husbandry related guidelines and resources.

3. Planning and delivering in person workshops and zoo visits to help train zoo professionals in the husbandry techniques needed to successfully manage and breed these species. This includes breeding and rescue centres run by government agencies.

4. Continuing to assist PKBSI in developing a zoo professional training program for zoo keepers to help in standardising and improving husbandry techniques in Indonesia for these species. This program would aim to provide some form of certification or accreditation from PKBSI for completing training courses.

5. Building capacity to increase husbandry training activities within Indonesia by means of a "train the trainer" programme, with the aim of equipping individuals in Indonesian zoos or breeding facilities, who already have relevant husbandry knowledge and expertise, with the skills to be able to train and mentor others. This capacity building will aim to create a network of trainers and mentors within Indonesian zoos that are available to PKBSI to help optimise general and breeding related husbandry practices for banteng, babirusa, anoa and Sumatran tiger. It will also help develop increased links between zoos for sharing of advice, expertise and connections to facilitate breeding transfer recommendations.

6. Research : Effective monitoring of animal welfare (Masters Project in place): Developing a customised welfare assessment processes for species within the GSMPs will help ensure the captive health and sustainability of the *ex situ* populations. The research objectives of this project are; to review and trial welfare assessment processes for Lowland anoa and Sumatran tiger in EAZA collections

(UK based). To adapt the assessment processes for use in Indonesian zoos and utilise the assessment process to inform wellbeing in the range of taxa and inform best practice for population management.

Key measures of success will include the following:

- Delivery of an in person tiger husbandry workshop in at least one location in Indonesia in 2023
- Delivery of at least two training events per year with additional support through in person visits and mentoring where possible
- Increase of successful implementation of breeding and transfers in PKBSI zoos.
- Creation and distribution of virtual and offline husbandry resources for Indonesian zoo practitioners on the four GSMP taxa by end 2025

8.4 Evaluation

In order to monitor the impact of the activities carried out by the Husbandry Training Working Group and to measure success, continuous evaluation will be required. Due to the wide range of activities there will be a number of way this will be done;

Quantitative:

- Number of people and zoos attending workshops
- Improved breeding success for each species
- Number of resources distributed
- Number husbandry trainers trained through the GSMP
- Number of Zoos with improved husbandry practices

Qualitative:

- Regular questionnaires measuring knowledge retention, application and what the barriers are
- Zoo visits to carry out informal engagement and to record changes in husbandry and issues that were highlighted
- Case studies and a technical reports from zoos that have received training to share progress and practice
- Husbandry training peer groups working to build their own capacity, self-reporting to Working Group/PKBSI
- Active participation in networks set up through working group and PKBSI to support husbandry training
- Professional Husbandry Framework and Certification for keepers implemented by zoos with the support of PKBSI and KKH

9. Zoo Education and Community Engagement activities

9.1 General approach for ex situ and in situ education

The threats faced by all of the GSMP species are human created, it therefore stands to reason that working to change human behaviours is key to their long-term survival. Effective conservation education has been shown to increase knowledge of species and conservation (Nekaris *et al.* 2017) and can influence public behaviour through fostering connectedness to nature and sense of environmental responsibility (Ancrenaz *et al*. 2018; Van den Born *et al*. 2017). Education is an underpinning factor in the One Plan Approach of the GSMPs.

In 2015, it was reported that 700 million visits were made to zoos globally (Barongi *et al,* 2015), and its likely this number is now far greater. In Indonesia alone there are over 50 million visits to PKBSI member collections per year. Zoos have an important role in nurturing a community with positive environmental values and creating the 'culture of conservation' needed to save species and conserve biodiversity (Barongi *et al.* 2015 '). The scale of their reach, combined with the evidence that effective education programmes delivered by zoos can lead to changes that are pre-requisite to pro-conservation behaviours,, represents enormous potential for zoos to support the conservation of GSMP species through education.

Additionally, there is great potential to reach beyond zoos, using digital means and collaborating with *in situ* partners, to achieve changes in attitudes and behaviours in the wider population, both local to where threats to species are present and internationally in order to galvanise support for conservation and reduce the threats of global consumption.

The WAZA/IZE Conservation Education Strategy (Thomas, 2022) outlines five key purposes for education that will underpin our approach:

- (COGNITIVE PURPOSE) Build knowledge and understanding about species, the natural world, and zoo and aquarium contributions to conservation.
- (AFFECTIVE PURPOSE) Foster positive connections, emotions, attitudes, values, and empathy toward species, the natural world, and zoos and aquariums.
- (INSPIRATION PURPOSE) Promote awe, wonder, enjoyment, creativity, and inspiration about species and the natural world.
- (BEHAVIOURAL PURPOSE) Motivate pro-environmental behaviours, actions, and advocacy to support species and the natural world.
- (SKILLS PURPOSE) Develop scientific, technical, and personal skills connected to zoos, aquariums, and biodiversity conservation.

9.2 Summary of achievements 2018 - 2021

Since the initiation of the Action Indonesia GSMPs actions relating to education have increased significantly. The creation of an Education Working Group was formalised during the 2nd GSMP Planning meeting in February 2018, since then the group has grown to include members from across EAZA, PKBSI and AZA collections.

The first Action Indonesia Day was hosted in 2019. It has continued as an annual event, taking place on the Sunday before Indonesian Independence Day each year. To mark the day, zoos and other interested organisations are asked to run educational activities with their visitors and to share social media posts relating to the target species and their conservation. Due to the global coronavirus pandemic, activities in 2020 and 2021 moved almost wholly online and participation was impacted by the other challenges that zoos were facing. However, momentum was maintained, and in 2022, hands on activities within collections resumed, more than 50 organisations were involved and the campaign's #ActionIndonesiaDay hashtag achieved a social media reach of 3.7million. The annual event is also now included in Peppermint Narwhal's widely respected calendar of world animal days.

There has been significant focus on the upskilling of educators with courses in education planning and programme design, engagement techniques and interpretative planning running during the 2018 – 2021 period. Across these three courses, 147 Indonesian zoo professionals have attended training co-ordinated by the GSMP Education Working Group. A WhatsApp group of more than 60 members has also been created, to enable educators who have participated in training to stay connected and to continue to share ideas and resources.

To further support educators and make delivering education about the GSMP species much easier, a bank of over 50 resources in both Bahasa Indonesia and English is now free to download from the Action Indonesia GSMP website. This includes templates for interpretation signage, 'how to' guides for educational activities, fact files, talk templates, animations and infographics about the GSMP and the target species.

In 2020, a dedicated website to share news and act as a hub for information about the Action Indonesia GSMPs was created. The website includes information about the GSMP species, the work of the GSMP, Action Indonesia Day, latest news and the resource bank described above. It also provides a portal for people to contact the GSMP to offer support or ask questions about how to engage. Alongside this, dedicated social media channels were also set up on Facebook and Instagram. By November 2022, these channels had accumulated 460 and 280 followers respectively. They are particularly active hosting live events and sharing content during the period around Action Indonesia Day. They were instrumental in enabling us to maintain an online presence for education activities, especially during the coronavirus pandemic when many facilities were closed or there were restrictions on face-to-face activities.

Activity to promote the work of the GSMP and to encourage greater participation in education activities relating to GSMP species has also included webinars and a number of conference presentations. Two GSMP specific webinars have been hosted so far, in 2021 and 2022. The first showcased the variety of different activities across the GSMP, whilst the second focused specifically on education activities and a call to action for organisations to participate in Action Indonesia Day. In the period 2018 – 2021, eleven conference presentations were given to a total of over 1,000 delegates. Conference presentations included the education themed conferences of BIAZA (2019), EAZA (2019) and WAZA/IZE (2018). As well as the general conferences of PKBSI, SEAZA, AZA and EAZA.

9.3 Strategy for phase 3: 2023 – 2025

Throughout 2022, the Education Working Group has met virtually to review activities, redevelop its Theory of Change and identify the objectives and actions that it will take forwards over the next masterplan period. Subgroups have been created to progress each of the education objectives below.

The Education Working Group actions will support the four Indonesian GSMP species; the ungulates (anoa, babirusa and banteng) and the Sumatran Tiger.

Objective 1: To better understand the human drivers of threats to Banteng, Babirusa, Anoa and Sumatran Tiger conservation, including underlying customs, beliefs and attitudes, so that we can target our education initiatives more effectively.

Threats to anoa, babirusa, banteng and Sumatran tiger have been identified in consultation with conservationists working across the GSMP, including those engaged in the *in situ* conservation groups. Threats are specific to the different species and in some cases to localities, and include habitat loss and degradation, community encroachment, human wildlife conflict, farming and agricultural practices, cattle grazing, illegal wildlife trade and hunting. In order to design effective education interventions to mitigate those threats we need to understand better the customs, beliefs, attitudes and capabilities that may be underlying them for each species and each area. Discovering the existing research evidence to support this and commissioning research where it does not exist is therefore essential to the further progression of a conservation focused education strategy.

To better understand the human drivers of threats, the GSMP Education Working Group needs to:

- Find out what research already exists in this area and identify researchers already working in this field
- Uncover gaps in existing research and where further research is needed relevant to GSMP education priorities
- Source opportunities for collaborating on research to enhance existing knowledge, including identifying funding
- Progress new research projects to inform approach to GSMP education and behaviour change activity
- Ensure research evidence is disseminated to education practitioners working in this area, with recommendations on how it can be used to inform education programme design

Specific actions that will contribute towards this objective during the 2023 – 2025 period include:

- Hosting a seminar to bring practitioners together and surface relevant research
- Desk research to map existing research and relevant individuals and organisations
- Gap analysis in relation to wider education plans
- Commissioning specific pieces of research to address priority gaps, and identifying partners and funders to collaborate with on this
- Producing and sharing research reports, including recommendations to inform the development of relevant education campaigns

Key measures of success for this aspect of our work include:

- By end 2023, participation of relevant researchers in a practice sharing seminar
- By end 2024, report identifying gaps in current research and opportunities for GSMP education research going forwards (including partners and funding)
- By end 2025, research informed recommendations are embedded into GSMP education campaigns and activities.

Objective 2: To develop relationships and identify opportunities for collaboration with National Parks and NGOs working *in situ* with target Action Indonesia species.

Engaging and empowering communities with the knowledge and skills to conserve their local wildlife has the potential to have direct impacts upon species and natural resources that both people and wildlife depend upon (Nekaris *et al*. 2017). As the *in situ* work of the GSMPs develops conservation education work will develop as part of a joined up approach to *in situ* conservation. There will be some crossover with the *ex situ* work and potential opportunities to share resources and provide similar capacity building for *in situ* educators. However, there will likely be greater focus on behaviour change and very specific actions linked to support for the species, such as reduction in hunting behaviours or habitat protection. In order for this work to be successful there needs to be successful collaboration with the National Parks and NGOs who are working alongside communities to conserve GSMP species *in situ*.

To develop collaboration and progress education work *in situ*, the GSMP Education Working Group needs to:

- Work as part of the wider GSMP team to develop *in situ* approaches, particularly linked to working in the four National Parks on Java that hold banteng.
- Understand existing education practices at relevant *in situ* sites and where there is need or opportunity for additional support from the GSMP Education Working Group
- Apply that understanding of existing practice and research evidence to develop proposals for *in situ* support
- Develop mechanisms for sharing practice and support across *in situ* and *ex situ* education practitioners

Specific actions that will contribute towards this objective during the 2023 – 2025 period include:

- Work with KKH and PKBSI to conduct a survey of existing *in situ* education provision
- Host a practice sharing webinar/event with organisations working *in situ*
- Scoping visits to relevant sites in Java and Sulawesi to build relationships and identify opportunities
- Identify options for further development of *in situ* work, building on scoping and research work and based on needs of potential partners.

Key measures of success for this aspect of our work include:

- By end 2023, report disseminated within GSMP on findings from initial scoping visits and survey of existing practice

- By end 2024, participation and report outcomes from webinar/sharing event
- By end 2025, options appraisal completed and shared with relevant partners
- Changes in attitudes and behaviour achieved through GSMP supported *in situ* education activities
- Number of people impacted by GSMP supported *in situ* education activities

Objective 3: To create targeted education campaigns that increase awareness of the species and the threats they face and that promote conservation action to support their protection

Building on the successes of Action Indonesia Day and awareness raising activities across the globe, there is now a need to develop education campaigns that more actively change behaviours and increase direct support for the conservation of our focal species. Campaigns need to be targeted to the needs of different audiences, the opportunities for conservation action that they have available to them and to mitigating the threats faced by the different species in different localities.

Indonesian zoos and Indonesia focused education campaigns have greater potential to engage with communities who may share environments with banteng, babirusa, anoa and Sumatran Tiger, and who may be engaged in behaviours that are directly impacting the conservation of these species. International audiences are more likely to be able to support the conservation of GSMP species in less direct ways, such as through financial support or changes in consumption of products that originate in range countries. In some aspects a unified approach may enable us to amplify messages and reach a greater number of people, whilst in some cases campaigns need to be tailored to very specific audiences and outcomes. Developing this multitude of more nuanced approaches is the focus for the development of education campaigns in this period.

The ungulate species remain less likely to be the focus of any sort of educational activities in zoos when compared to more charismatic and popular species, and there is a still a need to promote and facilitate their inclusion in the education programming of zoos in all territories, in order to drive support for their conservation.

To develop our education campaigns in this period, the GSMP Education Working Group needs to:

- Continue to encourage collections to run activities about the conservation of the GSMP species, raising their profile amongst zoo audiences and demonstrating the audience appeal of running quality educational activity about these species
- Make it easy for zoological collections and organisations that wouldn't normally focus on these species to run engaging activities with messaging tailored to their audiences and the most relevant conservation goals for them
- Build institutional support from zoos holding the respective species
- Develop an approach for education campaigns that enables us to achieve greater conservation impact through changing people's behaviour, acknowledging that this may require us to focus down on a limited number of audience types, actions or geographies

Specific actions that will contribute towards this objective during the 2023 – 2025 period include:

- Action Indonesia Day events each year, with messaging tailored to different audiences/outcomes
- Provide a range of resources to support collections from different territories to engage with Action Indonesia Day
- Identify meaningful actions relevant to global audiences, including behaviour change and tailored fundraising asks (sponsorship)
- Connect with the SAFE Species programme in the USA and incorporate this into messaging
- Review of different models for Pride and area specific campaigning, including building capacity of Education Working Group members
- Delivery of territory specific campaign in Indonesia designed to meet conservation goals for a particular species
- Map curricula in different territories and identify potential partners to explore potential for global youth focused campaign (delivery would be outside timeframe of this phase of the masterplan)
- Delivery of annual GSMP webinar to promote support for engaging in Action Indonesia Day and wider GSMP activities

Key measures of success for this aspect of our work include:

- Across 2023-2025, increased learning about target species (relevant to targeted messaging) amongst targeted audiences, including online audiences
- Delivery of annual Action Indonesia Day with participation from a minimum of 60 organisations each year and social media impressions in excess of 3million
- Attendance at annual webinar and resulting sign ups to take part in Action Indonesia Day and/or other GSMP activities
- Across 2023-2025, increased donations
- By 2025, delivery of at least one successful territory focused campaign
- By 2025, evidence of behaviour change driven by GSMP Education Working Group activities.
- By 2025, plan in place for larger scale global campaign

Objective 4: To extend the reach of our education campaigns and broaden understanding of the role of the GSMP through developing our website and social media channels.

Particularly during the pandemic period, when in-person educational engagement was not possible, the GSMP Education Working Group and the zoological collections we work with were able to realise the potential of digital channels to reach people and deliver live activities through digital means. Events such as Instagram and Facebook lives and targeted social media posts continue to form an important part of our engagement, particularly around Action Indonesia Day. In 2022, the #ActionIndonesiaDay hashtag was seen 3.7million times during the week of the campaign.

The Action Indonesia GSMP website has also become a hub for the distribution of resources that are key to providing ongoing support to educators and to collections developing Action Indonesia related educational activities for the first time. The group have also identified the opportunity for our digital channels to drive fundraising and to support the work of the GSMP more broadly, through sharing training resources relevant to a broader range of disciplines.

To develop our website and social media channels during this period, the GSMP Education Working Group needs to:

- Maintain the website as the go to place to find the latest information about the work of the GSMPs, ensuring content is relevant, up-to-date and showcasing a broad range of GSMP activities
- Increase engagement with our social media channels, particularly outside of the Action Indonesia Day peak
- Realise potential of the website and social media channels to drive engagement with education campaign messaging and with fundraising asks

Specific actions that will contribute towards this objective during the 2023 – 2025 period include:

- Building a content plan for social media to increase engagement around and outside of the core Action Indonesia Day peak, capitalising on other prominent world calendar days (e.g. International Zookeeper Day, International Women's Day)
- Sharing stories with other organisations, such as Conservation Optimism
- Identifying and developing potential to work with influencers
- Increasing the range of downloads available through the resources platform, starting with husbandry guides.
- Developing individual giving through digital channels, starting with use of Justgiving

Key measures of success for this aspect of our work include:

- Financial donations from zoos and the public received through digital channels (Justgiving)
- Number of posts and pieces of content shared across the website and our social media channels
- Number of resources available through the resources platform
- Engagement with social media channels (likes, follows, impressions and shares)
- Engagement with web pages (page views, sessions, dwell time, downloads of resources)

Objective 5: To enable increased and better delivery of conservation education linked to the target species through the delivery of training, provision of resources and mentoring.

Investing in training of zoo educators to develop and strengthen skills will support professional and education programme development and increase capacity to provide effective learning opportunities. Through sharing best practice and creating support networks, zoo educators can work together to raise international awareness and support for the Indonesian GSMPs, as well as deliver targeted educational campaigns to create conservation impact in their own locality. This is particularly relevant for educators working in Indonesian zoos, as there is less existing training and support for them than there is in Europe and America, where regional associations have dedicated education committees and provide opportunities to share best practice through conferences, online networks and regular meet-ups. Training delivered so far has been well received and the Education Working Group will build on this during the next phase of the plan.

To increase the capacity of zoo educators the GSMP Education Working Group needs to:

- Continue to develop the resources bank and promote it to educators across the globe
- Seek feedback on the training offering so that it continues to improve and the training programme is relevant to the needs of Indonesian zoo professionals
- Build capacity within Indonesia to deliver more training and amplify the impact of the training already delivered
- Maintain opportunities for educators to network with each other and to share practice

Specific actions that will contribute to this objective during the 2023 – 2025 period include:

- Delivery of 'Train the Trainer' training to enable training be cascaded and increase the capacity of Indonesian zoo professionals to deliver effective training
- Delivery of further training, to include Social Science and further aspects of educational delivery techniques
- Creation and dissemination of further resources to support educators to deliver more tailored and impactful educational activities relating to all four GSMP species
- Development of zoo to zoo mentoring and supported visits to develop educational capacity at individual zoos.

Key measures of success for this aspect of our work include:

- Number of resources distributed and used
- Number of educators receiving training and support through the GSMP
- Active participation in networks
- Number of educators implementing their training
- Number of zoos with improved education programmes

10. Banteng *in situ* Conservation Support

10.1 Strategy

The GSMP *in situ* goal is ensuring the existence of "genetically viable" wild populations of Javan banteng in its current distribution range. In the 2018 masterplan, the working Group defined the threats to the species and identified a range of ambitious activities to mitigate these threats. Whilst progress was made in the proposed activities, including the expansion of the population monitoring and assessment activity from one to two national parks, the holistic activities were unfeasible within the timeframe due to the number of stakeholders and relationship building involved, the limitations of the pandemic in 2020-21 and other reasons.

The banteng *in situ* GSMP proposes that in the coming three years there is increased collaboration between the four National Parks supporting banteng in Java, along with researchers and other partners. This will prepare the knowledge needed for linking these four populations following the metapopulation approach (animal transfers to maintain genetic diversity). In these three years it is therefore essential to gain relevant genetic and population information, as well as increase stakeholders' understanding of the concept, purpose, and reason of metapopulation management. By 2025, we aim to have successfully supported a Population Viability Analysis for banteng in Java based on the genetic and population data gathered in the four parks. The results of this analysis will guide the metapopulation approach and management actions in the following phase.

The GSMP proposes that future long-term management of Javan banteng maximises genetic diversity by occasional transfer of individuals between populations, or metapopulation management. This will increase the survival chance for the wild banteng in Java and minimise the effects to small population associated with the loss of genetic diversity

10.2 Current activities and planned activities 2023-2025

During the GSMP planning in 2022, the GSMP banteng *in situ* working group identified key activity areas for the immediate conservation attention. In 2023-2025, the GSMP will support the data collection and analysis needed to assess the banteng population in a PVA workshop led by KKH;

- Estimate population size in all national parks and outside national parks by 2024
- Sampling 20 biopsies of banteng in each of the four national parks and outside (including training for operators)
- PVA Modelling workshop by first half 2025
- Support education and awareness raising activities with communities surrounding National parks, beginning with Alas Purwo National Park in 2023.

Population estimate and monitoring in all parks

A banteng monitoring system was setup in Baluran National Park in 2014. This system makes use of 120 camera traps positioned in grids of 1x1km. Cameras are deployed for three months each year during the dry season (August-October) and analysed using Random Encounter Methodology. A banteng monitoring survey was also applied in Alas Purwo National Park in 2021 and 2022 using a similar survey design, in which 69 camera traps were positioned in grids of 3x3km across the park. Data collection and analysis was conducted by National Park staff in partnership with PKBSI and the GSMP, with the aim of supporting long term population monitoring in this park. Meru Betiri and Ujung Kulon NPs have conducted camera trapping in similar grid patterns and this data may be analysed using the REM analysis methodology. This will be further investigated in 2023. In order to gain a robust understanding of the population across Java, data collection and analysis must be comparable across all parks. In 2022, the GSMP worked towards this through supporting technical calls between the four parks to introduce the metapopulation approach and gaining feedback and population status updates from each park, ascertaining agreement to work cohesively in data collection and analysis.

In 2023-2025, the GSMP will:

- Continue to support population monitoring in Alas Purwo NP and Baluran NP using camera trapping and REM methodology.
- Provide technical support to build capacity for consistent population monitoring in all four parks. This will include training and mentoring in analysis and survey methodology.
- Support the collation and combination of datasets from all parks to build a picture of the current population across the parks

From the existing datasets across all four parks, it is evident that accurate banteng numbers remain elusive and that working cohesively is needed to get a better understanding of the current population densities and dynamics. It is anticipated that a common monitoring system will be in place during the 2023-2025 period and that banteng population data will be analysed for parks.

Sampling biopsies from all parks for DNA-analyses

The aim of the genetic work under the GSMP and PKBSI, is to characterize the genetic diversity of both wild populations and *ex situ* populations in Indonesian zoos. The international GSMP researchers from the Genetic Working Group will work closely together with their Indonesian counterparts on applying technical skills and building knowledge and resources in Indonesia enabling future use on other species, both *in situ* and *ex situ*. See the Genetic Working Group section for detailed description of activities.

In a technical call in early 2023, the MoEF and National Parks fully supported the genetic sampling activity to be conducted in 2023. This support and ownership by the MoEF and parks of the project will expediate permit processes and allow for easier implementation of the sampling, as well as being a very positive indicator of governmental support for the metapopulation approach for banteng in Indonesia. The GSMP team will support the Ministry of Environment and Forestry to coordinate biopsy collection as extended capacity building exercises in the respective parks.

In 2023-2025, the GSMP will support the following key activities:

- Transfer of the banteng samples (n=8) held at Baluran NP to BRIN for genetic analysis.
- Collection and assessment of the genetic diversity inferred from 20 samples from unrelated banteng per population (Baluran (n=14), Meru Betiri, Alas Purwo, Ujung Kulon). This will include training by the Baluran -Copenhagen Zoo vet in using the biopsy sampling equipment, and technical genetic assessment support from BRIN and from Copenhagen Zoo.

PVA modelling workshop

It was proposed that a PVA-modelling workshop should take place in the first half of 2025, using the information from the population assessment and genetic assessment to gain the most accurate and indicative results. This will support the development of a metapopulation management plan.

Support education and awareness raising activities with communities surrounding National parks

Engaging and empowering communities with the knowledge and skills to conserve their local wildlife has the potential to have direct impacts upon species and natural resources that both people and wildlife depend upon (Nekaris et al. 2017). The Education Working Group will work with the banteng In situ WG to support community engagement to reduce and mitigate threats to the species *in situ*, including conflict mitigation and poaching. Activities in this period will be guided by relationship building and scoping trips to sites in Java in 2023 and 2024.See the Education Working Group section for more detailed description of activities.

- Work with KKHSG and PKBSI to conduct a survey of existing *in situ* education provision
- Scoping visits to relevant sites in Java and Sulawesi to build relationships and identify opportunities
- Support communication of effective conservation messages through sharing and developing resources, potentially some training of education staff

Key measures of success for the banteng *in situ* activities will include:

- Standardised population monitoring data from 4 parks in Java
- Successful genetic assessment of the banteng in the 4 parks in east Java

- Successful population viability analysis and clear reporting of recommendations for the future conservation of banteng.
- Strategy document created and development of resources tailored to banteng in use in at least one national park in Java

11. Anoa and Babirusa *in situ* Conservation Support

11.1 Strategy

The GSMP *in situ* aim is that there are 'stable and safe *in situ* populations of anoa and babirusa'. This can only be achieved through defining and tackling short and long-term outcomes, as steps to deliver the aim. The status of anoa and babirusa in the wild is little known, for example current distributions and population sizes are rough estimates. Therefore, the first activities to achieve the outcomes are focussed on information collection. This will help to define the most appropriate solutions to the threats for the GSMP to have the greatest impact. Limited progress was made in the activities defined in the 2018-2021 masterplan. This was due in part to the pandemic and the need to build and develop relationships in Sulawesi that is integral to implementation.

From current knowledge, the five short-term outcomes that are identified as a priority to be addressed are:

- Knowledge of population sizes and trends.
- Change of knowledge, attitudes and behaviours in local communities/wider population.
- Knowledge of current offtake rates and trends.
- Habitat monitoring.
- Enforced legislation, effective patrolling.

These have been visualised in the *in situ* Theory of Change (see section 12.2). This diagram also outlines the activities that are required to achieve these outcomes. The scale of the aim and the diversity and number of activities defined mean that the resources of the GSMP will mean that successful achievement must be done in partnership with many other implementing and funding organisations.

During the GSMP planning workshop in 2022, it was decided that to progress with the *in situ* goals for anoa and babirusa it is important to prioritise and focus our efforts on the following conservation activities:

- Supporting an island wide population assessment of anoa and babirusa through trialling an established monitoring method in one priority site, and helping national and local government and NGO partners to replicate the methodology throughout the species' ranges in Sulawesi.
- Capacity building for awareness raising to conserve anoa and babirusa
- Support for confiscated and rescued anoa and babirusa in KSDA offices in Sulawesi

11.2 Planned Areas of Activities 2023-25

Population Monitoring

Accurate population estimates for anoa and babirusa are lacking, hindering conservation efforts. In 2022, the Action Indonesia GSMPs and PKBSI worked to develop relationships and plans to establish a long-term population monitoring programme in at least one protected area of Sulawesi.

The GSMP aims to work with partners to establish long-term population monitoring in at least one protected area of Sulawesi. Following consultations with *in situ* practitioners in Sulawesi, the Action Indonesia GSMPs aim to support a monitoring project for anoa and babirusa in the Faruhumpenai Nature reserve in South Sulawesi. This area has been identified as a priority site for anoa and babirusa populations.

We have developed a partnership with Faculty of Forestry, Universitas Hasanuddin (UNHAS) and BBKSDA South Sulawesi to conduct a camera-trap study in 2023 - 2024. The study will follow occupancy modelling methodology, developed and recommended as best practice by Wildlife Conservation Society Indonesia for the similar study in Bogani Nani Wartabone National Park (Hunowu et al., 2020; Johnson et al., 2020), using systematic random sampling with checkered-board pattern. This comparable study will provide valuable information on their population distribution, and will lay the groundwork for island-wide assessments and improved protection.

In 2023-2025, the GSMP will:

- Support park wide population data for Cagar Alam Faruhumpenai using occupancy modelling by 2024
- Support the setup of a network & activities of interested stakeholders across the range of Anoa and Babirusa through holding at least one annual information sharing call / workshop between parks and NGOs to compare monitoring methods
- Facilitate capacity building in agreed monitoring method where requested in the species range

Education/awareness raising in local communities

Anoa and babirusa face threats from human activities, such as habitat loss and hunting for the wildlife trade. See the Education Working Group's masterplan section (**s**ection 9**)** for their plans to better understand and begin to engage in tackling those threats with other stakeholders. Key activities in this phase will include:

- Research and gap analysis of customs, beliefs, attitudes and capabilities that may be underlying threats for each species to inform education activities
- Engaging with National parks in Sulawesi to share education strategies and resources

- Scoping visits to relevant sites in Sulawesi to build relationships and identify opportunities.

Support for confiscated and rescued anoa and babirusa in KSDA offices in Sulawesi

The GSMP will also work with KSDA offices to provide additional skills sharing in animal rescue and immediate health care (working with the Husbandry Training Working Group, see section 8). This is to address the issue that confiscated anoa and babirusa are held by KSDA offices, while their staff have limited skills in animal husbandry and care. In the last phase, the GSMP supported facility assessments of centres holding confiscated anoa and babirusa. These will be completed in person or through questionnaire in this phase, alongside the following activities:

- Provide a final report including recommendations for an island-wide process and structure to manage confiscated anoa and babirusa to achieve maximum conservation benefit.
- Supporting KKH's development of Standard Operating Procedures (SOP) to decide next steps for confiscated/rescued anoa and babirusa.
- Support the Husbandry Working Group in providing 1-2 training workshops for rescue office staff on husbandry and transportation of confiscated animals.

Key measures of success for this phase include

- Successful park wide population data of at least one survey at one site in Sulawesi
- Development of a network of parks and NGOs including at least one annual call to update on monitoring status
- Identification and support of population monitoring in other sites in Sulawesi.
- By end 2025, research informed recommendations are embedded into GSMP education campaigns and activities.

12. Fundraising and Communications

12.1 General Approach to Fundraising

The aim is to achieve the funding needs to implement activities as described for each WG in this document. This includes support for core costs, such as salaries for PKBSI GSMP coordination staff, as well as specific activities, such as a camera trapping study or a husbandry workshop.

In the past four years there has been a good level of funding raised to support many activities. As each area of work increases in this third phase, there is a need for larger funding. For example as we continue developing the population monitoring for banteng, anoa and babirusa using camera-trapping, the funding required for this increases. To date the zoological community has been the major source of funding. We plan for this to increase further as well as expanding to other funding opportunities to meet the increasing funding needs.

The process for raising and distributing funds is as follows. Annually funding needs are identified by each WG or coordination team (PKBSI and AWCSG staff) and proposed to the Fundraising WG. The Fundraising WG develops an annual funding needs document to share with potential supporters, covering these needs. Its then the group's role to secure funds for these needs before they are required for the activity. For funding that is received as unrestricted, the WG leaders review any proposed allocation of these funds by the Fundraising WG.

We are very grateful to all supporters of the Action Indonesia GSMPs. We hope that you will continue to provide your generous support for Phase 3.

12.2 Summary of Fundraising in Phase 2: 2018-2022

From 2018-2022 the annual funding received for the ungulate GSMPs increased from the previous phase of the GSMPs. This was an impressive achievement considering the covid pandemic impacted zoos income and security, meaning a number were unable to continue they support. This is summarized in Table 12.1, with the majority of funding received from AZA and EAZA zoos.

Table 12.1. Summary of funds received from regional zoo associations from 2018 to 2022

Region	2018 Funds	2019 Funds	2020 Funds	2021 Funds	2022 Funds
EAZA	£35,870.04	£6,690	£14,127	£4,841	£25,700
AZA	£20,529	£14,800	£9,216	£44,350*	£6870

Region	2018 Funds	2019 Funds	2020 Funds	2021 Funds	2022 Funds
PKBSI	£2970 (2)	£2544 (2)	**	**	£2640 (2)**

*includes AZA grant of £14,007
** Yonathan's salary contribution covered by PKBSI

In kind support has been provided, such as the cost of commercial lab and data analysis for genetic analysis thanks to Copenhagen Zoo and Queen Mary's University London.

This funding has allowed us to implement more training activities than in the previous phase. We have also implemented some new projects, for example banteng camera trapping in Alas Purwo and genetic sampling of the ungulate species in PKBSI zoos, as well as contributions to part or salaries of two PKBSI-GSMP coordination staff. We have also secured funding in this phase to begin new activities in the coming year. These are camera trapping study for anoa and babirusa in Sulawesi and support for PKBSI-GSMP Coordinator to conduct an MSc. in animal welfare in the UK.

12.3 Summary of Communications in Phase 2: 2018-2022

To date, information about the GSMPs has been disseminated via a newsletter (1-2 annually) and annual report, which is distributed to all GSMP members and interested parties, as well as an annual webinar in 2021 and 2022. The work of the GSMPs from 2019-2022 has also been covered in the newsletters of WAZA and EAZA Publications have also included a Reverse the Red case study for action Indonesia, as well as an article reviewing the activities of the GSMP since 2016. The GSMP activities have been presented at regional conferences for PKBSI, SEAZA, EAZA, AZA and BIAZA. News and updates about the GSMPs are also shared via the AWCSG and Action Indonesia websites and social media accounts (Facebook, Instagram and Twitter). In 2022 the Action Indonesia Day posts and hashtag were seen by almost 4 million people. This shows that the GSMP is effective at communicating, with potential to grow even further.

12.4 Activities and Actions for phase 3: 2023 – 2025

These are the Activities that the Fundraising Working Group will progress in the coming three years:

1. Continuity and security of funding from zoos, eg through increasing zoo engagement and multi-year agreements, especially with institutions holding multiple species
2. Increase support from Sumatran tiger holders as this GSMP benefits from the core GSMP activities and there are more tiger focused activities planned. This can include ZAA and JAZA

3. Investigate alternative funding sources, eg regionally based grants in North American and Europe, international grants and corporate grants for higher cost activities
4. Investigate funding from a range of Indonesian sources with PKBSI
5. Develop communications materials and trial crowdfunding, by contributing to the efforts of the Education WG
6. Develop the expertise and networks of this Working Group to support implementing above Activities

The Actions required to achieve the above Activities are described in more detail below.

1. Continuity and security of funding from zoos (EAZA, AZA)

This is a continuation of the successful efforts in the past years, with improved relationship management to secure greater commitment from certain zoos.

- Give presentations at relevant TAG meetings at AZA mid-year meeting and EAZA annual conference annually
- Focus on development of multi-year agreements, especially with institutions holding multiple species, including technical and financial support
- Provide funding needs document to interested zoos annually
- One to one communication with regular donors by WG members at least annually
- One to one communication with one to three potential new regular donor by WG members annually
- Submit AZA SAFE application and proposals
- Develop link with other consortia eg C2S2

2. Increase support from Sumatran tiger holders

As the Sumatran tiger GSMP is now integrated with the ungulate GSMPs it makes sense to encourage support from institutions that hold Sumatran tigers, as much as the other species. This funding for *ex situ* activities only. There are already organized fundraising efforts for *in situ* Sumatran tiger conservation, so one of the first steps is to define how fundraising for *ex situ* activities by the GSMP aligns with these existing efforts.

- Engage with current fundraising initiatives that support *in situ* work, led by EAZA and AZA networks to ensure aligned and non-competing approach to fundraising
- Give updates to Felid TAG of AZA mid-year meeting and EAZA Felid TAG meeting at annual conference annually
- Provide funding needs document to interested zoos annually
- Promote Sumatran tiger GSMP funding needs to ZAA and JAZA

3. **Investigate alternative funding sources (non-zoo)**

To diversify funding sources, as well as support higher cost activities a wider range of funding will be required.

- Investigate regionally based grants in North American and Europe, international grants and corporate grants for higher cost activities
- Working with Working Group leaders produce scaled packages of work, that will be attractive to the donor audiences

4. **Increase support from Indonesian sources with PKBSI**

Securing the financial future of these conservation efforts in Indonesia is essential to the transition of ownership at the national level. Working with PKBSI this will be advanced in these three years. It is appropriate to remain aware of the on-going consequences some zoos face from loss of earnings from closures due to covid in the past three years.

- Engage PKBSI office and Board in discussion of fundraising for GSMP activities
- Training workshop on fundraising for Indonesian zoo directors (fundraising + cooperative breeding).

5. **Develop communications materials and trial crowdfunding, by contributing to the efforts of the Education WG**

The Education WG has made considerable progress in raising awareness. There is an opportunity to build on this to increase funding support through crowdfunding. A JustGiving platform has been set up for incidental donations.

- Develop stronger link to Education WG, possibly through membership of both groups
- Contribute to fundraising aspect of Action Indonesia Day, working with Education WG
- Contribute to promotional materials for crowdfunding to target the specific audiences and social media with Education WG

6. **Develop the expertise and networks of this Working Group**

The network and experience of this WG to date has successfully led to a focus on securing funding from zoos. Adding members to this group that have different fundraising experience will increase opportunities for securing funding from a more diverse range of donors.

- GSMP Conveners, International Studbook keepers, and regional coordinators are engaged and join the group and utilize their networks to raise funds
- At least one individual with professional fundraising experience joins the group and engages to support fundraising with different audiences eg individual / foundation / corporate donor management experience

- One individual becomes a member or advisor to the group and actively gives input regarding fundraising in Indonesia
- Maintain database of potential donors/ grants / corporates linked to cattle, Indonesia, conservation/activities in range areas
- Increase administration support for this group from one zoo supporter
- Manage the process for managing funds described above – engaging WG leaders to define needs, and producing funding needs document, as well as tracking funds needed and secured

13. Monitoring and Evaluation

13.1 Monitoring and Evaluation Process 2023-2025

As the activities of the Action Indonesia GSMPs increase in both scope and number, there is a greater need for effective monitoring and evaluation to ensure their effectiveness. In order to do this, we will continue to use a Theory of Change based approach to guide our strategic progress towards our aims. The description of the Theory of Change process can be found in the previous Masterplan. During the Masterplanning process for the 2023-2025 activities, each Working Group reviewed and updated their Theory of Change Diagrams that applied to their activities (Figures 13a-c).

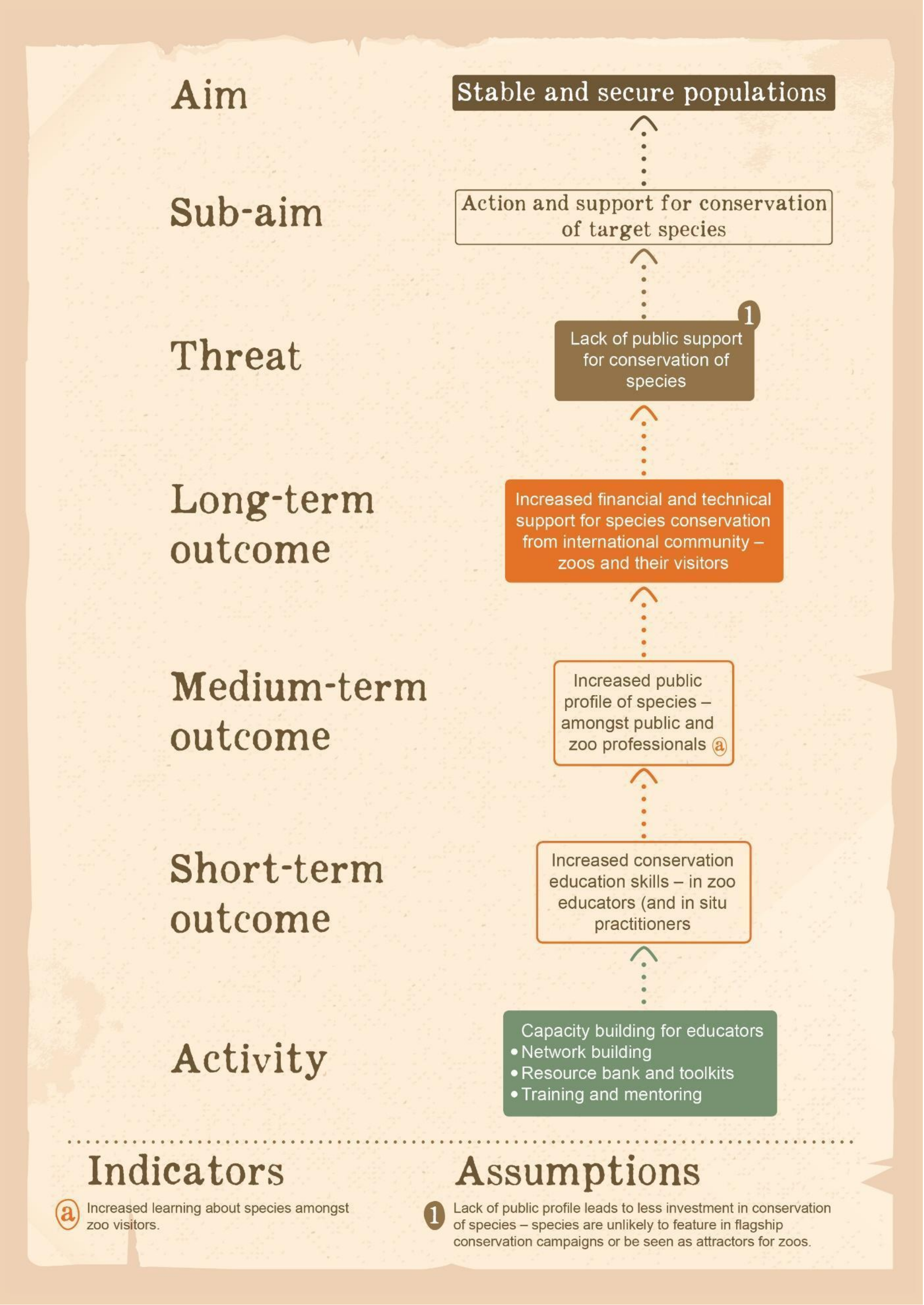
Each Working Group will monitor the progress of their own activities through the indicators and measurements of success as described in each masterplan chapter. In addition, quarterly Working Group leader calls will provide the opportunity to share and monitor each Working Groups progress in their stated activities. During the Masterplanning process each Working Group developed Action Tables, which reflect in more detail the activities described in this document. All working groups will update their Action Tables prior to the quarterly Working Group leader calls.

13.2 Theories of Change

Theory of Change is a model that helps to ensure that all **activities** contribute to the **outcomes** and overall **goals** that a programme is trying to achieve. This works by starting with the overall **goals** of the programme, and then working backwards to identify the **outcomes** that must be in place for these goals to be achieved. In these models, we have identified short-term outcomes which may happen immediately after an activity (for example, someone participating in education activities learning something new about babirusa), as well as medium and long-term outcomes that may happen later (for example changing a behaviour that was negative for banteng populations). The **activities** and **approaches** that can be best used to achieve these outcomes can then be identified. **Indicators** are the measurable factors that will be used to monitor and evaluate the success of the identified actions. Also included here are **assumptions**; these are the conditions or resources that are needed to achieve the outcomes and goals but are already in place and are not believed to be problematic.

Each Theory of Change covers all of the Action Indonesia ungulate GSMP species as well as Sumatran tiger where possible, and all three are linked by the overarching aim.

13.3 Theory of Change – Key



***Note to WAZA: Theory of Change images are currently being updated by a graphic designer and will be added to the document when complete.**

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Appendices:

Appendix 1: Partner logos

Thanks to all the Action Indonesia GSMP partners and supporters

Appendix 2: 5.1: Export filters

For regional analysis the following filters were used in ZIMS for Studbooks

- PKBSI: Geographic filter "INDONESIA"
- EAZA:
  - Europe: Geographic filter "EUROPE"
  - Singapore: Geographic filter "SINGAPORE
- AZA: Geographic filter "NORTH AMERICA"

Date span: 1 Jan 1974 – 20 July 2022

Individuals excluded from genetic analysis

The following individuals were excluded from the genetic analysis because it is believed they will never be able to breed (again) for the following reasons:

Stbk Number	Location	Reason for exclusion
T68	PASURUAN	Presumed post-reproductive
T69	SURABAYA	Presumed post-reproductive
T72	SURABAYA	Presumed post-reproductive
T74	SURABAYA	Presumed post-reproductive
T112	SURABAYA	Presumed post-reproductive
T154	BOGOR	Presumed post-reproductive
T162	GIANYAR	Presumed post-reproductive
T199	GIANYAR	Presumed post-reproductive
500	BERLIN TP	Presumed post-reproductive

T90	NY BRONX	Presumed post-reproductive
T91	NY BRONX	Presumed post-reproductive
T106	NY BRONX	Porcine preputial diverticulitis
T42	SINGAPORE	Presumed post-reproductive
T99	SINGAPORE	Presumed post-reproductive

Appendix 3: 5.2 ZIMS for Studbooks overlay

The following assumptions were made to deal with the pedigree gaps in the international studbook.

Global/Regional Association	World Association of Zoos and Aquariums (WAZA) / WAZA
Studbook Name	Babirusa (Babyrousa babyrussa) EEP, ISB
Overlay Name	Analytical overlay from 2021 studbook_CD
Date of Export	Jan 30, 2023

Studbook ID	Record Type	Field	Master	Overlay
Hypothetical 6	Transaction	Event Type		Birth/Hatch (Captive Birth/Hatch)
		Date		~from Jan 01, 1988 to Dec 31, 1988
		Location		SURABAYA
		Local ID		HYP106
	Transaction	Date		~from Jan 01, 1996 to Dec 31, 1996
		Location		SURABAYA
		Local ID		HYP106
	Parent	Sire		MULT5 (WILD1 (50%) WILD2 (50%))
		Dam		MULT7 (WILD6 (33%) WILD4 (33%) WILD5 (33%))
	Sex	Sex		Male
		Date		~from Jan 01, 1988 to Dec 31, 1988
Hypothetical 7	Transaction	Event Type		Birth/Hatch (Captive Birth/Hatch)
		Date		~from Jan 01, 1988 to Dec 31, 1988
		Location		SURABAYA
		Local ID		HYP107
	Transaction	Date		~from Jan 01, 1996 to Dec 31, 1996
		Location		SURABAYA
		Local ID		HYP107
	Parent	Sire		MULT5 (WILD1 (50%) WILD2 (50%))
		Dam		MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
	Sex	Sex		Female
		Date		~from Jan 01, 1988 to Dec 31, 1988
Hypothetical 8	Transaction	Event Type		Birth/Hatch (Captive Birth/Hatch)
		Date		~from Jan 01, 1995 to Dec 31, 1995
		Location		SURABAYA
		Local ID		HYP108
	Transaction	Date		~from Jan 01, 2002 to Dec 31, 2002
		Location		SURABAYA
		Local ID		HYP108
	Parent	Sire		Hypothetical 6 (100%)
		Dam		Hypothetical 7 (100%)
	Sex	Sex		Female
		Date		~from Jan 01, 1995 to Dec 31, 1995
1	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))

2	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD5 (33%) WILD4 (33%) WILD6 (33%))
5	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
6	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
7	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
8	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
15	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
16	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
47	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
48	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
49	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
50	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
208	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
209	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
210	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
211	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
212	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))

213	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
214	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
215	Parent	Sire	UND (100%)	MULT5 (WILD1 (50%) WILD2 (50%))
		Dam	UND (100%)	MULT7 (WILD4 (33%) WILD5 (33%) WILD6 (33%))
322	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
324	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
325	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
327	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
329	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
330	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
333	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
340	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
		Dam	UND (100%)	Hypothetical 7 (100%)
341	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
361	Parent	Sire	UND (100%)	Hypothetical 6 (100%)
T46	Parent	Dam	UND (100%)	Hypothetical 8 (100%)
T201	Parent	Sire	UND (100%)	MULT8 (T64 (80%) T200 (20%))
		Dam	UND (100%)	MULT9 (T77 (20%) T79 (60%) T199 (20%))
T426	Parent	Sire	T201 (100%)	MULT10 (T160 (10%) T157 (20%) T158 (20%) T161 (10%) T201 (40%))

Appendix 4: 6.1.Individuals removed from genetic analysis

The following individuals were excluded from the genetic analysis as they are permanent non-breeders. Male 1546 (FT WAYNE) is neutered; the rest are post-reproductive females.

PKBSI		EAZA		AZA		JAZA		ZAA	
SB#	Location	SB#	Location	SB#	Location	SB#	Location	SB#	Location
1191	BANDUNG	1197	LISBON	1210	HONOLULU	1327	KOCHI	1154	HAMILTON
1226	SURABAYA	1243	SHEPRETH	1284	ATLANTA	1328	TOKYOUENO	1294	BEERWAH
1227	SURABAYA	1279	BRNO	1314	LOUISVILL				
1266	JAKARTA	1280	YARMOUTH	1335	DALLAS				
1269	JAMBI ZOO	1286	HEADCORN	1336	DALLAS				
1272	UNGARAN	1299	ROTTERDAM	1338	WACO				
1290	LEMBAHHIJ	1300	FONTAINE	1372	TORONTO				
1343	JAKARTA	1301	ARDHEM	1546	FT WAYNE				
1347	BATUSECRE	1302	BOISSIERE						
1348	JAKARTA	1326	HEADCORN						
1352	JAKARTA	1339	NESLES						
1354	JAKARTA	1365	BEWDLEY						
1355	JAKARTA								
1526	BOGOR								
1527	BOGOR								
1804	YOGYAKART								
1847	CIKEMBUL								
1848	MEDAN								