# The Sumatran Rhinoceros: What Went Wrong and How to Move Forward

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John Payne, Karen K. Dixon, Sukianto Lusli, Zainal Zahari Zainuddin, Mochamad Indrawan, K. Yoganand, Kees Rookmaaker, Nan E. Schaffer, Ahmad Zafir Abdul Wahab, Petra Kretzschmar, Rasmus Worsøe Havmøller, and Muhammad Agil

**Abstract**

From the 1960s, flawed conservation strategies that failed to address the lack of successful reproduction as the root cause of the species decline accelerated the Sumatran rhino's downward spiral through the extinction vortex.

The factors that undermined Sumatran rhino conservation—and continue to this day—are rooted in the complex interplay of human psychology, group dynamics and institutional power set against a backdrop of the "sustainable development" paradigm, and fundamental shift of attention away from endangered species recovery.

In what little time remains to prevent the first mammal genus extinction in the twenty-first century the Government of Indonesia must provide adequate resources at the national, provincial and local levels to support capture of the last remaining wild individuals, natural breeding in managed facilities, application of assisted reproductive technologies (ART), bio-banking and the implementation of the metapopulation management-based recovery plans developed by Indonesian experts to ensure that every remaining Sumatran rhino is positioned to contribute to the survival of the species.

*It would be very depressing to lose the Sumatran rhino. It would be a wake-up call, and it would be something to literally weep over.*
—E. O. Wilson

## Introduction

The extent of natural forest in Southeast Asia was still vast when the Sumatran rhino had become critically endangered a century ago. The twentieth century was the period during which the extinction trajectory of *Dicerorhinus sumatrensis*

J. Payne (✉)
Borneo Rhino Alliance (BORA), c/o Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia

N. E. Schaffer
Borneo Rhino Alliance (BORA), c/o Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia

SOS Rhino, Kansas, MO, USA

K. K. Dixon
SOS Rhino, Kansas, MO, USA

S. Lusli
Habitat Restoration and Enhancement at PT. Kelola Habitat Indonesia, Jakarta, Indonesia

Z. Z. Zainuddin
Borneo Rhino Alliance (BORA), Kota Kinabalu, Malaysia

M. Indrawan
Institute for Sustainable Earth and Resources, Universitas Indonesia (I-SER UI), Depok, Indonesia

K. Yoganand
WWF-Greater Mekong, Vientiane, Lao PDR

K. Rookmaaker
Rhino Resource Center (www.rhinoresourcecenter.com), UK, Utrecht, The Netherlands

A. Z. A. Wahab
The Habitat Foundation, Penang, Malaysia

P. Kretzschmar
Leibniz Institute for Zoo and Wildlife Research, Berlin, Germany

R. W. Havmøller
Department of Zoology, Natural History Museum of Denmark, University of Copenhagen, Copenhagen, Denmark

M. Agil
Division of Reproduction and Obstetrics, School of Veterinary Medicine and Biomedical Sciences, IPB University, Bogor, Indonesia



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might have been halted and reversed, but that did not happen. The inability of humans in the last quarter of the twentieth century to critically assess field data and collaboratively determine appropriate science-based conservation strategies in order to avert extinction of the Sumatran rhinoceros is the underlying cause of the dire status of the species today. The Sumatran rhino story holds lessons for many parties, not least the IUCN and its SSC specialist groups.

The unremitting focus on trying to reduce Sumatran rhino deaths (i.e. to reduce poaching and illegal trade) rather than to address the more fundamental issues of not enough fertile Sumatran rhinos in any one place, and insufficient births, is the most significant reason for this species current status of being "nearly extinct" (Payne & Yoganand, 2017).

Why did this happen? The answer is largely to do with human emotions and cognitive biases, to which we are all captive to some degree. In the case of the Sumatran rhino, amongst the many biases that led to failure were shifting baseline (assuming wrongly that many small, scattered clusters of rhinos was normal) and not realising that constant repetition of the "habitat loss and poaching" slogan over many decades by mainstream NGOs, IUCN and the media (confirmation and availability biases) eclipsed the fundamental issues.

The systems in place, both within governments and internationally, were frequently not fit for purpose. From the early 1980s, there were always a few people—including some working in mainstream organisations—able and willing to do what was necessary (create and manage an international metapopulation, with inevitable failures and setbacks from time to time) but they experienced push-back from the system in which they were forced to operate.

Allowing small groups of passionate, experienced and competent people to self-organise and decide what to do based on objective analysis can give species like the Sumatran rhino a better chance of success. This is difficult under prevailing national and international institutions, but not impossible if the institutional structures support the small number of people with real expertise, and cease relying on stakeholders, committees and slogans.

With very targeted interventions in the next few years, there remains a small prospect that the total extinction of the Sumatran rhino can be prevented. But all parties must develop the same understanding and be willing to work collaboratively if we want to stop *Dicerorhinus* becoming the first large mammal genus to go extinct in the twenty-first century.

## Historical Overview

In prehistoric times the Sumatran rhinoceros (*Dicerorhinus sumatrensis*) was the Southeast Asian rhino, extending in distribution from what are now north-eastern India and southern China through much of mainland Southeast Asia to the equatorial islands of Borneo and Sumatra. (Rookmaaker, 2006; Antoine, 2012; von Seth et al., 2021; Payne, 2022).

It is clear that over the past few thousands of years, the species' range declined very markedly, through successive local extinctions, in a roughly north to southwards direction. This was undoubtedly a result of a combination of human population expansion, loss of the most optimal habitats, and demand over several millennia for rhino products within China. By a millennium ago, the Sumatran rhino was extinct throughout China and the demand for rhino horn was increasingly satisfied by trade between China and settlements to the south, on mainland Asia and the islands of Borneo and Sumatra. Starting in the eighteenth century, as even those regions also lost their Sumatran rhino populations, China started importing rhino horn from Africa (Lander & Brunson, 2018).

The Sumatran rhino's long, slow path towards extinction has been well documented. In fact, reports detailing the species' endangered situation have been published in every decade since 1880. By a century ago, the last scattered remnant clusters of Sumatran rhinos were in regions which combined extensive closed-canopy forests and very small, sparse human populations—namely in Sumatra, Borneo and the Malay peninsula, extending northwards through the Tenasserim hills range. Anyone compiling information available on the Sumatran rhinoceros in the 1920s would have been able to see that the species existed in fragmented clusters, with a patchy distribution, and everywhere with small and declining population densities (Harper, 1945; Rookmaaker, 1977; van Strien, 1974).

Theodore Hubback, first a hunter and later a fierce activist for wildlife during British Colonial rule of Malaysia, wrote extensively about his pursuit and conquest of big game in the Malay Peninsula. In his 1912 chronicle, Hubback describes his unsuccessful hunt for rhinos in an area where his guide had seen fresh tracks and "quantities of wallows" just a few years prior in 1908 (Hubback, 1912). By 1926, Hubback concluded that "*Rhinoceros sumatrensis* will disappear except in the more remote mountain ranges, but will be in such small numbers that they will have difficulty in holding their own. The *Rhinoceros sumatrensis* has been terribly persecuted by poachers during the last two or three decades and in many remote districts which used to be their haunts they have disappeared" (Hubback, 1926). Reports of the species' status in Borneo and Burma were equally bleak. A 1931 report of the rhinos' status in Borneo also references its "persecution" and notes that "it must be evident that such a slow breeding animal cannot stand destruction for long at this rate" (Banks, 1931). Writing in 1933, E. H. Peacock (quoted in Harper, 1945) stated: "In the days before the advent of fire-arms the Sumatran rhinoceros must have been fairly common throughout Burma … has been so heavily poached within the past twenty years that there are now vast stretches

of suitable evergreen forest from which it has been completely exterminated." That same year, *The Illustrated London News* published W. P. Pycraft's *A Plea for the Rhinoceros*, on 17 June 1933, and included a photo with the following caption: "A Most Interesting Animal Which Has Now Become Almost Extinct: The Sumatran rhinoceros, the Smallest and Most Hairy of the Family" (Pycraft, 1933).

By the mid-1930s, trade in Sumatran rhinoceros was prohibited by the Dutch authorities in Indonesia, even export to Dutch scientific institutions, as the species was feared to be on the verge of extinction (Minarchek, 2018). Captain Guy Dollman included the Sumatran rhino in his 1937 report detailing recently extinct mammals and mammals on verge of extinction throughout the British Empire and noted that the Sumatran was "getting rarer every day and soon will have disappeared from many of its favourite haunts" (Dollman, 1937). Hubback's 1939 monograph, *The Asiatic Two-Horned Rhinoceros*, which provided detailed information about the species' ecology and daily activities, noted that it was "being exterminated throughout most of its range". and identified the lack of successful reproduction as an additional root cause of the species decline:

> *Dicerorhinus sumatrensis* is on the threshold of a position that will inevitably cause it to disappear. I do not suggest that the last of its race will necessarily die a violent death but, due to disturbance and lack of proper facilities to enable them to exist under congenial and natural conditions, they will not breed. The *sumatrensis* is, I believe, a long-lived species, and as such there will be for many years a solitary one or two left in remote places. To save them from complete extinction, the only hope that remains for the rhinoceros in Malaya and I think in Burma, is to constitute inviolable sanctuaries in their own habitat where a suitable environment is known to exist. (Hubback, 1939)

By the late 1940s, the perilous state of the remaining isolated and scattered Sumatran rhinos had garnered international attention through Francis Harper's *Extinct and Vanishing Mammals of the Old World* (1945) and the 1946 publication of a letter to the Editor of The Times (London) from Tom Harrisson, after whom the Bornean subspecies *Dicerorhinus sumatrensis harrissoni* is named (Rookmaaker, 1977). Harrisson described the species' precipitous decline on the island of Borneo: "At the beginning of this century large numbers of rhinoceros roamed the mountain areas in the interior of Sarawak, Dutch Borneo, and British North Borneo. [T]oday, the rhinoceros is almost extinct in Borneo, … I doubt if there can be more than a dozen rhinoceros left alive, and several of these are single" (Harrisson, 1946).

Within a year of its founding in 1948, the International Union for the Protection of Nature (predecessor to the IUCN) established the Survival Service Commission (now the Species Survival Commission, hereinafter the "SSC" or "Commission") to assemble, evaluate and distribute information on all species of fauna and flora "that appear to be threatened with extinction, in order to assist governments and appropriate agencies in ensuring their survival." (Boyle, 1959). During the course of its inaugural 1949 meeting, the new Commission drew up its first "official list" and identified the Sumatran rhinoceros as one of 14 mammals and 13 birds "on whose behalf immediate and vigorous action was needed" if they were "to be saved from extinction" (Boyle, 1959; Fitter & Fitter, 1987). Between 1949 and 1954, the Commission attempted to collect information on its list of threatened species through literature reviews and correspondence, with limited success. Information was scarce or difficult to obtain about most of the rare animals, which "had retreated to the most remote corners of their former ranges" and the habitats of many listed species were directly impacted by active fighting during the Second World War and continued military actions or civil unrest during the early 1950s (Talbot, 1960).

When funding for a staff ecologist finally became available in 1954, the Commission engaged a young ecologist, Lee Talbot, to survey the status of the listed mammals in North Africa, the Middle East and Asia (Holdgate, 1999). Talbot's report, *A Look at Threatened Species*, detailed his 42,000 mile journey between April and October of 1955 through approximately 30 countries, including several within the Sumatran rhino's historic range: India, Thailand, Indonesia, Malaya, Burma, Cambodia and Vietnam. His report offered little hope for Sumatran rhinos located outside of Sumatra, because like Hubback, Talbot recognised that the wide dispersal of animals at such low densities would inhibit breeding:

> The fact that these individuals are so very widely separated would seem to seriously reduce their chances of reproduction. With so few rhinos, harassed as they are, the odds of one even encountering another would seem quite slight. The chances of this encounter coinciding with the biological periods for mating for both animals concerned are even more slight. (Talbot, 1960)

The successful breeding of the Indian rhinoceros (*Rhinoceros unicornis*) in 1956 and 1958 at the Basel Zoo in Switzerland demonstrated the critical role zoological gardens could play in preserving rare animals from extinction. Encouraged by this success, cooperative efforts between Indonesian officials and zoos in Denmark and Switzerland resulted in a plan to capture a few pairs of Sumatran rhinos and "try to make them breed in captivity in order to preserve the sumatrensis—at least in special national and zoological parks" (Skafte, 1964). With the aid and cooperation of the Indonesian military and Caltex Pacific Oil Company, the first expedition to capture rhinos from unprotected forest in the central Sumatra province of Riau commenced in 1959 (Skafte, 1964). During that summer, ten rhinos were captured: only one male (which managed to escape) and nine females. One female died shortly after capture (Skafte, 1964), the Bogor, Basel and Copenhagen zoos each received a single female rhino and the rest were released back into the forest. The

females sent to Bogor and Basel both died in 1961, the latter from "incurable anaemia" (Andersen, 1963). While "Subur", the female sent to Copenhagen waited for a male, the zoo's staff, perhaps unaware of the available literature, learned through trial and error about the Sumatran rhino's basic needs for shade, humidity, access to mud wallows, salt licks, a proper diet and an enclosure substrate other than sharp gravel for its soft feet (Andersen, 1963). A second expedition in 1960 to capture males from Riau was unsuccessful (Taman, 1961).

In 1963, based on recommendations stemming from "First World Conference on National Parks" convened by the IUCN the previous year, Oliver Milton sought and received permission from the Indonesian government to conduct surveys in Aceh, North Sumatra and central Sumatra for the purpose of identifying areas within the Sumatran rhinos' natural range *"into which individual animals can be moved to promote increased reproduction"* (Adams, 1962; Milton, 1964). Milton's 2-month survey in North Sumatra, which he described as "one of the few remaining areas in which these persecuted animals are to be found," represented Phase I of an IUCN/SSC sponsored study. Reports from local hunters indicated at least 20 rhinos were killed between 1942 and 1959, but that individuals still survived in nine different locations and were described as "frequent" in three of the nine. In Phase II of the study, Milton surveyed the area in central Sumatra where Skafte had successfully captured rhinos for the Copenhagen, Basel and Bogor zoos. Milton noted that his guide, who had accompanied Skafte 4 years earlier, "was at somewhat of a loss" when they found "that most of the former rhinoceros habitat—which he had known—had been completely denuded of forests" and rhinoceroses (Milton, 1963).

By 1964, the IUCN SSC had developed a classification scheme to characterise the now 204 mammals and 312 birds included in its *Preliminary List of Rare Mammals and Birds*. The Commission designated the Sumatran rhinoceros as a species of "special importance … giving cause for *very grave anxiety*" and assigned a Category 1 status: "[v]very rare and believed to be decreasing in numbers" based on the Commission's assessment that "100–170 exist in a few isolated localities in Burma, Malaya, Sumatra and North Borneo" (Scott, 1965 *emphasis in original*). The species' status was also documented by the World Wildlife Fund (WWF), established in 1961 to provide funding and expertise to prevent the extinction of endangered wildlife. The WWF's first report, *The Launching of a New Ark*, included both the Commission's 1964 List and an assessment of the species: "This small, hairy two-horned rhinoceros is probably the most acutely threatened large animal species in the world today." Echoing Hubback's analysis 25 years earlier, the report also proposed the establishment of "one or more special reserves where scattered animals can be brought together for release" (Hubback, 1939; Scott, 1965), an idea that once again failed to gain traction.

By 1980, all available literature showed that the species was on the very edge of extinction. By then the last hope for sustaining the species in the wild was on the island of Sumatra, where three breeding populations still existed as of 1985 (Nico van Strien pers. comm. to Francesco Nardelli).

The idea of preventing the extinction of the Sumatran rhinoceros by captive propagation through collaborative effort involving multiple institutions was raised seriously within wildlife professional circles, not by any international body, but in 1982 by Thomas Foose, conservation coordinator of the American Association of Zoological Parks and Aquariums (AAZPA, now AZA; Payne, 2022). Foose's 1982 unpublished paper, *In Pursuit of the Sumatran Rhino*, served as a preliminary proposal to the AAZPA Board. Foose presented the finalised paper, *Captive Propagation of the Sumatran Rhinoceros—A Proposal* to the AAZPA Annual Meeting in September 1983, and it was submitted to the range state authorities immediately thereafter (Foose, 1983). The proposal outlined the fundamental threat to species' survival based on estimates of the small size and fragmented distribution of remaining isolated populations:

> Numbers are precariously low and the decline continues inexorably. Both Borner (1979) and Flynn & Abdullah (1984) document the disappearance of rhinos from areas of former occurrence, even of moderate abundance, during the last ten years. One by one, the last remnants are being lost.
> Even where rhinos do and will survive in natural habitats, populations may be so small and fragmented as to be genetically unviable. Such populations tend to lose the genetic diversity vital to enable species to adapt to constantly changing environments. The gene pool becomes a collection of gene puddles. Population biologists have advised that a genetically effective population ($N_e$) of 500 may be necessary for long term survival of a species (Franklin 1980, Soule 1980). A number of population biologists believe even this number may be too few. Moreover, loss of genetic diversity and vitality is not the only problem. Small populations are vulnerable to extinction from other types of perturbations such as natural disasters, demographic stochasticity, etc.
>
> For the Asian two-horned rhino, there are several sanctuaries and populations that might be preservable in the wild because they are large enough to accommodate a genetically viable number of animals and because they can probably be protected from poachers and development (Borner 1979; Andau and Payne 1982; Flynn and Abdullah 1984; M. Kahn and N. Van Strien, personal communication). The five most probable places … are: Gunung Leuser and perhaps Kerinci/Seblat in Sumatra; Endau Rompin and Taman Negara in Western Malaysia; and the Silabukan Forest Reserve in Sabah.
> The other surviving rhinos are fragmentally distributed over the range of the species in remnants of usually one to five animals, frequently in areas with poor protection.
> These remnants cannot contribute to the survival of the species because:
>
> (1)The groups are too small to be viable genetically or even to permit reproduction.

(2)The animals cannot be protected from poachers or their habitats from development for purposes other than wildlife preservation. (Foose 1982)

Foose attempted to address anticipated pushback over such issues as the alternative approach of leaving the rhinos in the forest guarded by protection teams, the perceived need to keep the Sumatran and Bornean lines separate, and where any captured rhinos should be maintained. He also outlined the various pros and cons, including the options of translocation into a single wild habitat to boost numbers and genetic diversity, versus closely managed captive breeding, summarising in favour of the latter option:

> Although a few populations of Sumatran rhino can hopefully be preserved in the wild, it may still not be possible to maintain large enough numbers to insure long term survival…. In contrast, a captive program for the Sumatran rhino could provide significant advantages against these problems. Presumably, animals would be easier to protect from poachers. More importantly, a captive population could be managed to maximize its $N_e$ By carefully regulating the reproduction of rhinos (i.e. who mates with whom and how many offspring each animal produces in a lifetime) the $N_e$ of a captive population could actually be greater than the number of animals maintained. Finally, recent advances in reproductive technology (artificial insemination, embryo transplantation, gamete storage) could perhaps productively be applied to the Sumatran rhino. Research is already under way in the AAZPA on white, black and Indian rhinos. (Foose 1983)

There are relevant precedents to the option of applying captive breeding for effective population recovery. Three large herbivorous mammals were saved from extinction during the twentieth century by this means. After the last wild European bison (*Bison bonasus*) died in 1927, the species was bred up by a few dedicated citizens in several countries, from two founder groups of seven and 12 individuals that were still alive in zoos at that time. Progeny of these were reintroduced to suitable habitats and recovered to over 7000 individuals by the early 2000s (Pucek et al., 2004). The last wild takhi, or Przewalski's horse (*Equus przewalskii*), died around 1970. This wild horse taxon exists today due to zoos and privately owned parks in Europe. They bred the species from 12 individuals that had been captured as foals in 1902 by an animal trader supported by interested landowners. Now, there are several hundreds of individuals in the wild again, as well as over 1800 in zoos and privately owned parks (King et al., 2015). In addition, assisted reproductive technology has been used to enhance genetic diversity in the captive Przewalski's horse metapopulation. The first birth of this species by artificial insemination occurred in 2013, and the first from somatic cell nuclear transfer in 2020. The Arabian oryx (*Oryx leucoryx*) went extinct in the wild in 1972. A programme of captive propagation, which had been initiated a decade earlier with nine Arabian oryx, resulted in more than 200 offspring which were distributed to various zoos globally. Since 1982, they have been reintroduced in several countries, resulting in over 1000 in the wild and 6000–7000 in captivity (IUCN SSC Antelope Specialist Group, 2017).

What do these success stories have in common? Firstly, collaboration between small groups of people from different backgrounds and different nations, including from zoos and private landowners. Secondly, capture and translocation of animals between different nations. For all three species, after breeding in captive or privately owned conditions was underway, management of the animals as a metapopulation was done ad hoc, by the passionate people involved, in the absence of externally mandated plans. Most striking is the absence of both government bureaucracy and the application of restrictive rules to disrupt cross-border exchange, as well as a lack of involvement of conservation NGOs, of stakeholder consultation, and of plans drawn up by supervisory institutions.

In more recent times, the Californian condor (*Gymnogyps californianus*) and black-footed ferret (*Mustela nigripes*) have been saved from extinction by captive propagation, despite the strong objections of some detractors (Nielsen, 2006; USFWS, 2008). These cases were successful in large part because there was no need for either collaboration between more than one nation (all the animals were in one country, United States) or for advice from international institutions.

Prompted by Foose's AAZPA proposal, the IUCN Species Survival Commission (SSC) convened an "Ad Hoc meeting on Sumatran rhinoceros" in Singapore, 3–4 October 1984 (Scott, 1984). One of the co-authors of this chapter was present (J. Payne). The meeting was organised in a highly credible way, ably facilitated by Robert Scott, executive officer of the IUCN Species Survival Commission, with Ulysses Seal of the IUCN Captive Breeding Specialist Group taking the Minutes (Seal, 1984). Two representatives were present from each of Indonesia, Peninsular Malaysia and Sabah, along with four from US zoos (Los Angeles, San Diego, Cincinnati and Bronx); two from Howletts and Port Lympne Animal Parks in the UK, plus three from the Singapore Zoo, which hosted the meeting. Additional participants included Tom Foose; Nico van Strien (the only participant with extensive knowledge of the species in the wild) (van Strien, 1985); Tony Parkinson (a practitioner with experience trapping large mammals in tropical conditions); and Professor Rudolf Schenkel, chair of the IUCN Asian Rhino Specialist Group, whose philosophical but unrealistic arguments at the meeting were supported by cetacean taxonomist Dr Peter van Bree. All possible viewpoints were present within the minds of the 20 participants, and aired, with the intent to reach decisions on ways forward.

The stated Agenda of the meeting included the following "General Objectives":

1. Consider critically and comprehensively various possibilities, proposals, and problems for captive propagation of Sumatran rhino.
2. Attempt to formulate and hopefully finalise an acceptable plan for a captive propagation project as part of an overall strategy for conservation of the Sumatran rhino. Aspects to consider:
   (A). Relation of captive propagation to conservation of wild populations.
   (B). Criteria to identify animals as possible candidates for capture.
   (C). Specifics of number of animals to be captured and of where they are to be placed in captivity (S.E. Asia, North America, United Kingdom).
3. Develop coordination and oversight through some IUCN SSC committee for implementation of any plan or plans approved (Seal, 1984).

Schenkel intervened, requesting an agenda with a much bigger philosophical perspective. Robert Scott responded that "the SSC position is that it will not endorse any proposals unless they are part of a coordinated approach to the conservation of the species." Schenkel made it clear that he was against any form of capture and managed reproduction, stating: "Every species is the result of evolution. This evolutionary process is co-evolution of the species together with all the components forming the ecosystem as a self-regulating system. Isolated from the ecosystem the species loses the functional connections which have shaped it and loses its meaning and 'dignity'".

As the only attendee with field experience observing Sumatran rhinos in their natural environment, Nico van Strien was a key expert at the meeting. His field study in Gunung Leuer National Park between (1975–1980) indicated that the core area of rhino distribution in the upper Mamas valley (Borner, 1979) still held at least several tens of Sumatran rhinos with a good breeding rate. Unfortunately, this finding provided false hope that there might be similar sites elsewhere and that protection from poaching might allow a recovery in numbers in sites with even fewer rhinos. In fact, it is now evident that van Strien's study area contained the only remaining cluster of Sumatran rhinos that was potentially viable at that time. Indeed, as of 2024, it is the only one that still exists, only now as a smaller cluster. Occasional reports in social media of rhino births in van Strien's study area have continued to provide false hope that the population is rebounding. Numbers can still decline overall, even if births still occur. Indeed, all of the other Sumatran rhino clusters that existed in 1984 are now entirely or functionally extinct (Havmøller et al., 2015), although many showed reproduction before they disappeared.

The possibility of capturing Sumatran rhinos from "protected areas" (Parks and Wildlife Reserves) for captive breeding was not raised explicitly at the 1984 meeting—because everyone present already knew that this was not up for negotiation. Foose presented the framework and rationale for a global captive breeding programme in London at the 1982 International Union of Zoological Gardens (IUDZG) Symposium. The symposium attendees, which included the IUCN SSC Chairman and members of the Asian and African Rhino Specialist Groups, generally supported the captive breeding concept with the caveat that, "only animals outside the main sanctuaries and protected areas be considered candidates for the captive programs" (Foose, 1983). Looking back now, we can see a common human cognitive bias: for the management of a critically endangered mammal, whether or not those mammals live in a "protected area" is often irrelevant. Indeed, wild animals are "quite indifferent to boundary lines, marked or unmarked" (Hislop, 1961). The boundaries of those areas are usually based on what was possible at the time of their establishment in the context of human society, and does not necessarily bear any relevance to whether or not the habitat will be adequate to allow the recovery of a depleted cluster of a particular species. We should not assume that all sections of vast protected forest areas can support Sumatran rhinos, and it is safer to assume that only small parts of protected areas provide adequate nutrition to sustain a viable wild Sumatran rhino population (Payne, 2022).

There were two particularly problematic disagreements raised during the 1984 meeting. One was whether captured rhinos should stay in their country of origin. The Peninsular Malaysian representatives argued that all rhinos captured in Peninsular Malaysia should remain and be managed there, a view that seemed at the time to some participants to be unnecessarily restrictive. Sabah was open to having some rhinos be moved out of the State in exchange for expertise and funding after the first two pairs had been captured but, after a change in State Government in 1985, an ongoing process to cement an agreement between the government and the US zoos was cancelled (Payne, 2022). The view that Sumatran rhinos should stay in Malaysia or Indonesia later proved to be correct when it became apparent that the diets provided in late twentieth century temperate climate zoos were unsuitable for the Sumatran rhino. It also became apparent to many observers that the US zoos with Sumatran rhinos from Sumatra were treating them more as exhibition animals than as members of a managed metapopulation. But the fundamental disagreement during the 1984 meeting was even more profound—over capture or no capture. After 2 days of discussion, agreement was reached to capture animals to form a global captive metapopulation. The main principle in the agreement, however, was that "Animals selected for capture in the wild are to be 'doomed' individuals or come from 'doomed' populations or habitats; that is, those whose future long-term viability or contribution to the survival of the species is determined to be unsatisfactory as

measured by objective criteria subject to continuing refinement". That decision was probably the only possible outcome of the meeting. The definition of the term "doomed" was never subsequently refined.

The 1984 Singapore meeting was absolutely a landmark, from several angles. It marked a very different viewpoint from that seen from the late nineteenth century up to the 1960s, where belief in captive breeding and involvement of zoos and other non-governmental players seemed self-evidently necessary. The 1984 meeting most notably exposed and helped to cement a sharp dichotomy in the wildlife conservation world that seems to be firmly in place today. The dichotomy in thinking is: either create "protected areas", leave animals in the wild, list the species as "totally protected" in wildlife legislation, establish field teams and projects to reduce poaching and illegal trade, promote "awareness', and hope for the best; or, devise and implement a programme to create gene flow between wild and captive populations in order to maximise reproduction.

Unfortunately, in 1984, the adjective "doomed" had been applied to the wrong noun. Whereas individual rhinos to be labelled as doomed were not the only ones in that predicament, the entire programme was doomed because many promising breeding animals would be left in the forest, while a high proportion of captured rhinos were too old, injured or infertile to be able to contribute their genetic material without human intervention and access to assisted reproductive technology. In Singapore in 1984, with meeting participants generally jubilant that an agreement in principle had been reached, this key point was not understood. Apart from the cluster in Nico van Strien's study area (Van Strien, 1985), all clusters are now gone or non-viable. The non-viability of small clusters of rhinos, initially expressed correctly as a matter of fact by Foose, became symptomatically evident in 2001, when the extreme loss of reproductive viability was confirmed in the wild (Bosi et al., 2001; Schaffer et al., 2020).

Between 1984 and 1994, 40 Sumatran rhinos were captured, nominally as part of the 1984 IUCN-endorsed programme, from Sumatra, Peninsular Malaysia and Sabah (Borneo), with the individuals going to at least eight facilities in the range states, the United states and the UK (Rookmaaker, 2019). Although all of the rhinos could have been justifiably categorised as "doomed" under the 1984 meeting's definition, no rhinos were captured from the protected areas containing reproductively viable animals.

## Reproductive Problems in Wild and Captive Populations

Loss of reproductive fitness affected the captive breeding programme from its inception. The first sign of reproductive problems in wild female Sumatran rhinos appeared in 1986, when "Subur" (Studbook #10), one of the first females captured from Sumatra, died 4 months later. Necropsy revealed a tumour in her uterus, which was a slow growing type of tumour that had surely started developing before she entered captivity. Necropsy results also noted that both ovaries were dormant, suggesting that she had never been pregnant. (Furley, 1987).

The early investigation of reproductive problems in the Sumatran rhino through ultrasonography between 1991 and 1994 revealed uterine cysts and tumours in three out of four females captured from isolated populations in Peninsular Malaysia (Schaffer et al., 1994). By 1999, Schaffer et al. (2001) had documented ubiquitous signs of severe tumour growth in several females. The initial data on these reproductive problems was presented at the 1999 meeting of the IUCN SSC Asian Rhino Specialist Group and the data book was distributed to AsRSG members (Schaffer, 1999). Also noted at the meeting was recurrent abortions by a female at the Cincinnati Zoo. The 2001 postmortem examination of a poached wild female in Sabah found evidence of severe uterine cysts and tumours, which would have prevented pregnancy (Bosi et al., 2001; Payne, 2022). Schaffer warned that such prevalent severe pathology along with repeated abortion was compromising breeding and that there was evidence that it was happening in the wild. One young captive female in Indonesia developed cysts and a tumour shortly after reaching maturity. The last two isolated females caught in Sabah, Malaysia, both had extensive reproductive pathology.

Schaffer et al. (2020) collated data from the 1990s forward to illustrate the extent of reproductive problems in female Sumatran rhinoceroses captured or born into captivity between 1986 and 2018, which numbered 32 (Fig. 12.1). Of these, 25 females had records addressing reproduction. Out of the 25 records, only three females were without reproductive aberration. Of these three, one was pregnant when captured and delivered an offspring in captivity, the other two had normal reproductive tracts on postmortem. Evidence of compromised animals occurred in both Indonesia and Malaysia. The picture was clear: well over half of all adult female Sumatran rhinos had problems that precluded or compromised reproduction. In addition, researchers at the Leibniz Institute for Zoo and Wildlife Research (IZW) provided supporting evidence that the condition occurs in other species of rhino in captivity when females fail to become pregnant (Hermes et al., 2006, 2014). Reproductive disorders, along with ovarian exhaustion, can render female rhinos irreversibly infertile earlier in their reproductive life-span (Hermes et al., 2004).

Of the 41 Sumatran rhinos captured for the captive breeding programme between April of 1984 and November 1995, only one relatively young pair (Emi and Ipuh), brought together at the Cincinnati Zoo, mated and eventually produced offspring, but only as a result of human intervention

and intensive management. Between 1997 and 2000, Emi suffered at least five miscarriages. At the Asian Rhino Specialist Group meeting in February, 1999 Schaffer suggested that altrenogest—an orally administered synthetic progesterone-like hormone—might be an effective treatment to prevent abortion in the Sumatran rhino based on a successful protocol developed for a Black rhino with a similar history of miscarriage (Schaffer et al., 1995; Khan et al., 1999).

Once administered, the altrenogest treatment proved successful and in September of 2001, Emi finally brought a pregnancy to term and delivered Andalas at Cincinnati Zoo under the supervision of Steve Romo and Terri Roth. Although Emi was able to carry her final two pregnancies to term without altrenogest (female Suci in 2004 and male Harapan in 2007), every Sumatran rhino female that has produced offspring in captivity (Emi, Ratu, Rosa & Delilah) has needed a synthetic progesterone like altrenogest to maintain their first pregnancy and stop the cycle of abortion (Muhammad Agil, pers. comm. May 2024).

Despite the high occurrence of reproductive problems (pathology, miscarriage, lack of pregnancy) in both the Indonesian and Malaysian captive populations, reproductive problems were never included on the agendas of the IUCN SSC Asian Rhino Specialist Group meetings and never mentioned in reports. Despite the serious reproductive problems compromising the captive breeding programme in both countries, concerns expressed about infertility or pathology were summarily dismissed as a "Malaysian problem".

With so few rhinos remaining and the potential for reproductive issues so high, the production capability of each animal must be accelerated through assisted reproductive techniques (ART). Many cell and gamete collection techniques have been attempted, providing some source material. Ovum pick-up was used to collect oocytes for ICSI (intracytoplasmic sperm injection) from females in Sabah, Malaysia for the first time in 2014 (Fig. 12.1). ICSI is an in vitro fertilisation technique used when the number of available gametes is very small, and assistance is needed to ensure that a good quality sperm enters the egg cell. Subsequently in

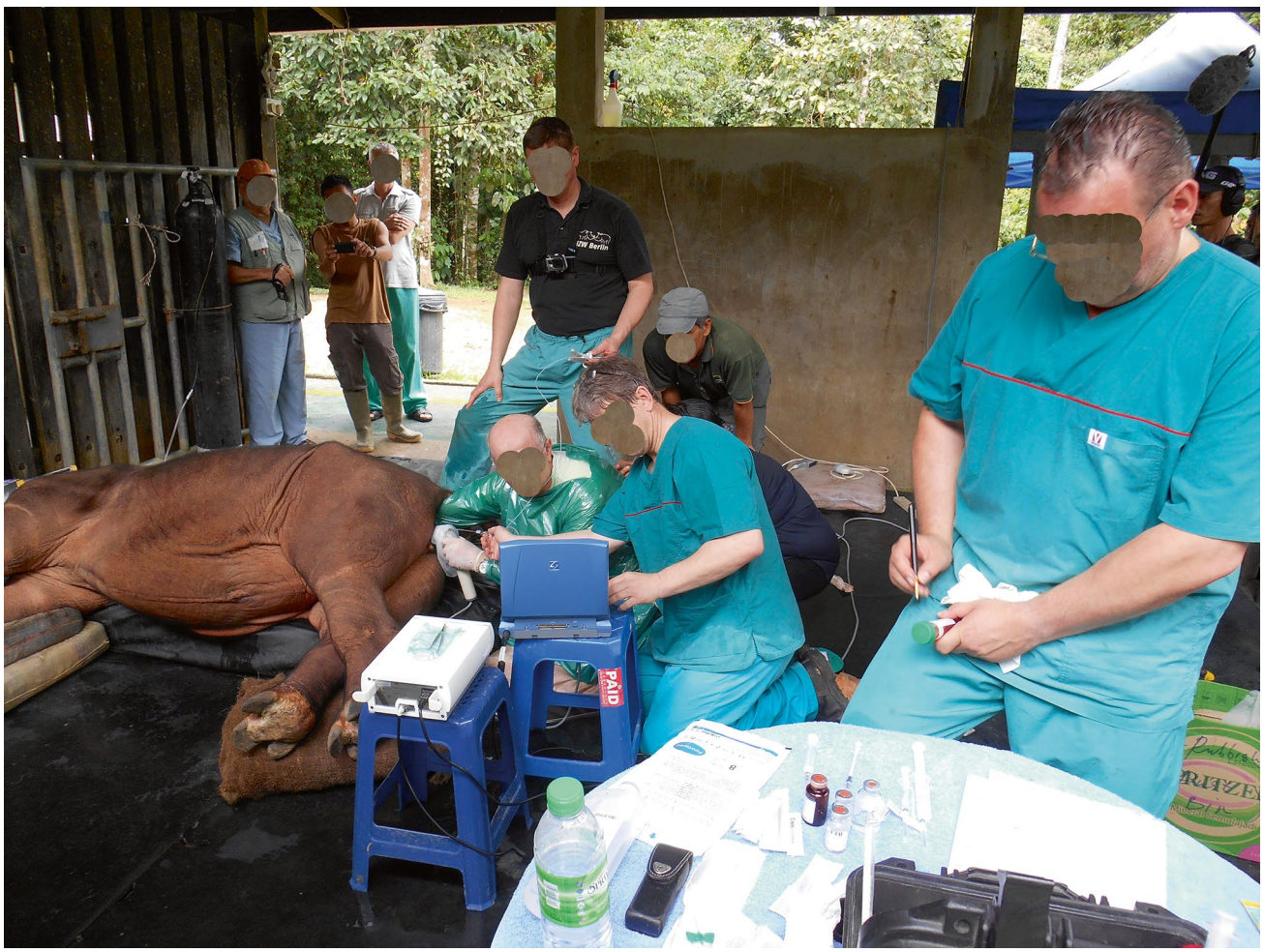


**Fig. 12.1** First harvest of egg cells from Iman under general anesthesia by Professor Cesare Galli and the IZW team. (Photo by John Payne)

2015, IZW partnered with Cesare Galli of Avantea, Italy and Arief Boediono of IPB University in Bogor, Indonesia, to harvest gametes from Sumatran rhinos in Sabah for in vitro fertilisation attempts using ICSI (Galli et al., 2016; Hildebrandt et al., 2021; Fig. 12.1). None of the attempts resulted in embryos.

## Biological Hurdles and Unaddressed Ecological Needs

In addition to reproductive problems, several biological aspects of the Sumatran rhino have not been adequately recognised or addressed in the many forums on this species held in recent decades. But the following hurdles could have been addressed and overcome (even in the United States) if attention to species' basic requirements which were well documented by the late 1980s had been applied.

### Nutrition

The preferred food plants of Sumatran rhinos tend to be species of forest edge and canopy gaps, suggesting that extensive closed-canopy forest might not be optimum habitat for the Sumatran rhino (Candra et al., 2016; Payne, 2022). Even the natural diet of the Sumatran rhino may lack adequate sodium and phosphorus (van Strien, 1985; Dierenfeld et al., 2006). Payne (2022) also notes that horse pellets had to be fed daily to maintain captive Sumatran rhinos in good condition in Sabah, even with an otherwise optimum array of food plants offered. All observers of this species over the past century noted the close correlation of the presence of Sumatran rhino breeding clusters with natural concentrated mineral sources, a type of resource that is patchy, localised and absent from most areas. This suggests that Sumatran rhino food plants in many areas of seemingly suitable habitat may lack some essential minerals, implying that regions lacking such mineral sources cannot support Sumatran rhino breeding populations.

The Sumatran rhino's dietary needs and feeding behaviour were documented and understood long before animals began entering captivity in the mid-1980s. (Hubback, 1939; Hislop, 1968; Kurt, 1973; Borner, 1979; Van Strien, 1985). However, the diet of captive rhinos in several zoo facilities was often limited to fruits and vegetables (2–5 kg), various hays and livestock concentrate pellets (~1–3 kg). The majority of animals fed this type of diet died within a few years of entering captivity, many with signs of iron storage disease (Paglia & Tsu, 2012) as reflected in pathology reports in 1992 and again in 1995 (Schaffer, 1999). In 1994, at the insistence of the Head Keeper, Steve Romo, the Cincinnati Zoo introduced fresh browse into the diets of the last three Sumatran rhinos still alive in the United States. The animals responded immediately and began to flourish, marking the crucial start of the breeding programme in western zoos. Browse was the primary food source of in-country sanctuaries (Zainuddin et al., 1990). A natural diet that is rich in fibre and tannins is essential, especially given the tendency of this species to suffer poor health and early death from iron storage disease. Accordingly, breeding facilities for Sumatran rhinos must be located in Indonesia or Malaysia where a variety of browse is readily available (Candra et al., 2012).

### Environment

Individual Sumatran rhinos living in lowland tropical forests (Fig. 12.2) wallow in liquid mud daily, for several hours during the hottest hours of the day, in large part to reduce heat stress, which on hotter-than-average days approaches "severe" level for large herbivores (Hardwick et al., 2015; Moran, 2005). When captive animals began developing cataracts in open facilities, it became clear that Sumatran rhinos spend very little time in open canopy and in direct sunlight (Kretzschmar et al., 2009). Whether humid equatorial rainforest is an ideal habitat for sustaining reproducing populations of *Dicerorhinus* is an issue that can no longer be investigated because the remaining rhinos are too few and too remote.

### Ecology

Protected areas do not necessarily represent sufficient habitat for the Sumatran rhino. These areas may be large in extent (e.g. the National Parks Bukit Barisan Selatan in Indonesia and Taman Negara in Malaysia) but, for the reasons outlined above, not necessarily adequate in quality in relation to nutrition. The locations and size of protected areas tend to be where, by coincidence rather than any ecological vision, a few Sumatran rhinos remained by the twentieth century, and where setting aside of the land for wildlife was socially and politically possible due the low potential of that land for human settlement or agriculture. In other words, it cannot be assumed that any 'protected area' set aside for Sumatran rhinos is adequate to sustain a viable breeding population.

### Husbandry

Capture of the last remaining wild Sumatran rhinos and translocation from remote forest sites to managed, fenced facilities represent major challenges Fig. 12.3). But then other sorts of challenges emerge. The Sumatran rhino is a particularly difficult species to propagate under human man-

**Fig. 12.2** A Sumatran rhino called Tam, after emerging from his mud wallow in his daytime forest paddock, Tabin Wildlife Reserve, Sabah, Malaysia (Borneo). (Photo by Azrie Alliamat, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah)

agement. The low reproductive viability of females interfered with the initial development of husbandry protocols. Captive Sumatran rhinos must be maintained in separate enclosures (Fig. 12.4), to prevent violent clashes on the 95% of days when the female is not receptive to males (Zainuddin et al., 1990, 2005). Females presenting with irregular cycling made guessing the appropriate timing a risky endeavour. The severe wounds occurring from inappropriately timed introductions led to considerable hesitancy to put pairs together. Edwin Bosi (1996) addressed these concerns by developing standard protocols to ensure safe and successful introductions between pairs.

## Allee Effect

The solitary nature of the Sumatran rhino exacerbates a tendency for the Allee effect (e.g. Stephens & Sutherland, 1999; Courchamp et al., 2008), also known as depensation, to drive its extinction. The simplest definition of this effect is: "a positive correlation between population density and individual reproductive fitness". When reduced to very low densities, some populations experience disproportionately reduced rates of reproduction. Recovery from low densities may be significantly delayed or not occur at all.

## International Support for in situ Protection

A decade after the 1984 meeting and the capture of 40 Sumatran rhinos, two "red flags" should have been evident: (1) mounting evidence of widespread reproductive problems in the species; and (2) the declining numbers of wild rhinos. Thoughtful discussions surrounding the first point, linking reproductive problems in captivity with overall fitness and the high likelihood that similar reproductive problems were affecting the small, isolated wild populations, were again dismissed and downplayed. The reaction to the second was markedly different and represented a peculiar phenomenon of the 1990s, whereby progressively overestimated—instead of lower—numbers of Sumatran rhino were reported at consecutive international meetings on the species, even though

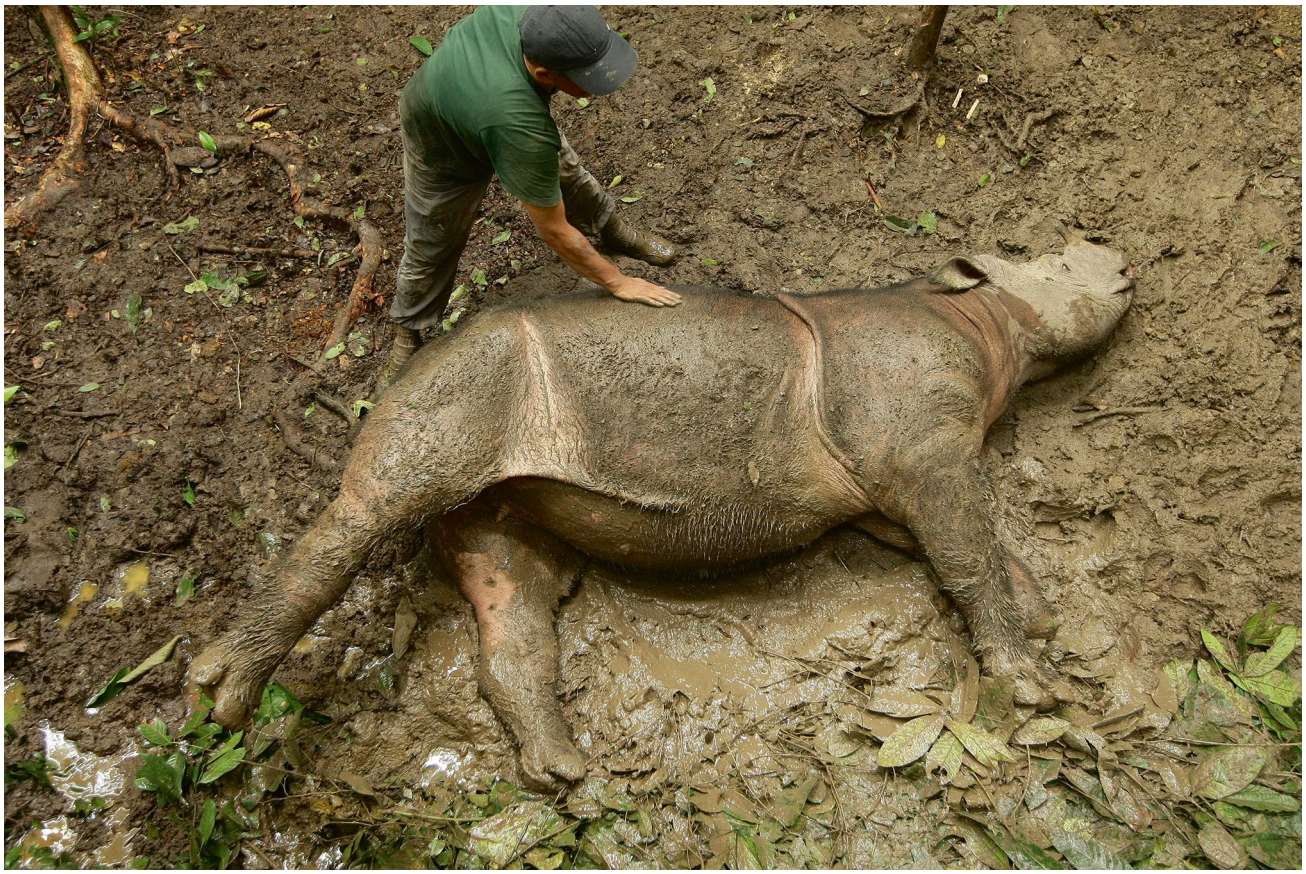

**Fig. 12.3** Puntung with veterinarian Dr Zainal Zahari Zainuddin, a day after her capture in 2011, the last wild rhino in Tabin Wildlife Reserve, Sabah, Malaysia (Borneo). (Photo by Azrie Alliamat, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah)

the numbers were simply guesses, and not data from robust analysis (e.g. Zainuddin, 1995).

From 1995, the mood in governments, donors and civil society turned towards formation of 'rhino protection units' (RPU), a politically safer option which would be seen by the public to be protecting wild rhinos, even though almost all of the protected rhino clusters continued to shrink and disappear. The switch to funding for RPUs and abandonment of the insurance provided by captive propagation efforts was a debilitating feature of a Global Environment Facility (GEF) project that commenced in 1995.

The GEF project was entitled "Indonesia and Malaysia Conservation Strategies for Rhinos in Southeast Asia". The GEF/UNDP funding allocation was US$2 million, with additional inputs from governments stated as US$588,700 from Indonesia and US$1,058,000 from Malaysia. The project document (UNDP, 1994) states that the justification for intervention was the declining numbers of Sumatran and Javan rhinos. Although the idea of initiating a single programme was excellent, the very first sentence of the 73-page document ("Rhinoceros serve as a flagship and umbrella species for the preservation of the ecosystems which they inhabit") revealed a project not truly designed to prevent the extinction of the Sumatran rhinoceros. Instead, the overall objective was stated as: "To enhance the conservation of biodiversity in Indonesia and Malaysia by providing technical training, operational support, and a long-term funding strategy to improve the effectiveness, sustainability and benefits (to local, national, and global human communities) of protection and management programmes for the Southeast Asian rhinoceros". Additional elements were "to enhance the capabilities of conservation agencies to arrest and reverse the decline of rhinoceros due to poacher activity and habitat disturbance" and "to develop more involvement by local communities". These stated objectives meant that there could be no review or definition of what was needed to recover the Sumatran rhinoceros. Had the project allowed for this, there would have been a realisation that the existing information from wild rhinos revealed nothing of value to the species' management. Captive propagation was glaringly absent from the GEF project. However, the project did provide money and governmental endorsement as an incentive to keep teams in the forests, seeking rhinos, irrespective of the numbers or reproductive viability of those rhinos. This narrow approach, focussing on benefits to human communities, capacity building and reducing poaching, instead of management of rhinos

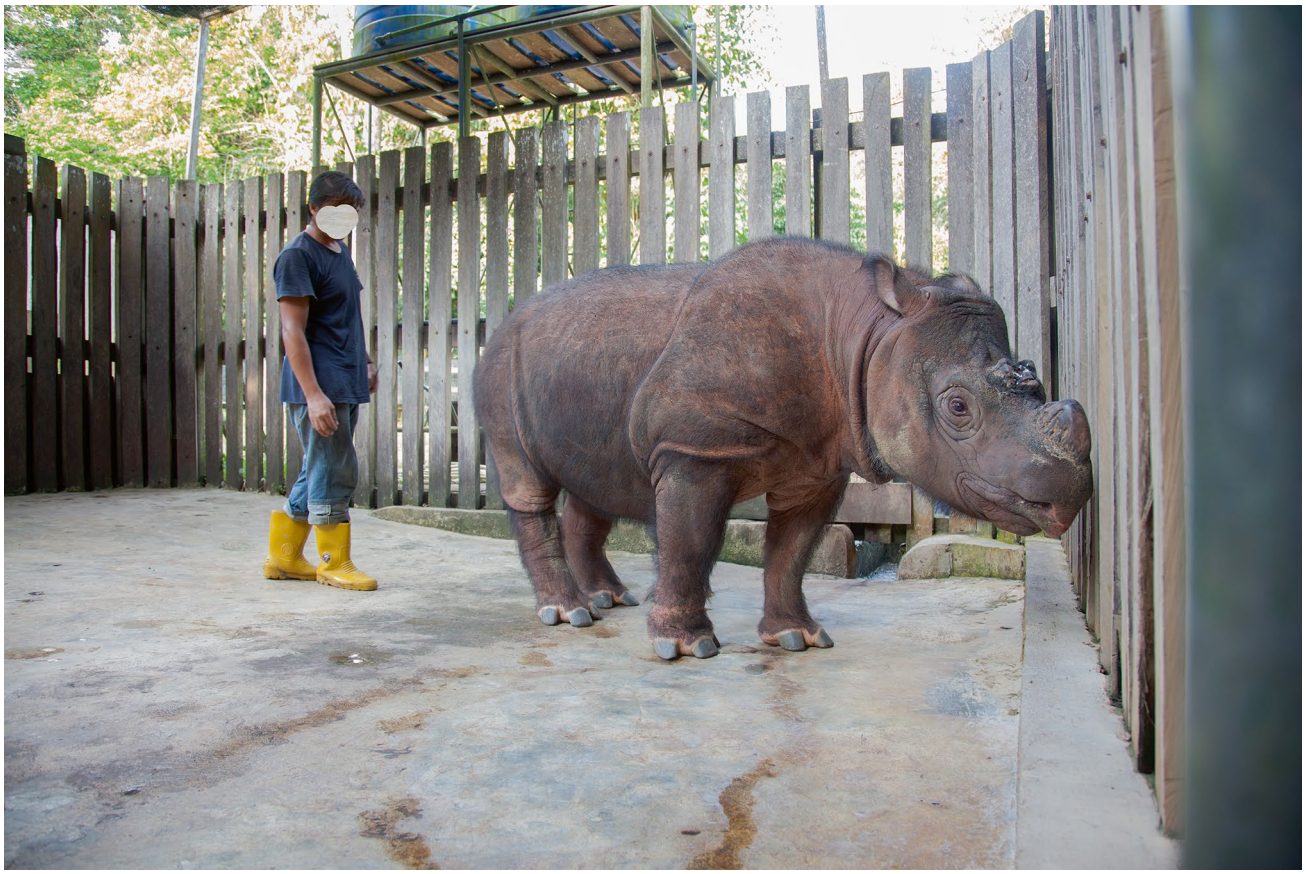

**Fig. 12.4** The male Sumatran rhino, Tam, in his night stall in Tabin Wildlife Reserve, Sabah. (Photo by Rasmus Worsøe Havmøller)

as a metapopulation to increase rhino numbers, became perennially attractive in South-east Asia thereafter, not only for Sumatran rhino but for other large, rare mammal species in general. In some cases, this has been of great value, for example in removing snare traps from the forest. In some cases, however, there emerged valid concern that the approach merely serves to monitor the inevitable extinction process while providing jobs. In fact, no form of collaboration or global cooperation between Indonesia, Peninsular Malaysia and Sabah as a result of the GEF Project ever materialised. No strong party, whether individual, scientific, institutional or collaborative, emerged to push continuously and persistently for captive breeding. When the project ended in 1998, little had changed since 1984, other than that there were far fewer Sumatran rhinos alive (although the optimistic guesses provided in reports falsely suggested otherwise), and there was better knowledge of Sumatran rhino reproduction (knowledge that was not adequately understood or appreciated except by a few veterinarians). The misguided belief that the species could be saved solely by protecting rhinos in the wild had become even more embedded than in 1984.

Respected field biologist Alan Rabinowitz published a paper (1995) arguing strongly and explicitly against captive propagation and for enhanced in situ protection of wild rhinos. Despite noting in his unpublished 1992 report that a recent survey in Danum Valley, Sabah, found evidence of only four to seven rhinos (Rabinowitz, 1992), he did not use these figures in public domain. Instead, he stated in his published paper that there might be 13–23 rhinos in the greater Danum area, which included areas adjacent to Danum Valley. His reasoning did not address the problem of the Allee effect on this and other small clusters of wild rhinos. In taking a stand that Sumatran rhinos should stay in the wild, the fact that no information existed on the reproductive status of those wild rhinos was ignored. Written responses to Rabinowitz in the following months in 1995 by AAZPA, SSC Asian Rhino Specialist Group, Government of Indonesia and Government of Sabah, published as letters in the journal *Conservation Biology* (Volume 9(5), pages 977–981), had a defensive tone, and instead of providing a robust counter argument in favour of expanding captive breeding and assisted reproductive technology, they sought to demonstrate a need for multiple approaches. Given that

the captive breeding programme up to 1995 had failed to yield a single birth, those responses were not surprising. Proponents of captive breeding failed to counter-argue that reproductive fitness was the key issue or that insufficient young fertile rhinos had been made available for the captive programme. Thus, no strong alternative view was presented in response to Rabinowitz, either in peer-reviewed journals or submissions to the relevant governments. There was also an explicit and dubious assumption raised in Rabinowitz's polemic that there is a certain limited amount of money available for either protecting wild animals or managing the same animals in captivity, and choosing one will deprive the other, a fallacious argument that is still heard today in relation to most critically endangered species. The paper caused consternation in Malaysia and Indonesia, putting government officers who favoured captive propagation into an awkward position, and subsequently no more rhinos were captured, until the unplanned captures of female rhinos Rosa and Ratu in Sumatra in 2005 and male Tam in Sabah in 2008 (Fig. 12.2).

By 1998, some were using the lack of success in captive breeding as reason enough to end the program. In the light of strong support from governments and international conservation institutions alike for the approach adopted under the GEF project, even Tom Foose was drawn into emphasising in situ protection. In 1998, along with Nico van Strien, he wrote, "Under the conditions that have prevailed in Indonesia and Malaysia over the last five years, Rhino Protection Units (RPUs) appeared to be the best method to effectively protect tropical forest rhinos." However, despite the setbacks and mounting pressure to abandon captive breeding as an integral part of Sumatran rhino conservation, both Foose and van Strien supported the establishment of the 100 hectare fenced, closely managed Sumatran Rhino Sanctuary in Way Kambas National Park, Sumatra, which was completed in 1998. The Sanctuary consists of adjacent fenced paddocks under forest cover. Without that, interest in and funding for the species would have waned entirely. The unplanned and fortuitous capture of two unrelated young female Sumatran rhinos (Ratu and Rosa) in southern Sumatra in 2005, and their placement in the Sumatran Rhino Sanctuary, brought new hope for preventing the species extinction, which eventually resulted in the first births of Sumatran rhinos in managed, captive facilities in Indonesia (Figs. 12.5 and 12.6). Nevertheless, in the absence of strong support for captive breeding by the IUCN or mainstream NGOs, the opportunity to bring additional Sumatran rhinos into at Way Kambas was not seized and transformed into government policy. Whether or not the key people involved continued to believe that unmanaged small clusters were viable, or they were tired of arguing, is difficult to judge now. What was and is clear, however, is that the regrettable choice to leave Sumatran rhinos in isolated fragments of forest is—for risk-averse mainstream human institutions—a simple, albeit ineffective, option that will be free of public controversy.

## 2013 Sumatran Rhino Crisis Summit

In early 2013, K. Yoganand of WWF-Malaysia scoured all existing literature on wild Sumatran rhinos and collated information from experts in the known Sumatran rhino sites, concluding that almost all the numbers presented in available reports were unreliable guesses, since no information could be gleaned to back up any of the numbers quoted, and that there were likely fewer than one hundred Sumatran rhinos in existence. This conclusion was the stark finding of the Sumatran Rhino Crisis Summit, hosted by Wildlife Reserves Singapore, from 31 March to 4 April 2013. Originally conceived in Sabah in 2012 as a gathering to draw the attention of advisers and decision-makers to the dire status of the Sumatran rhino, and secure buy-in from international parties and Government of Indonesia, the Summit was instead subsumed into an ongoing IUCN process of international meetings on Asian rhinos in general. Thus, the original idea of using the terms "crisis" and "summit" were lost by the time the crisis summit was held. One hundred and nine global experts and interested parties participated, including representatives of the species' range governments at national ministerial and implementation levels, NGOs, veterinarians, rhino researchers, zoos, African rhino specialists, people who had been involved in successfully preventing the extinction of the Californian condor and black-footed ferret by captive breeding, the US Department of State and various interested individuals.

At the heart of the Summit—which involved the most informed collection of range state and international experts on Sumatran rhinoceros ever assembled in one place at one time—were population viability assessments (PVAs; Gerber & González-Suárez, 2010) prepared by modelers Caroline Lees and Andrea Putnam of the IUCN SSC Conservation Breeding Specialist Group. The analysis by Lees for wild Sumatran rhinos indicated that to have high confidence of population survival, there would need to be at least 20 fertile individuals in one area, a roughly even sex ratio and with production of one calf every 4 years by every female (Lees, 2013). It was known to all Sumatran rhino specialists present that, with the possible exception of Nico van Strien's 1970s study site in Aceh, no such population existed, either then or during the previous five decades. Paired with the wild rhino assessment, Putnam's model of a captive population (Putnam, 2013) provided an even bleaker picture:

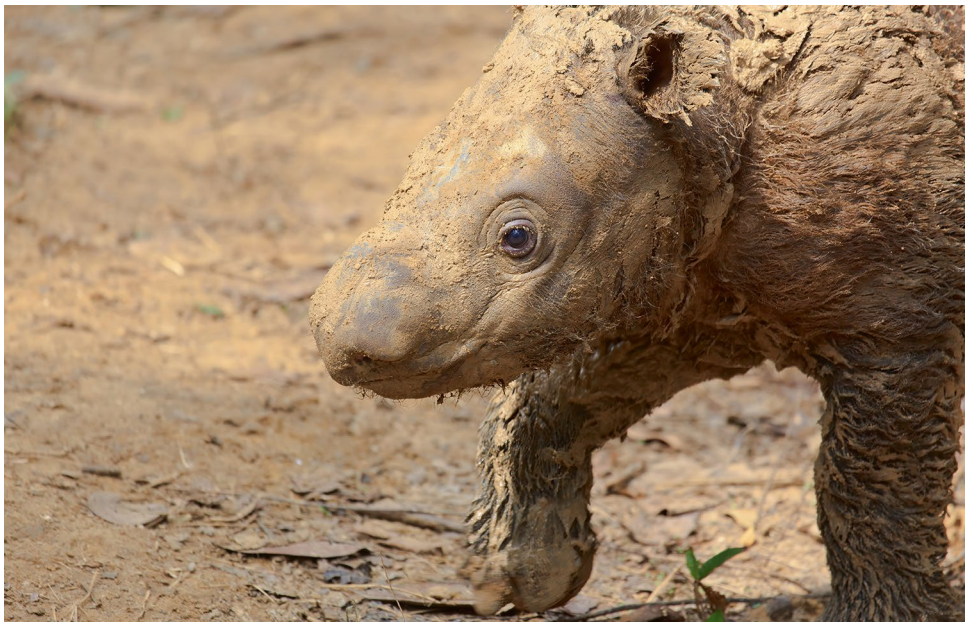

**Fig. 12.5** Juvenile Sumatran rhinoceros in the Sumatran Rhino Sanctuary, Way Kambas National Park, Indonesia. (Photo by Rasmus Worsøe Havmøller)

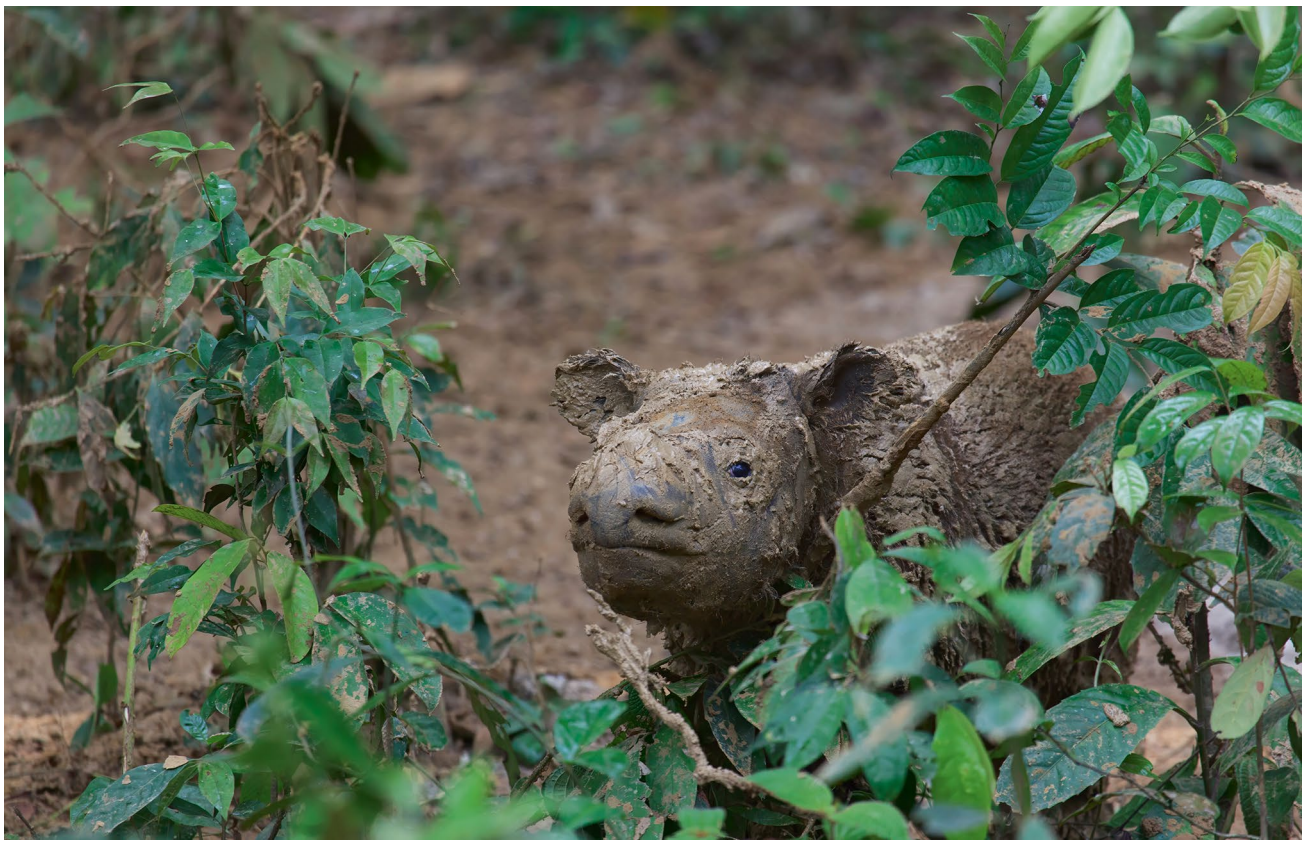

**Fig. 12.6** Juvenile Sumatran rhinoceros in the Sumatran Rhino Sanctuary, Way Kambas National Park. (Photo by Rasmus Worsøe Havmøller)

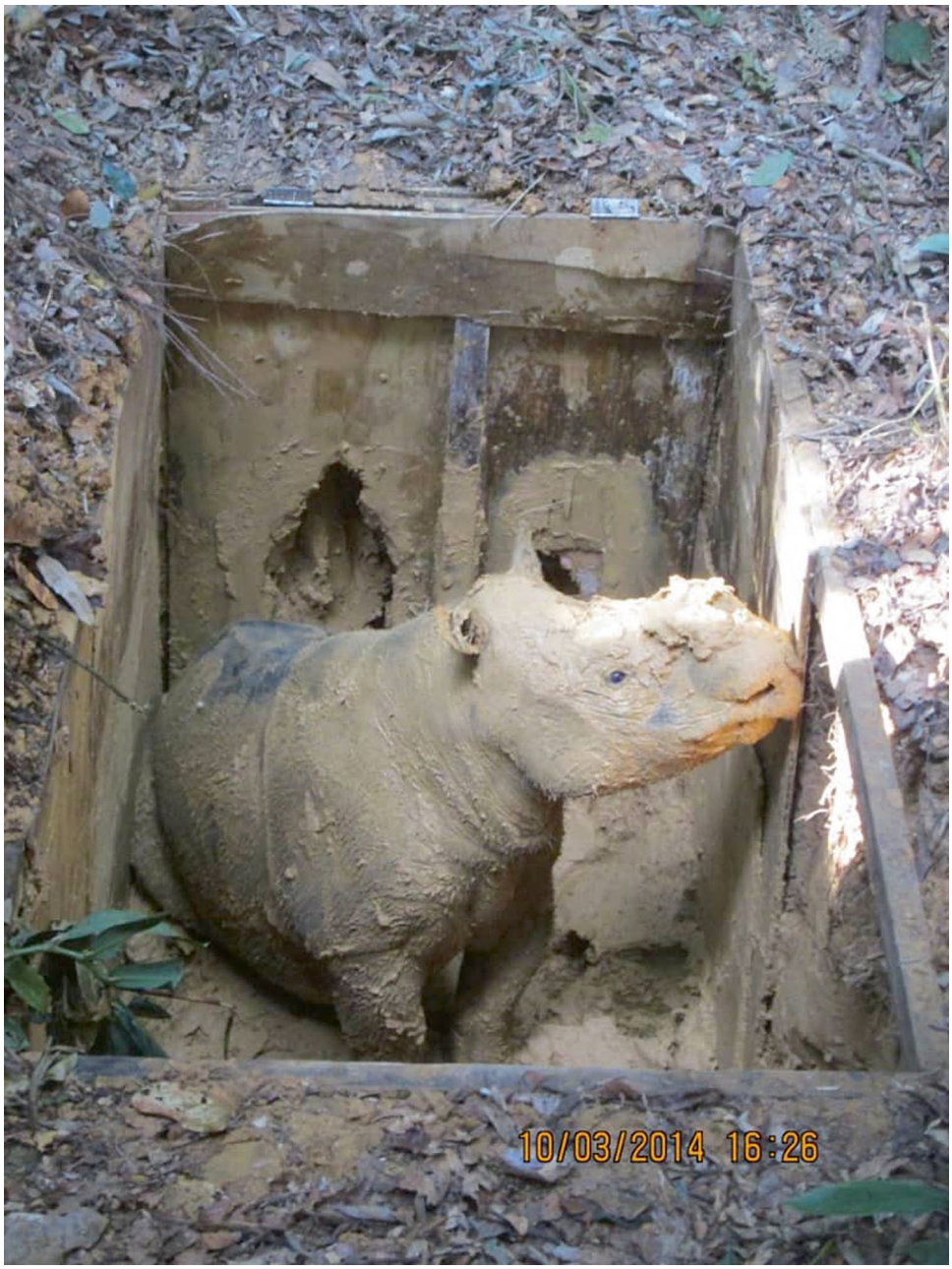


**Fig. 12.7** Iman just after her capture in Danum Valley, Sabah, Malaysia, and still in the pit. (Photo by Rasaman Jaya)

> Given the reproductive problems seen in the current captive Sumatran rhinoceros population, there is an 85%-98% probability that the captive population will go extinct in 50 years if no additional wild-caught [fertile] animals are brought into captivity.
> To reduce the captive population's extinction probability below 10%, approximately 16 adult wild-caught [fertile] rhinoceros need to be transferred into captivity and either be managed globally, or as 2 populations with an interbirth interval of 3 years (i.e. no fertility problems).
> Reproductive problems are currently the most significant impediment to captive population growth.
> ***
> In order to maintain a captive population that is able to regularly transfer rhinoceros back into the wild 15 years from now, 24 animals need to be brought into captivity within the next 10 years to grow the captive population to a sufficient size without risk of extinction (Putnam 2013).

The implication of this assessment is clear, and forms the basis for the only possible way forward to prevent the extinction of the Sumatran rhino—namely, to capture fertile wild rhinos (Fig. 12.7), wherever they may be located, in the hope that at least 16 could be found. Yet the recommendations contained within this assessment have never been endorsed or promoted by IUCN or any major international conservation NGO, and they were not implemented.

## Challenges Following the Summit

Two macro-level conclusions could be made after the 2013 Crisis Summit: one, the more people present in the meeting, the less likely that a useable consensus can be reached; and two, arranging a meeting as a part of an ongoing process (in this case, IUCN Asian rhinos) does not necessarily lead to a better outcome.

The IUCN Sumatran Rhino Emergency Plan (Anon, 2013) and draft Emergency Plan Framework prepared by IUCN was submitted to the Government of Indonesia in July 2013. Instead of highlighting a small number of clear policy decisions that were needed to address the situation, based on Lees' and Putnam's analyses, and the proven success of the Sumatran Rhino Sanctuary model at Way Kambas, which had led in 2012 to the first captive birth of a Sumatran rhino in Indonesia, the Emergency Plan introduced the ambiguous terms of "intensive protection zones" and "intensive management zones" (Havmøller et al., 2015). Application of assisted reproductive technology and sharing of knowledge and of gametes was hardly mentioned, and instead there were numerous recommendations on information gathering and rhino detection (involving a vast, expensive and unnecessary camera trapping effort), protection, infrastructure, monitoring and awareness-raising. Although the actual Sumatran experts (veterinarians and reproductive physiologists) who attended the Crisis Summit knew that fertility could not be assessed unless animals were brought into captivity, the majority of participants simply did not understand this basic concept.

Following the Crisis Summit meeting, the Sumatran rhino expert circle—never cohesive or visionary—fragmented yet more. The split is usually perceived as between Indonesia and Malaysia, and that is to some extent true, as demonstrated by the inertia of the two nations to share expertise, rhinos and gametes after 2013, despite numerous meetings. But that interpretation of the split is not entirely accurate. The bigger gap was between the "Protection-focussed" institutional group comprised of the IUCN, WWF-US, International Rhino Foundation (IRF), Yayasan Badak Indonesia (YABI) and WWF-Indonesia, which followed the advice of African species rhino advisers versus the "Propagation-focussed" group comprised of independent veterinary and reproduction experts from IPB University in Indonesia, US-based SOS Rhino, Germany's IZW team, the Borneo Rhino Alliance and WWF-Malaysia. In essence, the protection-focussed group was content to maintain the status quo and summarily dismissed the need for assisted reproductive technology (Fig. 12.1), whereas the propagation-focussed group prioritised augmenting the existing captive breeding programme with the capture of new animals with the greatest potential for fertility and the full implementation of a robust assisted reproductive technology programme. Essentially, the 1984 ad hoc meeting was repeated in 2013 but the direction recommended was even less clear than before. Tensions do exist between Indonesia and Malaysia (Ali Jibran, 2018), as is common in many pairs of adjacent nations globally, but the IUCN made no attempt to facilitate collaboration between Indonesia and Malaysia on the Sumatran rhino. The main problem was that the IUCN led protection-focussed group continued to adhere to the politically safe, minimal intervention approach and provision of funding only to Indonesian efforts while studiously ignoring the need for range state collaboration, rhino capture and assisted reproductive technology. Repeated attempts by Malaysia, along with independent Sumatran rhino experts in Indonesia and elsewhere, remained unsupported by the former group, so efforts to generate a collaborative programme bore no fruit and ended in 2019 when the last two Sumatran rhinos in Malaysia died.

The split in the Sumatran rhino conservation arena was also evident at a workshop conducted in February 2015 in Indonesia, at which a Population Viability Analysis for the Sumatran Rhino was conducted (Miller et al., 2016). According to IRF, IRF was the organiser of this PVA, funded by The Disney Conservation Fund, with the IUCN SSC Conservation Breeding Specialist Group contracted by IRF to run the workshop. Well respected Malaysian and other international expert practitioners were not invited to be present. A glance at the list of participants reveals the presence of only two Sumatran rhino reproductive specialists. The previous fundamental PVA analyses of Lees (2013) and Putnam (2013) were utterly ignored. Instead, the workshop organisers apparently allowed 58 participants to accept unverified assumptions from unverified sources about rhino numbers, sex ratios and fertility, along with the inclusion of irrelevant factors, to reach erroneous conclusions. In the absence of a strong body of Sumatran rhino expertise, and dominance of "stakeholder" opinions, it is perhaps not surprising that the meeting report includes items that were known by Sumatran rhino experts to be unsupported by evidence, such as: "In summary, for the foreseeable future the viability of all remaining rhino populations will depend on complete protection from poaching". Reproductive pathology was mentioned briefly under "Facts" and erroneously summarised as "Occurred in Malaysian populations in low populations [sic]" even though such pathology had first been observed in a wild rhino captured in Sumatra in 1986. Sensitivity analysis was done for several parameters including female birth interval, but the fact that more than half of all Sumatran rhino females would be sub-fertile and not reproducing was not noted or included in the analyses. This faulty 2015 PVA report replaced the superior 2013 analyses, and helped to cement a tragic misunderstanding that the Government of Indonesia relied upon and that persists still today: that if

there are at least 15 Sumatran rhinos in one place, then the cluster should be left as it is.

There are several terrestrial vertebrates which could have been brought into captivity in the 1980s in order to prevent extinction, but were not, and are now extinct. The Christmas Island pipistrelle (*Pipistrellus murrayi*) was regarded as common until 1984. After a marked decline in numbers during the 1990s, a formal governmental process was established to address the decline, eventually resulting in a decision to opt for captive breeding but, by the time capture was to start, extinction had already occurred (Martin et al., 2012). Similarly, the decision to prevent the extinction of the Hawaiian black-faced honeycreeper (*Melamprosops phaeosoma*) by captive breeding came too late, when there were only three alive, all in the wild (Vander Werf et al., 2006).

Following surveys in accessible hills in southern Vietnam, which found evidence of ten or more individuals of the Asian mainland population of the Asian lesser one-horned (Javan) rhino (*Rhinoceros sondaicus*; Schaller et al., 1990), the last ones on mainland Asia, one might have expected that the impetus to capture them soonest would be apparent. But instead, the usual "explanations" of poaching, habitat loss and weak law enforcement were highlighted repeatedly (Brook et al., 2014), even after 2000 when this last cluster of Javan rhinos was clearly too small to be viable if left in the wild. The idea of captive breeding for both Southeast Asian rhino species was raised repeatedly from the early 1980s (T. Foose, 1982, in litt. to J. Payne; Nardelli, 1985, 1986, 2014, 2016, 2019), but prominent figures within mainstream international wildlife conservation organisations were blind to reality. Why have experts and conservation organisations consistently failed to identify what needs to be done in order to save a species until it is too late to rectify such failures?

## The Questionable Role of Outside Experts

The existence of IUCN tends to run counter to the proven model of small groups of passionate people being allowed to take charge of situations like that of the Sumatran rhino. By its nature, particularly the strong influence of governments and big, mainstream NGOs in IUCN policy and positions, this is inevitable. But even within the SSC of the IUCN system, dysfunctionality is apparent in the case of the Sumatran rhino. Although the 1984 Singapore meeting incorporated multi-stakeholders with many views that would need some compromise, the difference of opinion between the IUCN Captive Breeding Specialist Group and the IUCN Asian Rhino Specialist Group could not be resolved except by a compromise that favoured failure, because the least promising breeding stock were selected for captive breeding, while leaving the individually fertile but collectively unviable clusters to drift to extinction in the wild. Since then, the Asian Rhino Specialist Group has failed the Sumatran rhino on almost every count: repeating the "habitat loss and poaching" deviation (as if Sumatran rhinos are forest-dwelling equivalents of the African and Indian rhinos); accepting inflated guesses as actual data; avoiding the need to be realistic about management of a metapopulation; avoiding serious discussions about the need to get more fertile rhinos into captive facilities; downplaying the fact of female reproductive pathology; and refusing to fully support the application of assisted reproductive technology. In September 2014, the IUCN SSC African Rhino Specialist Group further muddied the deliberations, when its scientific officer wrote to the European Association of Zoos Rhino advisory group Chair, IUCN SSC Asian Rhino Specialist Group chair, IRF and others, recommending against the use of assisted reproductive technology for the Sumatran rhino, and proposing instead camera trapping, habitat manipulation and enhanced anti-poaching efforts.

The idea that Sumatran rhinos should be captured for managed breeding only if they are "doomed", thereby crippling the goal of a managed metapopulation, has been supported by many players in the Sumatran rhino arena, right up to today. That view should have been revisited, debated and amended, but it was not.

## Human Perceptions and Assumptions

Few people would confuse chimpanzees, gorillas and orangutans. The same is not true of rhinoceroses. The five extant species are frequently lumped as if they represent a rational unit for discussion and actions. They are not. Other than being in the same zoological family and therefore having basic biological similarities, *Dicerorhinus* is in many respects very different from the African and Indian subcontinent rhinos (Figs. 12.2, 12.8, 12.9, 12.10), whose situations are radically different. Overall, African rhino numbers increased significantly over the past century (e.g. Player, 1972; Rookmaaker, 2000, 2002; Emslie et al., 2016), although poaching has subsequently reduced numbers greatly since the beginning of the twenty-first century. The African rhino problem is how to reduce poaching of a prevailing relatively large number of living rhinos, involving species whose propagation is not a significant problem. The Sumatran rhino problem is very different, and consists of deciding and acting to boost the numbers of this species that is about to go extinct, where many of the people involved in "saving" the species seem to lack understanding that chronic isolation, insufficient reproduction and reproductive problems can be addressed only by captive management of remaining rhinos. There are also big differences in the human societies that decide whether a species will go extinct or not. Several African nations with relatively large rhino numbers, espe-

**Fig. 12.8** Great one horned rhino, Kaziranga National Park, India. (Photo by Bibhab Talukdar)

cially South Africa, have a long history of wildlife management involving research-based active interventions and private interests. Indonesia and Malaysia have no such background.

Before the 1950s, *Dicerorhinus sumatrensis* was sometimes called the Sumatran rhinoceros but equally commonly referred to in published literature as the Asiatic or Asian two-horned rhino or Lesser two-horned rhinoceros (Hubback, 1939; Harper, 1945; Thom, 1943) and only a few authors (Lekagul & McNeely, 1977; Payne, 1990; Khan, 2014) continued to use these English names thereafter. Only now that the very last fertile individuals of this species are confined to the island of Sumatra is the name Sumatran rhinoceros truly appropriate. One of the many cognitive biases that humans are subject to is that what we name something influences our thinking on how we understand and treat it. If this rhino had a different name there might, just possibly, have been earlier and better international focus and cooperation on preventing its extinction. If the name "Asian two-horned rhinoceros" had been used consistently through the twentieth century, the sentiment within Indonesia over the past four decades that this rhino is a Sumatran—and therefore exclusively Indonesian—species might have been honed towards a more collaborative approach.

International institutions' continual repeating "poaching and habitat loss" (Payne & Yoganand, 2017), along with inaccurate reporting by non-governmental organisations, resulted in the Government of Indonesia to be satisfied with the existence of the Leuser ecosystem, Bukit Barisan Selatan National Park, Way Kambas National Park and Kerinci-Seblat as adequate habitat for the Sumatran rhinoceros. In this context, "inaccurate reporting" includes: multiple unverified claims over many years in field reports of "rhino signs"; a conclusion that lack of rhinos in camera trap images was due to placing the cameras in "the wrong places"; excitement over images of a mother rhino with calf, when the mother may have been the last fertile female in the region; the presence of a very few rhinos in one place multiplied by the area of forest in the region used wrongly to generate claims of large numbers of rhinos. The most egregious case was of

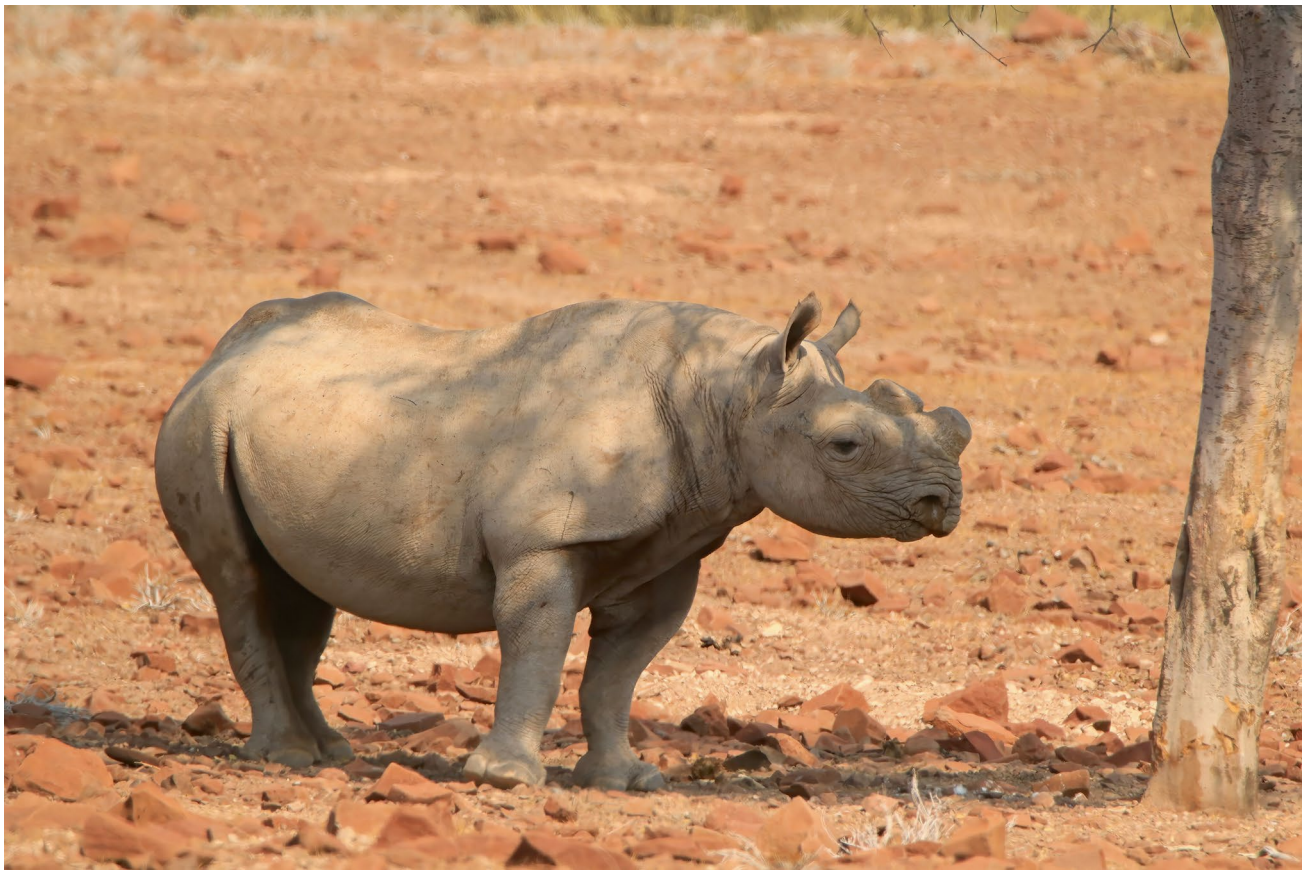

**Fig. 12.9** Black rhino, Damaraland, Namibia. (Photo by Mario Melletti)

Kerinci Seblat. The "known numbers" of rhinos in Kerinci-Seblat, Leuser, Bukit Barisan Selatan and Way Kambas, were stated by the 1993 Asian Rhino Specialist Group as 64–77, 60, 25–60 and 3–5 respectively. For Kerinci-Seblat, the field surveys on which these numbers were derived found signs of only two (sic) rhinos in a "permanent study site" of 22,000 hectares. That very low population density of rhinos was extrapolated on the assumption that the same density occurred throughout the entire adjacent forested region. In later years, it was claimed that there had been 500 rhinos in Kerinci-Seblat in 1990 (https://www.terradaily.com/2004/041219070226.sfdxmem8.html), while the 3–5 wild Sumatran rhinos estimated to be present in Way Kambas National Park in 1993, was inflated to 24–30 following the GEF project, and retained as 25–35 thereafter, irrespective of repeated intensive survey results, which were themselves never independently verified, but which indicated very much lower rhino numbers.

Malaysian reports were no more reliable than those from Indonesia. The number of Sumatran rhinos in Peninsular Malaysia estimated by the wildlife authorities rose from 22–41 in 1979 to 67–109 in 1987 to 72–130 in 1993. A Peninsula-wide survey coordinated and conducted by one of us (Zainuddin, 1995) under the GEF "Indonesia and Malaysia Conservation Strategies for Rhinos in Southeast Asia" project subsequently found evidence of a sum total of only 28–30 rhinos in scattered areas. The case of Taman Negara was particularly egregious with four to six rhinos reported there in 1979, 22–36 in 1993, and two to four in 1995. In fact, no definite signs of rhinos in Taman Negara were ever seen again after the late 1990s, and it is likely that the last one died there before 2000 (Payne, 2022). The chair of the IUCN SSC Asian Rhino Specialist Group at this period was also the Director-General of the Malaysian Wildlife and National Parks Department. There was a perception at the time that rangers who reported higher numbers of rhinos than their data warranted would receive more attention and equipment. One of the authors of this chapter (J. Payne) was not immune to groupthink either (Janis, 1971). Although he was sure that there were 13 rhinos in the Tabin Wildlife Reserve area in the early 1980s, based on the distribution of footprints and sightings throughout the area (it was being intensively logged by five contractors in different parts of the Reserve, and easy to move around to cover tens of thousands of hectares within a short period) there were no means to be sure that the same number were alive in 1995 during a GEF project-convened Asian Rhino Specialist Group meeting at which he was present and endorsed that number. The official number of rhinos

**Fig. 12.10** White rhino, Kruger National Park, South Africa. (Photo by Mario Melletti)

in Sabah given at that meeting was "probably about 30 individuals". The Sabah Rhinoceros Action Plan 2012–2016 (Sabah Wildlife Department, 2011) stated that there were 7–15 rhinos in Tabin Wildlife Reserve, yet a retrospective assessment (Payne, 2022) found it unlikely that there were more than five rhinos in the Reserve by year 2000.

Husbandry and reproduction in the Sumatran rhino present great technical challenges, but knowledge of the key elements started with the initial 1984–1985 captures and has increased greatly since then. Yet as recently as 2017, safe capture methods perfected by 1990, were reviewed and made more complicated, expensive and risky through "stakeholder consultation" involving about 100 people who had no knowledge of the subject. Knowledge of how to care for and breed Sumatran rhinos has been available from the early 2000s, but largely wasted because targeted capture of rhinos from breeding clusters has been avoided. Expertise in the main elements of assisted reproductive technology in relation to the Sumatran rhino have been available since the 2010s (Pennington & Durrant, 2018). One of the crucial procedures, safe harvesting of egg cells, has been perfected by a small number of practitioners (Galli et al., 2016), but their services have not been requested except by Sabah. There are multiple reasons why the captive breeding programme experienced initial failure and multiple setbacks with low quality breeding stock (most were either old, or injured by snare wounds or shotgun pellets, or infertile or sub-fertile) and lack of genuine collaboration between the parties involved being the two key reasons (Ahmad et al., 2013). Sub-optimal conditions in some of the US and range-state facilities (typically too much light and unclean mud wallows) combined with unsuitable diets provided by the facilities outside Indonesia and Malaysia contributed to declining health and early deaths.

The foregoing texts should make it clear that the dire status of the Sumatran rhino is now down to human failings, both at institutional and individual levels. These must and can be redressed now and for the future, in relation not only to the Sumatran rhino but to all critically endangered wild animal species.

## Human Psychology

A quintet of human cognitive biases helps to explain why no decisions and wrong decisions were made repeatedly. The human psychological elements in the story are intertwined with all the issues described above, and can be formulated in

various ways, but we can discern shifting baseline, risk aversion, us-and-them, fashions and opinions.

Shifting baseline syndrome (Pauly, 1995) is perhaps the greatest bias affecting wildlife conservation. In the absence of past information or personal experience of historical conditions, people of each new generation accept the situation in which they were raised as being normal (Soga & Gaston, 2018). This has been one of the contributory reasons from the 1984 Singapore meeting onwards on why the need to bring Sumatran rhinos together under a single recovery programme has apparently not been obvious to everyone present: although the people involved are aware of the endangered status of the species, they remain unaware that scatter of individuals surviving after the 1930s is highly abnormal and a sign of the very last stage of an extinction process.

In the case of humans who have to make decisions on how to proceed with the Sumatran rhino, the lowest risk approach is always to go with the universally acceptable view that poaching and habitat loss are the problems to address. It is important to understand that the risk is not in connection with the technical aspects of what should be done. All forms of technical work that could or should be involved in Sumatran rhino management are already well perfected and of low risk. The risk lies in the decision-makers being criticised by small elements of human society.

Any group of humans divide themselves into smaller groups, typically two main groups that each regard themselves as us, as opposed to them (e.g. Gray et al., 2014). This happens even when a group consists of members who are similar and have a common interest. The arbitrary apportionment of Sundaland by British and Dutch colonists in the nineteenth century, resulting in the creation of Malaysia and Indonesia in the twentieth century, is perhaps a contributory reason why late twentieth century humans were unable to manage a single Sumatran rhino metapopulation.

Some of the things that we see as being normal in biological conservation efforts are in fact fashions. Two previously non-existent fashions have become prominent in recent decades. One is an antipathy towards captive propagation. The other is a liking for stakeholder consultation, a process which is appropriate when there is discussion of proposals that, if implemented, will affect people. But there is limited need for such consultation when the proposal is to prevent extinction of a critically endangered species, whereby extinction or prevention of extinction affects no-one except those trying to prevent it.

Opinion-based decision-making has driven the Sumatran rhino tragedy. Here are some of the misguided opinions provided by influencers during meetings on Sumatran rhinos during the past 10 years:

- Poaching is the main threat to Sumatran rhinos (although, of the last 47 rhinos captured from the wild, most would have died without reproducing, even in the absence of poaching, either from reproductive problems or age-related disease or because there were no mates available);
- Rhinos should not be captured until we know how many there are and more surveys are needed (although for the past few decades, all clusters were already too small to be viable in the wild);
- There must be a few more rhinos left somewhere, because the forest is so vast (in fact, if no-one has ever reported the species from a particular area, or if they have in the past but no signs of rhino have been found in the past 10 years, then it is correct to conclude there are no rhinos present);
- Let us capture rhinos from the smallest clusters first (although the single main lesson from the 1990s onwards was that isolated rhinos tend to be reproductively compromised);
- Using assisted reproductive technology is too far into the future to make a difference (even though every female Sumatran rhino in captivity has needed assisted reproductive technology in the form of synthetic progesterone to maintain the first pregnancy).

Opinions have their origin not in facts or rational analysis, but instead in numerous cognitive biases, the widespread patterns of deviation from rational thinking that are common to all of us. Here are some that have adversely affected the Sumatran rhino:

Avoidance bias: Actions that are currently unfashionable or uncomfortable are avoided before they can be opened for discussion. Probably the main one for Sumatran rhino has been the need to capture fertile females.

"Boiling frog" bias: As with an imaginary frog in a saucepan of cold water placed on a stove, we watch as numbers of a rare species decline over the decades until there is too little habitat and too few breeding animals left to sustain a viable population, by which time the opportunity to jump is too late because the frog is already dead.

Confirmation bias: This is the tendency to seek, interpret and prefer information that confirms or supports one's prior belief. Thus, the habitat loss, fragmentation and poaching slogan is continually reinforced, while other key issues remain ignored. This is reinforced by Availability bias, the tendency to think that examples that come readily to mind are the most important.

Human benefit bias: According to WWF in 2006 (WWF, undated), saving endangered species helps reduce poverty and improve the lives of local communities. This might be true in some circumstances, but since around the year 2000, stakeholder consultations on wildlife conservation projects tend to bring in a wider variety of people than previously, and many wildlife projects now require that the beneficiaries

be human, rather than the wildlife that the project is intended to help.

Individual tragedy bias: At the individual level, we can imagine someone being brought into a hospital emergency room. But we can also imagine a national health service that is already in place. This is a simile for endangered wildlife. Every Sumatran rhino that has died in captivity in the past few decades drew sympathy and the last few were reported in the media as a tragedy. The real tragedy, however, was not that these animals were displaced or died, but that their genetic material was wasted because Foose's metapopulation model was never realised.

Geographical bias: Global reporting on the deaths of the last Sumatran rhinos in Sabah, Tam and Iman, highlighted that the Sumatran rhino was now extinct in Malaysia, but not yet in Indonesia. The main reason why the species is not yet extinct in Indonesia is that the combined land area of Kalimantan and Sumatra is 2.8 larger than the combined land area of Peninsular Malaysia, Sarawak and Sabah. That the species disappeared first from the land area controlled by Malaysia may simply be a function of probability in relation to land area under Malaysian control.

Numbers obsession bias: People always want to know the numbers of individuals of rare species, but a number is not really a proxy for anything. Much time can be spent trying to find out how many living individuals still exist but, whatever is the result, it does not help in deciding the best interventions. The important elements of the story for the remaining Sumatran rhinos that still exist in small, isolated and declining populations within Aceh include the individual's age, fertility, health and genetic diversity—information that can only be obtained in captivity.

Technology displacement activity: From 1990s onwards, several suggestions were made on how to acquire more detailed information on wild rhinos, including camera trapping, thermal imaging and seeking rhino DNA in samples of stream water and leech blood. Technology was used as a displacement activity in lieu of discussing and making necessary decisions to address the fact that there were not many fertile rhinos alive, and that they were too scattered to be able to reproduce.

Umbrella species: This is the assumption that there can be one species whose conservation is expected to confer protection to a large number of naturally co-occurring species (Roberge & Angelstam, 2004). The arguments for designating Taman Negara (the Peninsular Malaysia National Park; 1930s), Tabin Wildlife Reserve (1980s), and Endau-Rompin Park (1980s) in Malaysia all included that of being a "refuge" for Sumatran rhinoceros. Once the protected areas had been established, people believed that the job was done: by virtue of being "protected" the endangered species should start breeding and reverse its decline. Once that thinking had been established unchallenged, the subsequent need to remove the rhinos for a managed propagation programme was then challenged. The problem is that the umbrella species concept may be used to get a decision to preserve a forest area, but those same advocates might then argue against more holistic interventions to prevent the extinction of certain endangered species.

Visibility bias: Vital aspects of the Sumatran rhino that cannot be seen (e.g. their gametes) and those at entire population level (e.g. the home ranges of rhinos in a vast forest area might not overlap) are ignored in favour of actions that can be applied to a few individual living animals that can be seen.

## Conclusion: What Hope Is Left?

The phrase "better late than never" can still be applied to the Sumatran rhinoceros. A review of such profound failure may tempt some to cast blame on the individual dissenters in the Sumatran rhino saga for their inability to educate members of the public or to persuade policy makers to implement the appropriate strategy of bringing fertile rhinos into captivity in order to maximise reproduction and genetic diversity through metapopulation management aided by assisted reproductive technology. However, such criticism ignores the existence of cognitive biases and the inherent difficulty of challenging prevailing powers, especially in Asian societies. As a result, the strategies advocated by a handful of experienced biologists and veterinarians were dismissed in favour of conservation practices championed by the IUCN and mainstream NGOs from the Global North.

Preventing extinction of the Sumatran rhino is a formidable challenge for the Government of Indonesian, but with the support of an Indonesian-led small coterie of genuine Sumatran rhino experts, there may still be hope. Indeed, the Government of Indonesia launched an Emergency Action Plan in 2018, which included capture of the last wild individuals in Aceh and Lampung for consolidation within the ex situ breeding facilities (Indonesia—Direktorat Konservasi 2018) and identified assisted reproductive technology and bio-banking as key components of the metapopulation management strategy to facilitate movement of rhinos and gametes between conservation areas and captive facilities to promote rhino births and harvest genetic diversity. Time is of the essence and every component of Indonesia's strategy must be fully implemented. Delays to this programme regarding the quantum or allocation of funds must not be allowed to result in the extinction of an ancient mammal genus. Funding made available under the Tropical Forest Conservation Action for Sumatra (TFCA-Sumatra) programme, a debt-for-nature swap scheme created by the US Government and the Government of Indonesia, can still be supplemented with other domestic and international sources.

The future of the genus now lies in the hands of Indonesian veterinarians, scientists and the country's next generation of conservation leaders.

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