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Editors

Editorial board

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Cover photo: Bornean Keeled Green Pit-viper, *Tropidolaemus subannulatus*, Southern part of Central Kalimantan, Indonesia © Fachrul Reza.

Editorial

Biodiversity conservation - from a crisis-discipline to proactive meta-population management

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With the onset of the industrialization 250 years ago, the World's natural resources have been exploited at an alarming rate. Some fossil commodities, such as coal and crude oil, are diminishing rapidly, and sustainable use is impossible, because the formation of new oil and coal deposits require millions of years. In contrast, biodiversity generally has a rapid "recycling" time. Given the right conditions most animal and plant species can sustain significant levels of continuous harvest, provided that off-take does not exceed the rate of reproduction. Unfortunately, biodiversity is in rapid decline across the World. The extinction of species has reached a rate that is 1000-10.000 times higher than the "normal" rate (IUCN, 2007), and exceeds the cataclysmic Cretaceous–Paleogene extinction event that triggered the end of the dinosaur era (Keller, 2012; Renne et al., 2013; Schulte et al., 2010).

In contrast to the Cretaceous–Paleogene extinction, the modern time rapid extinction of species is caused by a combination of all-too-familiar threats such as climate change, habitat loss, over-exploitation, invasive species and diseases. Whereas this often results in "direct" extinctions the collateral damage caused by anthropogenic activities can also have serious negative impact on species, for example, as a result of wild populations becoming small and fragmented. When this happens a new threat emerges. The added vulnerability of small populations to random stochastic processes (e.g. environmental variation, catastrophes, random variation in survival and reproduction, skewed sex ratio, genetic drift, inbreeding etc) that can feed back into each other, will cause a species to be caught in a so-called "extinction vortex" described by Gilpin and Soulé (1986). Once caught in this downward spiral, it is extremely difficult to reverse the extinction, even if the original primary threats (e.g. poaching, habitat destruction, diseases) are removed. Biodiversity conservation therefore needs to consider all threats to species survival, both long-term and immediate, and both deterministic and stochastic, because more species will require intensive management at the level of populations and individuals to avoid extinction in the future. In practice, this means that species conservation must evolve from being largely a "crisis discipline" that focuses mainly on the results of failure - extinction - to a proactive discipline that incorporates the major biological attributes of success (Redford et al., 2011). For many species it is not solely about preventing individuals from going extinct, but to manage the *risk* of extinction across a meta-population. This requires a high degree of "integrated conservation" that includes scenarios with hardly any human intervention in wild populations as well as intensively managed populations in human care (Gusset and Dick, 2013; Byers et al., 2013). For example, small, fenced reserves can play critical conservation roles for species on the edge of extinction, however, such setups necessitate periodic translocation of animals to mimic natural dispersal and maintain gene flow (and Gusset, 2013; Gusset et al., 2009).

In the past decade, Indonesia, along with all other countries in Southeast Asia, has enjoyed a tremendous economic growth. Much of this have been sustained through agricultural expansion at the expense of ecosystem integrity with severe habitat fragmentation across the landscape. This new ecological state of affairs requires a new conservation approach that embraces the ecological and social reality of the 21st century. The role of national authorities responsible for natural resources management must develop far more proactive conservation management than merely removing primary extinction causes. Managing the

Figure 1. A very rare picture of two Critically Endangered Javan leopards, *Panthera pardus melas*, photographed in Baluran National Park, East Java, in October, 2013. The total remaining wild population is estimated at below 200 individuals in small fragmented habitats. ©Indra Warman.

extinction risk is critical, and authorities must consider genetic flow, exchange and enrichment when and where necessary. Failing to do so will result in local extinction that in turn can lead to regional extinction --- that is, the extinction vortex has begun (Beaune et al. 2013; Canale et al., 2012; Gibson et al. 2013).

Vast undisturbed ecosystems (e.g. Northwest territories in Canada, Serengeti in Tanzania and Kenya, Siberia) require relatively little extinction risk management. In contrast, countries with heavily fragmented landscapes (e.g. United Kingdom, Denmark, Germany) require constant meta-population management of rare and endangered species. In Southeast Asia, Thailand, Cambodia, Vietnam and Malaysia have long joined the group of nations with heavily fragmented landscapes, and Indonesia is rapidly approaching this ecological condition too. Particularly Java, Sulawesi and Sumatra need effective meta-population management for many charismatic species such as Sumatran tiger (*Panthera tigris sumatrae*), Javan warty hog (*Sus verrucosus*), Javan and Sumatran rhino (*Rhinoceros sondaicus* and *Dicerorhinus sumatrensis*), Javan leopard (*Panthera pardus melas*) (Fig.1), Banteng (*Bos javanicus*), Babirusa (*Babyrousa sp.*), anoa (*Bubalus quarlesi*) and a long list of critically endangered birds and amphibians. Conserving a species is no longer as confined to simply removing human influences. In many countries many species have become reliant on the direct and indirect ways and magnitudes in which humans manage the world, including changed land use patterns, alteration of landscapes (e.g. dams), creation of new physical structures, availability of alternate foods, presence of new competitors and mutualists, and even changed flows of energy and nutrients (Berger, 2004; Gusset et al, 2009; Laurance et al., 2004; Redford et al 2012; Redford et al. 2011; Watson et al. 2005).

Southeasth Asia suffered a critical extinction crisis in the recent decades and biodiversity conservation needs a boost in meta-population management across the region. With numerous species listed as “critically endangered” on the IUCN-redlist, however, with a well-established natural resources management infrastructure, Indonesia is in a favourable position to provide a much needed lead in transforming biodiversity conservation practice from a crisis discipline into a proactive integrated and success discipline in Southeast Asia.

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News and Notes

New publications

Mani, A., Mullainathan, S., Shafir, E. and J. Zhao (2013). Poverty Impedes Cognitive Function. *Science* **341(6149)**: 976-980. DOI: 10.1126/science.1238041

Burden of poverty can have profound long-term impact on nations' successful development. Lacking money or time can lead one to make poorer decisions, possibly because poverty imposes a cognitive load that saps attention and reduces effort. Mani et al. gathered evidence from shoppers in a New Jersey mall and from farmers in Tamil Nadu, India. They found that considering a projected financial decision, such as how to pay for a car repair, affects people's performance on unrelated spatial and reasoning tasks. Lower-income individuals performed poorly if the repairs were expensive but did fine if the cost was low, whereas higher-income individuals performed well in both conditions, as if the projected financial burden imposed no cognitive pressure. Similarly, the sugarcane farmers from Tamil Nadu performed these tasks better after harvest than before. The authors suggest that poverty itself reduces cognitive capacity and add that this is because poverty-related concerns consume mental resources, leaving less for other tasks

Yasamin, Kh.I., Lim, T.T., Westaway, K.E., Earl of Cranbrook, Humphrey, L., Muhammad, R.F., Jian-Xin, Z. and Lee Chai Peng (2013). First discovery of Pleistocene orangutan (*Pongo sp*.) fossils in Peninsular Malaysia: Biogeographic and paleoenvironmental implications. *Journal of Human Evolution* (http://dx.doi.org/10.1016/j.jhevol.2013.09.005).

This study presents the results from fossil extraction from two cave sites in Peninsular Malaysia, Badak Caves in the state of Perak, and Batu Caves in the state of Selangor. The authors isolated nine fossil Pongo teeth from two cave sites, which are the first fossil *Pongo* specimens recorded in Peninsular Malaysia. The authors argue that these new records from show that ancestral Pongo successfully passed the major biogeographical divide between mainland continental Southeast Asia and the Sunda subregion before 500.000 years ago, but that environmental conditions of the peninsula during the Last Glacial Maximum evidently became inhospitable for Pongo, causing local extinction. The authors also suggest that, after the latest climatic change, a new sea barrier prevented re-colonization from the rainforest refugium in Sumatra, accounting for the present day absence of Pongo in apparently hospitable lowland evergreen rainforest of Peninsular Malaysia.

Colchester, M. and S. Chao (Eds) (2013). Conflict or Consent? The oil palm sector at a crossroads. Forest Peoples Programme, Sawit Watch and TUK Indonesia. 428pp.

This report presents results from 16 case-studies concerning how well palm oil companies live up to their promises of respecting communities legal and customary rights, and only develop plantation on their land after free, prior and informed consent. All case studies presented in the report focus on plantation companies that are members of the Roundtable for Sustainable Palm Oil (RSPO) that require members to comply with the standards outlined in the "Principles and Criteria" (P&C). This includes refraining from developing plantations on lands regarded as "high conservation value" as well as respecting communities' legal and customary rights. The 16 case studies took place in seven different countries with Indonesia (7) the target of seven studies, followed by Cameroon (2), Liberia (2), Malaysia (2), Thailand (1), Philippines (1) and Democratic Republic of Congo (1). The findings are sobering. Many RSPO member companies have adopted new standards and procedures, and improved their practices on paper, but on the ground not much has changed. According to the report, land grabs continue, land conflicts are escalating and too often palm oil companies, even RSPO members, pursue business as usual. The report provides insightful details of target companies, local communities and respective traditions. It concludes that most of these problems stem from unjust legal and governance frameworks which fail to protect local communities' and indigenous peoples' rights. The editors recommend that respective operational managers in the field must receive more training, and that Governments must change the way they regulate the industry and adjust land tenure systems so communities are se cure in their rights.

Kawanishi, K., Clements, G.P., Gumal, M., Goldthorpe, G., Yasak, M.N. and D.S.K. Sharma (2013). Using BAD for good: how best available data facilitated a precautionary policy change to improve protection of the prey of the tiger *Panthera tigris* in Malaysia. *Oryx*, **47**, pp 420-426. doi:10.1017/S0030605312000294.

A study by the Malaysian Conservation Alliance for Tigers (MYCAT) suggests that the Endangered Malayan tigers (*Panthera tigris jacksoni*) is being undercut by dwindling prey. The paper presents a camera trapping study spanning 40,303 trap-nights resulting in a total of 10,145 wildlife photographs. Unfortunately, the results confirmed the worst predictions --- that is, tiger prey species are slowly disappearing, and with them the tiger too. The study reveals that the species least-detected - sambar, bearded pig, and gaur - were especially rare in unprotected forests. The favourite prey, sambar deer and bearded pig, are intrinsically linked to the tiger, and the authors believe that the demise of such important prey species will also result in the demise of the tiger. MYCAT propose that the sambar deer is upgraded to a legal status as a "totally protected" species, which will bring about a $90,000 fine and/or 10 years in prison for illegal hunting and trading.

Lim, E.A.L., Mariapan, M., Su Ming, Y.A., Abi, J., Aziz, A. and M. Zakaria (2013). Rural Students' Attitudes Toward the Malayan Tapir. *Human Dimensions of Wildlife* **18**:469–470.

This study looked into the attitudes of secondary school students in rural Malaysia towards the Malayan tapir, *Tapirus indicus*. Pictorial stimulations were used to qualitatively elicit students' cognitive beliefs and emotions toward the Malayan tapir and its threats. This study was carried out in 2012, in Jerantut, Pahang, Malaysia with 81 secondary school students as target group. The results showed that most students had heard of "tapir" but some were more familiar with the local names - tenuk or cipan. Most students regarded the Malayan tapir as "favourable", because of its unique physical appearance, with specific reference to its body shape and size, body pattern and color, and proboscis. Students also shared their associations of the picture stimulations to the tapir's natural habitat, its natural role and threats to its population. Students had positive emotions toward the Malayan tapir. Strong emotions of love and desire for direct contact with the Malayan tapir were prominent. The findings suggest that students' important beliefs and emotions toward the Malayan tapir should be integrated into the design of effective environmental education programs and that this constitutes a critical wildlife management tool that can be used to increase public support for the conservation of the target species.

Figure 1. The Javan warty hog, *Sus verrucosus*, is one of Java's critically endangered species that is believed to exists in only one or two locations on mainland Java. It was believed that the Bawean Island subspecies, *Sus verrucosus blouchi*, had gone extinct but a recent survey confirmed that a small population still roam Bawean Island. ©Florian Richter.

Hog deer make comeback

New populations of hog deer, Indochina's most endangered breed of deer, have recently been discovered in Kratie and southwest Cambodia. Discovered by a joint team from the Royal University of Phnom Penh and Fauna & Flora International wild hog deer were found in five out of 10 potential areas of habitat. This is good news for conservation, because Cambodia is the only country in Indochina with any hog deer remaining.

IUCN tiger programme receives €20 million

The German government through the KfW Development Bank has commited to providing 20 million EURO to support tiger conservation. This is a direct follow-up from the St. Petersburg Tiger Summit where several range countries committed to doubling the number of tigers occurring within their territories by 2020. The aim of this five-year *Integrated Tiger Habitat Conservation Programme* is to increase the number of tigers in the wild and improve the livelihoods of communities living in and close to their habitat. This includes improving the management of tiger habitats, tackling tiger-human conflicts, increasing anti poaching efforts and law enforcement and involving local communities in tiger conservation work.Eligible countries include Bangladesh, Bhutan, Cambodia, India, Indonesia, Laos, Myanmar, Nepal and Viet Nam. Whereas €20 million will not sufficiently cover all tiger conservation activities across the range, the gesture is certainly a "put your money where your mouth is" action and a challenge to tiger range countries to live up to their end of the bargain.

IUCN Wild Pig Specialist Group

The IUCN Wild Pig Specialist Group convened a workshop from 19-21st of November, 2013 at Cikananga Conservation Breeding Center, Sukabumi, West Java, Indonesia. It was timely as the last such event took place twenty years ago (1993). The event saw 25-30 participants from Europe, South Asia and the ASEAN region assess the conservation status of wild pigs in Asia. It soon became aparent that many of Asia's wild pigs are in immediate danger of going extinct. The conservation challenges across the region are similar whether it concerns Javan warty hog (Fig.1), *Sus verrucosus*, Babirusa, or the pygmy hogs, *Porcula salvania*, in the floodplains of Assam, Northeastern India. Reports from India, Indonesia and the Philippines paint the same picture i.e. habitat loss and hunting are the main drivers of the population declines for all wild pig species. In some instances hybridization is also a concern, for example, evidence suggests that *Sus verrucosus* have hybridized extensively with Banded pigs, *Sus scrofa vittatus*. In other cases, successful captive breeding programmes face challenges in finding suitable habitat to reintroduce captive bread individuals, because the former habitats have disappeared, as reported from the Philippines. The one positive report came from Bawean Island where a recent survey confirmed the existence of a small population of *Sus verrucosus blouchi*, once considered extinct, on the island.

The workshop participants also discussed how captive breeding facilities could contribute in pig-conservation, and which role such facilities could play. The participants unanimously agreed that, for many species on the bring of extinction, conservation breeding was an absolut necessity, and that resources-support should be offered to private as well as government facilities to encourage a more systematic and collaborative conservation breeding effort of priority species.

Finally, the workshop dealt with general challenges concerning pig conservation, especially how to address hunting problems, how to integrate pig conservation into other conservation actions, and how to promote better and more effective pig conservation on the ground. There is also a need to assess the status of feral and introduced pigs on Southeast Asian islands and to review the taxonomic status of babirusa, especially with regards to the species' presence on other islands.

The participants of the workshop thanked Erik Meijaard and Resit Sözer for organising the workshop, and the entire team at Cikananga Conservation Breeding Center.

Thiemo Braasch
Zoologische Gesellschaft für Arten- und Populationsschutz

IUCN Primate Specialist Group

The IUCN Primate Specialist Group, Section for Small Apes, convened a "Reintroduction, rehabilitation and translocation" workshop. Originally set to take place in Cat Tien National Park, Vietnam, from 12-15th November, 2013, the event was rescheduled due to sudden lack of support from local stakeholders. Instead, the organisors Ben Rawson, IUCN SSC PSG SSA Vice Chair/Fauna & Flora International; Clare Campbell of Wildlife Asia (WA)/Silvery Gibbon Project (SGP) and Susan Cheyne (OuTrop) managed to set up the workshop in Phnom Penh, Cambodia, from 6-10th of January, 2014.

The objective of the workshop was to reignite regional networking and information sharing amongst conservationists working with small apes, and to develop a practical "IUCN Reintroduction, rehabilitation and translocation" guidelines for gibbons. Approximately 30 conservationists from Southeast Asia, North and South Asia, Indochina, Australia, Europe and Northamerica engaged in very useful information sharing through a range of interesting presentations and subsequent discussions. Topics ranged from rescue, rehabilitation and husbandry efforts concerning Javan gibbons, *Hylobates moloch*, Bornean gibbons, *Hylobates muelleri*, Pileated gibbon (Fig.3), *Hylobates pileatus*, in Cambodia and Thailand, Hoolocks, *Hoolock leuconedys*, along with informal status assessments of many other gibbon species. The participants discussed many different topics relevant to reintroduction, rehabilitation and translocation and how to prepare a set of IUCN-guidelines that will be practical for the endusers. The organisors will compile the workshop details and prepare a draft "IUCN-guidelines for reintroduction, rehabilitation and translocation of gibbons" to be presented and endorsed at the 25th congress of the International Primatological Society in Vietnam (11-16th August, 2014).

Figure 3. A Pileated gibbon, *Hylobates pileatus*, in Phnom Tamao Wildlife Rescue Centre outside Phnom Penh, Cambodia. ©Carl Traeholt.

Carl Traeholt

Upcoming Events

The 4th International Conference on Oil Palm and Environment (ICOPE), will be held on 12-14th February, 2014, at The Stones Hotel, Kuta, Bali. This conference is organized jointly by SMART Tbk. Indonesia, WWF Indonesia and CIRAD France. The objective is to demonstrate how the oil palm industry is developing towards becoming a model for tomorrow's sustainable agriculture. More information about the event can be found at http://www.icope-series.com/.

Forest Asia Summit 2014 will take place in Jakarta, Indonesia, on the 5th and 6th of May, 2014. The meeting will engage Southeast Asian Ministers in a bilateral and multilateral exchange with their counterparts, business executives, civil society and development experts from Europe, the Americas, and elsewhere in the Asia-Pacific will seek to find new green-growth pathways. The event is organized by the Center for International Forestry Research (CIFOR), Bogor, Indonesia. More information about the event can be found at *http://www.cifor.org/forestsasia/.*

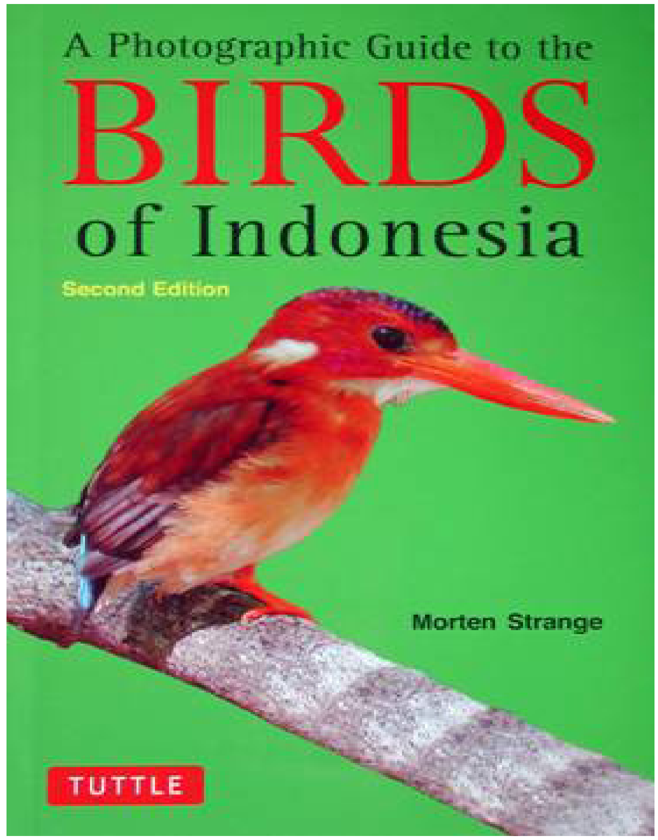
Regional Conferences on Protected Areas and Biodiversity Management in Southeast Asia. The is organised jointly by Yayasan Sabah, NepCon and the SAFE Project. The conference will take place on 24th and 25th of June, 2014, in Kota Kinabalu, Sabah, Malaysia. The intention is to promote sharing experiences in the management of protected areas in the tropics and discuss topics such as landscape fragmentation, management of meta-populations and biodiversity conservation as a "crisis discipline". Fore more information, please contact fize.busu@gmail.com or lailatuneliyana@yahoo.com.

The Association for Tropical Biology and Conservation (ATBC) will hold its 51st annual meeting from the 20-24th of July, 2014, in Cairns, Australia. The meeting also includes ATBC's Asia Chapter meeting where up to 800 participants will convene in one of the World's premier international conservation biology meetings. More information about the event can be found at http://www.atbc2014.org/.

International Primatological Society (IPS) will hold its 25th congress from 11-16th of August, 2014, at the Melia Hotel, Hanoi, Vietnam. Congress details can be found at http://ips2014.vnforest.gov.vn/.

Society for Conservation Biology - Asia Chapter - will hold its 3rd regional conference from 19-22th August 2014 at Equatorial Hotel, Melaka, Malaysia. The conference will bring together more than 200 of the regions foremost researchers, practitioners and students of conservation biology. Information can be found at http://scbasia2014.org/.

Book review



Indonesia has one of highest number of bird species in the World, including the number of endemics and threatened bird species. And the number is still increasing with the description of new species. Currently only a few bird field guides are available for the entire Indonesia. Most field guides available focus on specific biogeographic areas such as Sundaland, Wallacea or Papua. This book cover all of Indonesia with some taxonomix changes. The author, Morten Strange, is already well-known for his many high quality pictures of birds, as well as bird-guides for the Southeast Asian region. The first edition of his "A Photographic Guide to the Birds of Indonesia" was the first comprehensive photographic guide to the birds of Indonesia ever available. This best selling volume covered 686 species in one of the world's most diverse avifauna regions. This second edition is a major upgrade with nearly 250 more species depicted for an incredible total of 912 species illustrated. Another very useful feature is the comprehensive checklist of all 1605 recorded species in Indonesia, along with a description of where the species may be encountered and their endemic and threatened status. Its compact size makes it a good field guide that will not be a burden to carry on excursions. Despite the limited depictions of many Javan and New Guinean endemics this guide is a worthy companion for those who are interested in the Indonesian avifauna.

The Editors

Debate forum

Preventing the extinction of the Sumatran rhinoceros

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The decline of the Sumatran rhinoceros in the 20th century

Sumatran rhino (SR), *Dicerorhinus sumatrensis,* represents one the oldest surviving mammal genera. Due to its role in traditional Chinese medicines, the horn of SR has been sought for well over a millennium and for many years the price of SR horn by weight rivalled that of gold. Extensive hunting lead to a precipitous decline in distribution and numbers of SR, particularly during the first decades of the twentieth century (van Strien, 1975) and it seems little short of a miracle that the species is not already extinct. By the mid twentieth century, the species was depleted from its former range and in danger of extinction in Malaya and Borneo (Hubback, 1939; Metcalf, 1961; Medway, 1977; Rookmaaker, 1977), and elsewhere on mainland Asia (Harper, 1945). Flynn and Abdullah (1984) suggested 52-75 SR roamed Peninsular Malaysia in the early 1980s, including 20-25 individuals in the Endau-Rompin area, while Davies and Payne (1982) estimated 15-30 SRs in Sabah. By 1981, the only clear evidence of periodic breeding in wild SR in Malaysia was in Endau-Rompin and the Tabin area of eastern Sabah. At that time, the species was disappearing rapidly from the 20 or more locations where it had been present just a few decades earlier (Payne, 1990). Zainal Zahari (1995) found evidence of only five SRs, all adults, in Endau-Rompin by 1995, showing that published estimates of SR numbers were notoriously unreliable, and that actual numbers had declined by half over the preceding decade. The 1995–1998 Global Environment Facility-UNDP Sumatran Rhinoceros Conservation Strategy project saw SR numbers declining still further, but inflated numbers kept appearing in public domain, largely due to some proponents' disbelief that two decades of effort had failed. Zainal Zahari et al. (2001) plotted the disastrous decline of large mammals in Peninsular Malaysia from 1975-99.

The 1st Sumatran Rhino Crisis Summit

In October 1984, twenty persons convened on SR in Singapore by IUCN and, in the absence of reliable information on the population density of SR or on the species' breeding biology, representatives from governments, zoos and wildlife institutions made plans to prevent the species' extinction. The participants called for enhanced protection of wild SR populations, awareness, and development of a global captive breeding population drawn from SR in areas that were to be converted to plantations. Unfortunately, by 2013 the numbers of wild SR remained unknown despite evidence of a precipitous decline from several hundred individuals in 1984 to less than 100 in 2013.

The 2nd Sumatran Rhino Crisis Summit

The 2nd Sumatran Rhino Crisis Summit (SRCS) was also held in Singapore, from 31 March – 4 April 2013. About 100 people from governmental institutions, and non-governmental organisations (NGOs), together with Asian and African rhino experts, passionate individuals and people who have been involved in succeeding or failing to prevent the extinction of other species in recent decades participated. Originally conceived in Sabah as a NGO-led event, SRCS was eventually convened by IUCN, hosted by Wildlife Reserves Singapore (WRS).

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Figure 1. The Sumatran rhinoceros, *Dicerorhinus sumatrensis*, is on the edge of extinction. Conservation breeding actions, using all the knowledge about reproduction as well as international collaboration, is needed to prevent this charismatic species from being the next large mammal to go extinct in Asia. ©Carl Traeholt.

SRCS covered far more detail than the 1984 meeting, and discussions were far more nuanced, but the gist of the conclusions was similar (JP, pers. obs.). The SR is on the edge of extinction, and without immediate and committed conservation intervention drawing on the experience and resouces of Governments, scientists, captive and natural facilities, the species will almost certainly be extinct within the near future.

Simulations run in conjunction with SRCS found that female inter-birth interval was the single most important predictor of population performance. To have good chance of surviving through protection there is a need for a minimum 30 individuals with an inter-birth interval of three years or less. The future of populations numbering less than 30 individuals is bleak even if healthy and completely protected. Using a more realistic average inter-birth interval of 7 years, a starting population of 50 SR has a negative growth rate of about -3% per year. This effectively means that, without active intervention, all possible known wild and captive populations are in an extinction vortex and not sufficiently abundant to increase populations in isolation of each other. To reduce the current captive population's extinction probability below 10%, approximately 16 adult wild-caught rhinoceros need to be transferred into captivity and managed with an interbirth interval of three years.

The main specific actions agreed upon at SRCS were for Indonesia and Malaysia to collaborate, and to obtain critical ecological information about wild SRs, using ground observations, camera traps and faecal DNA analyses. Despite pledged commitment and support from all sides, some important, hard questions were not resolved at SRCS.

The hard reality

Between 1984-2013 forty-four SR have been captured from the wild, with only four captive births, all descendants from the same pair in Cincinnati Zoo. Disastrously, of the forty-four, 40 had died by early 2014. By 2014, there were only 9 SR in captivity: one mature male (born in Cincinnati Zoo, 2001), three fertile females and one male infant (born 2012) in the Sumatran Rhino Sanctuary, Way Kambas National Park, Sumatra, Indonesia; a sister and brother, both born and present in Cincinnati Zoo; a fertile female with endometrial cysts, and an aging male in the Borneo Rhino Sanctuary temporary facilities in Tabin Wildlife Reserve, Sabah, Malaysia. Despite a few positive results the conservation breeding effort has been an outright failure, and much more needs to be done before success can be achieved.

Unfortunately, after 1970 the dominating conservation approach has been to save highly endangered species in the wild, rather than to bring them into fenced, managed conditions. This was already apparent at the IUCN SR meeting in Singapore in 1984, where the majority of the participants expressed that protection of wild Sumatran rhinos and their habitats should be the prime means to save the species, with captive breeding as a supplement (JP, pers. obs.). In his 1995 polemic, Rabinowitz (1995) took the view that precious funds had been wasted on the captive breeding efforts, which should have been spent instead on guarding wild rhinos. Unfortunately, his as well as many others' reasoning, did not address the likely impacts of stochastic variables on small isolated wild populations (e.g. the Allee effect), and made no analysis of the particular faults and problems that were associated with the captive breeding attempts 1984-95. Today, it is well-known that the vulnerability of small wild populations to stochastic variables is critical and the catholic approach to captive breeding will likely send the respective species into an irreversible extinction vortex.

Sumatran rhinoceros in Malaysia

There is finally a realisation in Malaysia that SR is most likely extinct in Peninsular Malaysia, and on the verge of extinction in Sabah. Malaysia muddled through with SR in the past fifty years, recycling fabricated population estimates and refraining from making necessary conservation decisions. Now, government and NGOs alike implicitly agree that the sole imperative is to produce Sumatran rhino embryos. This can only be done by bringing every rhino into closely managed facilities, and making maximum use of their gametes. Having these rhinos and gametes as part of a globally managed meta-population is essential, and attempts at natural breeding and artificial insemination must continue as long as either is possible. In the absence of agreement to share rhinos and gametes between nations and facilities, current scope in Malaysia is extremely limited. Thus, a key element of effort commencing 2014 is the cryo-preservation of gametes and cells that might be used in the future to restore the species after its extinction in Malaysia.

The lesson from Malaysia is that the over-riding priority should have been to increase the number of SR pregnancies per year rather than to hope that the mortality rate of wild SR through poaching could be reduced. Protecting wild SRs may be an over-ambitious option and captive breeding may have a greater chance of success than prevailing wisdom admits.

The 1984-95 Sumatran rhino captures and breeding programme

From 1984 – 1995, 22 SR were captured in Malaysia (Table 1) with the intention to build a captive breeding programme. When SR captures commenced in the 1980s, nothing was known of SR reproductive biology other than basic anatomy. The only captive SR birth during the 1984-95 period was of Minah, from a mother who was pregnant when captured (Table 1).

An analysis of the fate of these SRs reveals several kinds of failures which should not have been allowed to occur with such a precious, critically-endangered species. For a start, although the possibility existed to exchange individuals between Peninsular Malaysia and Sabah for captive breeding, this was never seriously discussed because of a belief that the Peninsular Malaysian and Borneo rhinos are different sub-species. This notion arose from a paper by Groves (1965), who examined the skulls of thirteen Dicerorhinus rhinos from Borneo, Sumatra, Malaya and Burma, and concluded that the Borneo form is "markedly smaller" with a forward-sloping occiput (back end of skull), and therefore ranked as a distinct sub-species (*D. r. harrissoni*), with *D. r. sumatrensis* regarded as a single form occurring in Sumatra and Peninsular Malaysia. Despite the small sample size and subjective nature of the judgement, this publication served as a basic constraint to rational discussion. Amato et al. (1995) recommended mixing the "sub-species", a recommendation later endorsed by Goossens et al. (2013), which implicitly questions the validity of the sub-species separation. Despite acceptance by Groves (1965) that the Peninsular Malaysia and Sumatra Dicerorhinus are the same sub-species, there was only one attempt at exchanging rhinos. Peninsular Malaysia provided a female (Dusun, who had been captured in 1984, healthy and with no obvious reproductive pathology) to Indonesia in 1987, while a male (Napangga) captured on 15 June 1986 in Sumatra was sent to Peninsular Malaysia, which at that time lacked a captive male. However, Napangga was suffering from severe and chronic snare wounds in his front left leg, which had resulted in a fractured meta-carpus and severe exostosis of several bones, rendering it almost impossible for him to mount a female. Dusun was kept in Rangunan Zoo, Jakarta, for 11 years, before being sent to Way Kambas in 1998, where she died without breeding in 2001.

Although there was clear knowledge well before 1980s that SR live in closed-canopy forest and that wild SRs typically wallow in clean mud for 5- 6 hours daily (Ng et al., 2001), most SR were kept in conditions of exposure

Table 1. Summary of Sumatran rhinos, *Dicerorhinus sumatrensis*, brought into captivity in Peninsular Malaysia and Sabah from 1984 to present.

Rhino name	Sex	Date of capture	Characteristics & history	Death (cause; location; date)
Peninsular Malaysia				
Jeram	F	30/04/84	Mature at capture; from oil palm near Sungai Dusun peat swamp forest in Selangor; never bred	Old age related; Melaka Zoo; 09/07/02
Erong	M	01/05/84	Caught at age about 2 months; fed full cream cow's milk from cartons; later analysis of captive SR showed that SR milk is very low in fat and high in protein	Feeding unsuitable milk ; Melaka Zoo; 01/06/84
Melintang	F	18/04/85	Mature at capture; Perak State; sent as gift from King of Malaysia to King of Thailand, July 1986	Dislocation of neck & suffocation between bars of inappropriate fence; Dusit Zoo, Bangkok; 28/11/86
Rima	F	15/12/85	Pregnant at capture; Johor; retained in Melaka Zoo & Sungai Dusun	Likely mucoid *E.coli* infection (previously reported in public domain as tetanus); Sg. Dusun; 12/04/03
Sri Delima	F	01/07/87	Mature at capture; Selangor; retained in Melaka Zoo & Sungai Dusun	Salmonellosis (Salmonella blockley); Melaka; 15/12/89
Dusun	F	09/09/86	Mature at capture; sent to Jakarta 25/05/87 in exchange for male	Old age related; Way Kambas; 07/02/01
Panjang	F	25/07/87	Mature at capture; Selangor; retained in Melaka Zoo & Sungai Dusun	Bacterial infection; Sg. Dusun; 09/11/03
Minah	F		Captive born to Rima in Melaka Zoo on 23/05/87; a progesterone implant was inadvertently placed into her bladder by a Universiti Pertanian Malaysia specialist, an error inadvertently attributed in public domain to ZZZ	Bacterial infection; Sg. Dusun; 16/11/03
Julia	F	06/07/86	Mature at capture; Selangor; retained in Melaka Zoo	Uncertain; Melaka Zoo; 23/09/88
Mas Merah	F	26/08/87	Mature at capture; Selangor; retained in Melaka Zoo & Sungai Dusun	Bacterial infection; Sg. Dusun; 17/11/03
Shah	M	01/03/88	Estimated age at capture 2.5 years (weight 446 kg); Selangor; retained in Melaka Zoo & Sungai Dusun	Mucoid *E. coli* infection (previously reported in public domain as colitis or emphysema); Sg. Dusun; 19/01/02
Seputih	F	11/07/88	Mature at capture; Pahang; retained in Melaka Zoo & Sungai Dusun	Bacterial infection; (previously reported in public domain as intestinal torsion); Sg. Dusun; 28/10/03
Ara	M	24/08/94	Mature at capture ; retained in Melaka Zoo & Sungai Dusun	Bacterial infection; Sg. Dusun; 08/11//03
Sabah				
Linbar	M	28/03/87	Mature at capture	Internal injury & respiratory failure at trap site; lower Segama; 28/03/87
Tenegang	M	14/07/87	Mature at capture	Hindgut obstruction was cited, without details; Sepilok; 22/04/92
Lokan	M	24/05/88	Mature at capture	In pit trap; 25/05/88
Lun Parai	F	22/04/89	Juvenile at capture; first mated 28/10/95 but no pregnancy; retained at Sepilok & Tabin	Uncertain ; Sepilok; 23/08/00
Tekala	M	05/05/91	Mature at capture; retained at Sepilok	Reported as tetanus; Sepilok; 08/05/95
Sidom	M	27/08/92	Mature at capture; mated unsuccessfully with Lun Parai and Gelogob at Sepilok	Uncertain; Sepilok; 20/01/97
Bulud	M	07/07/93	Mature at capture; escaped through electric fence into Tabin Wildlife Reserve, 30/11/93	Unknown (but seen in June 1995, 30 km from escape site, identified by radio-collar around neck)
Tanjung	M	20/07/93	Mature at capture; retained at Sepilok	Falling tree branch; Sepilok; August/06
Malbumi	M	22/11/95	Mature at capture; retained at Sepilok	Unknown; Sepilok; 04/12/97
Gelogob	F	17/06/94	Mature at capture; mated 26/10/95 but no pregnancy; retained in Sepilok, Tabin & Lok Kawi	Died 11/01/2014
Kertam (Tam)	M	15/08/08	Mature at capture; front right leg with snare wound; coaxed into crate in in oil palm at Kretam. Retained in Tabin.	Alive
Puntong	F	18/12/11	Pit trap in Tabin; mature on capture; front left foot absent, clearly amputated in early infancy; significant reproductive tract pathology. Retained at Tabin.	Alive

to sunlight and in some cases without access to clean mud wallows. SR skin condition declines drastically when this species is provided only with water or watery mud in which to wallow, leading to poor condition and stress. Frequent sunlit conditions have been linked to partial and complete blindness in some captive SRs (Kretzschmar et al., 2009). In summary, many SR were kept during 1984-95 in conditions which facilitated poor health and stress. Other mistakes made in the 1980s included feeding unsuitable milk to an infant SR and keeping a SR in an enclosure which allowed the rhino to entrap its head between the bars, and asphyxiate.

Most egregious of all, basic hygiene was generally poor, with at least some SRs kept for long periods in facilities that lacked basic hygiene protocols and biosecurity measures, and lacked experienced veterinary care so that identification and treatment of disease came too late or not at all. Prior to the development of the Sungai Dusun Rhino Conservation Centre (SDRCC) in Peninsular Malaysia, SRs were maintained at Melaka Zoo, where treated piped water was installed only after the deaths of Sri Delima and Julia (Table 1). Aidi et al. (2004) reported that the SDRCC rhinos died as a result of trypanosomiasis, supposedly originating from buffalo on private land nearby. Monthly monitoring of blood for parasites and blood parameters had been done for all captive SR for almost a decade prior to the deaths of six SR in SDRCC in year 2003, however, and no trypanosomes had been detected. Blood was taken from the buffaloes living near to the SDRCC facility after the six SR deaths in 2003, and inoculated into mice, but no trypanosome infection was detected. In only two of the seven SR that died at SDRCC were trypanosomes detected, while abundant pure bacterial growth was found post-mortem in the vital organs, mucoid *Escherichia coli* in five animals and *Klebsiella pneumoniae* in four animals. The death of Shah in January 2002 from mucoid *E.coli* should have prompted the facility to be on strict alert. Sensitivity tests were done in 2002 to determine the most effective treatment. Gentamycin was found to be the only effective treatment and, although it was available at SDRCC during the period of the final six SR deaths, it was not used. Seven years later, between 17-29 September 2010, at the same facility, seven Malayan tapirs died from mucoid *E.coli*, and only one of the tapirs showed trypanosomes in the blood. Our opinion is that trypanosomes might have infected SR and tapirs at any time at Sungai Dusun, and that natural resistance effectively supressed their growth until the advent of poor health and compromised immune response resulting from chronic mucoid *E. coli* and *Klebsiella* infection. The conclusion that trypanosomes were the cause of the SDRCC deaths may have been reached erroneously, in order to allow parties involved to avoid responsibility for chronic poor hygiene in the facilities.

Other SR facilities also had issues with hygiene and treatment. In the most detailed publicly-available documentation of a SR death in captivity, Furley (1993) wrote that the female SR named Subur in Port Lympne Wild Animal Park, United Kingdom, was diagnosed as having "died from acute bacterial toxaemia caused by *Klebsiella pneumoniae* in an environment subsequently found to be heavily contaminated with this organism" as well as with *E. coli.* High quality management, husbandry and veterinary care is essential at all times wherever SRs are kept in fenced facilities.

Post 1995 SR captive breeding

It was only in the mid 1990s that the key elements of SR reproductive behaviour had become clearer (Zainal Zahari et al., 1990, 2005; Bosi, 1996). But by the end of 1995, 4 captive SRs had died in Indonesia, 5 in Peninsular Malaysia, 4 in Sabah, and 6 in US and British zoos (Christman, 2010), and the captive breeding programme had become less appealing to governments, donor and commentators. The Sumatra-caught SRs Emi and Ipuh were not only alive, however, but fertile and compatible, and received excellent care at Cincinnati Zoo, resulting in live SR births in 2001, 2004 and 2007. Since then, attempts and advances continue to be made in assisted reproductive technologies for rhinos. Examples include the cryo-preservation of oocytes by vitrification (Saragusty and Atav, 2011), successful artificial insemination and subsequent live births of white, *Ceratotherium simum*, and Indian rhinos, *Rhinoceros unicornis*, (Hermes et al., 2009a; Anon, 2013), and in vitro fertilization (Hermes et al., 2009b; Stoops et al., 2011).

Major reasons for the 1984-95 failures

Allee effect and the Sumatran rhinoceros

The Allee effect (Allee, 1931) formally refers to a "positive correlation between population size or density and the mean individual fitness", indicating that when a population declines to very low numbers, breeding success declines in tandem both absolutely and in terms of population size percentage change (Courchamp et al., 2008). Not everyone involved in making decisions on how to manage very small populations can digest mathematical texts on wildlife population modelling, but it should be clear that very small populations of solitary, slow-breeding species such as SR will have a very small number of annual births. The stochastic factors associated with very low numbers (e.g. difficulty in finding a mate, narrow genetic base, random skewed sex ratio, reproductive tract pathology linked to long periods without breeding) contributed to driving SR numbers lower and lower during the twentieth century, even in places with suitable habitat and zero human off-take. In small, scattered and non-contiguous "populations", it is just a matter of time before average annual death rate exceeds annual birth rate, and before the population goes extinct.

How do we know that the Allee effect is having a significant impact on prospects for survival of wild SRs? Firstly, all records of wild juvenile SR are essentially anecdotal, with no information available on actual annual increase (or decrease) in wild population size. Secondly, SR numbers have been very low for at least many decades in most if not all areas where they are still present, so inbreeding is very likely. Thirdly, a skewed sex ratio was observed during capture of SR in Malaysia from 1984-95, where the Peninsular Malaysia ratio for adult wild caught rhinos was 1:9 (male:female), while for Sabah this was the opposite, 8:1. Worse still, it was ten years after the capture of the first mature female before the first and only mature male was captured in Peninsular Malaysia (Table 1). In Sabah, all the males captured were mature or old, from the same 1,000 sq km of forest being converted to plantations. Fourthly, reproductive tract pathology is common in SR females, a phenomenon associated with lack of either breeding or carrying of foetuses to successful birth that appears to particularly afflict rhinos (Hermes et. al, 2006). More than 50% of Malaysian female SR have such a problem, and in most of these rhinos, the problem was present at time of capture (Schaffer et al., 1994, 2001). Of 9 female captive Peninsular Malaysian SRs examined, six had reproductive tract pathology, comprising of masses, cysts and tumours, observed via ultrasonography and/or post mortem.

It is manifestly unsafe to assume that wild SR populations are characterised by an average annual birth rate that matches annual death rate, are not inbred, have a non-skewed sex ratio, that females are mainly fertile, and that wild populations exceed the minimum necessary characteristics to sustain a constantly positive rate of increase. Rather, we should assume the opposite, lest we continue to field teams to protect an inherently non-viable population. The Allee effect has likely been present in all SR populations over an extended period, effectively entering SR into the extinction vortex irrespective of whatever protective measures might be put in place in the wild.

We suggest that major reasons for the failure of the 1984-95 efforts on captive breeding of SRs (with current situation in parentheses) were : (1) Insufficient knowledge of key elements of Sumatran rhino breeding biology (now largely rectified), (2) inadequate constant, high-quality veterinary care and husbandry in captive facilities (rectified at Sumatran Rhino Sanctuary in Indonesia and Borneo Rhino Sanctuary in Sabah by full-time presence of experienced veterinarians employed independently of government bureaucracy), (3) unsuitable diet in some facilities, with insufficient attention paid to the risk of iron ferritin disease (Dedi et al., 2012), (4) stress on SRs due to weaknesses in facilities design and poor visitor control (rectified at Sumatran Rhino Sanctuary in Indonesia and Borneo Rhino Sanctuary in Sabah), (5) more than 50% of all female SRs with reproductive tract pathology, making natural breeding difficult or impossible in these females (assisted reproductive technology is now better advanced, including artificial insemination attempts), (6) absence of suitable males in Peninsular Malaysia, (7) probably, some males in Sabah with low or no sperm production, (8) rhinos not shared between Peninsular Malaysia and Sabah due to fears over "different sub-species" (a fear now discounted), (9) rhinos not shared between Peninsular Malaysia and Indonesia due to loss of trust after the initial exchange, (10) rhinos not allowed to USA due to governmental decisions within Malaysia, (11) some pairings involved inexperienced or incompatible rhinos, (12) artificial insemination was never attempted due to lack of knowledge that is now available.

The hard questions

Which option is more likely to save the Sumatran rhino: protection in the wild or close management in fenced, managed facilities?

Before answering these questions it is important to draw knowledge from similar successful "rescue" interventions that have taken place for other species on the edge of extinction. In the late nineteenth century, the white, *Ceratotherium simum*, and black rhino, *Diceros bicornis*, species were saved from extinction by active management (Skinner and Chimimba, 2006). The same was done for American, *Bison bison*, and European bison, *Bison bonasus*, (Hornaday, 1887; Pucek et al., 2004), Przewalski's horse, *Equus przewalskii*, and the Arabian oryx, *Oryx leucoryx* (Ryder and Wedemeyer, 1982; Saltz, 1998; Spalton, 1999) with all four saved from extinction by zoos and private land owners. More recently, the Californian condor and black-footed ferret have been saved by captive breeding, despite the strong objections of some detractors (Nielsen, 2006; USFWS, 2008). In contrast, species which could have been brought into captivity in the 1980s but were not, and are now extinct, include the Vietnam rhino (Brook et al., 2011) and Christmas Island Pipistrelle, *Pipistrellus murrayi*, (Martin et al., 2012).

The first option is "politically" safer because no agency or individual can ultimately be held accountable for extinction, if that occurs. Also, there is no risk of adverse public comment, domestically or internationally. There is zero risk of accidents during capture. However, there are two major risks. One is that of catastrophic poaching which can wipe out many rhinos before action can be taken (this could also occur with captive rhinos). The other risk is that a positive outcome is based on the hope that birth rate and survival are adequate to surpass death rate over the coming decades, and that inbreeding does not represent a significant threat. If those two risks are under-rated, then the whole exercise of protecting wild rhinos will eventually prove to have been fruitless.

The second option can mitigate those two risks. We have three concerns that lead us to this belief. Firstly, we do not believe that anyone, even with better data on SR numbers, sex ratio and breeding signs in the remaining wild populations, can state whether those populations are of sufficient size and fecundity to assure their survival, even in the absence of poaching. Secondly, we believe that the risk of a very few catastrophic and fatal poaching events will always remain high in wild populations, and that such events would likely be the final nail in the coffin that will lead to the species' total extinction. Thirdly, we believe, based on our own personal experience, that the failure of the 1984-95 captive breeding efforts should be a hard-earned lesson for us, to inform us of what should now be done, rather than be viewed as a reason not to bring SRs into fenced facilities. However, this second option entails risks which are the opposite of the first. The agencies and individuals involved in making the decisions, and in capturing, transporting and caring for the rhinos, carry responsibility for failure. Any decision to capture Sumatran rhinos from the wild is sure to incur objections, domestically and globally, both from specialists who do not support capture, and the many people who make comments through the digital media. If the decision to capture is made and implemented, there is a whole array of risks thereafter, but with the knowledge now available, all can be mitigated.

Options for fenced, managed facilities

Four ways to manage SRs in captive conditions can be imagined (Table 2), the first two of which have already been proven to be capable of producing SRs. However, two additional options merit consideration as alternative or additional possibilities.

Sabah wasted more than a year (2008-10) in considering the model of a large enclosure under rainforest, which had been suggested in 2008 by an African rhino specialist. The reasons why such a model was found to be impractical in Sabah were: (1) not enough remaining fertile rhinos to make it worthwhile, (2) there is insufficient flat land under natural forest remaining, (3) approximate cost of the perimeter fence and motorbike track for the provisionally agreed facility was about US$10 million and (4) the alignment and maintenance of fencing under prevailing conditions of slopes, high rainfall, branch falls and erosion would render the concept impractical. It is vital to stress that a perimeter fence consisting merely of electrified wire is not suitable for the conditions that prevail in Malaysia and Indonesia. Not only will the hot wire be breached naturally and frequently by tree and branch falls and erosion, but years of experience show that at least some wild elephants as well as rhinos may barge through the wire or push trees down on to it. The only practical way in which the large enclosure under rainforest model could work will be to select a flat area, where fence alignment, construction and maintenance is not unduly complex, and to combine the hot wire with a physical barrier, such as that already used in Sumatran Rhino Sanctuary and Borneo Rhino Sanctuary. In Sabah, the cost of constructing such a fence (concrete posts at 3 metre spacing, bracing posts at corners and slopes, five strands of steel cable, hot wire and netting) in a moderately remote forest site at time of writing is approximately US$80 per metre. Fencing for a 1,000 hectare sanctuary would thus cost around US$1 million. The only site of which we are aware suitable for such a large rainforest enclosure would be Way Kambas National Park. However, it is also vital to note that a fence which is a physical barrier may have significant adverse implications on a variety of other large terrestrial mammal species.

Some of the problematic issues associated with the large enclosure concept could be addressed by considering a location in a plantation, such as an oil palm plantation. The underlying concept of a big fenced enclosure on private land is well-accepted in America, Europe or Africa, but might be regarded as bizarre by some in Malaysia and Indonesia. It would be possible to build and maintain a robust perimeter fence along existing roads and terraces, irrespective of

Table 2. Possible ways to manage Sumatran rhinos, *Dicerorhinus sumatrensis*, in fenced facilities.

Option	Advantages	Issues of concern
Zoos	Very close monitoring possible. Sub-fertile rhinos can potentially receive treatment. Readily-identified diseases can be treated. Attempts at sperm collection, oocyte harvesting and artificial insemination can be done frequently.	Ideal diet may be difficult to ensure (Dedi et al, 2012). Clean clay soil for wallows required. Disease may result in mass mortality due to close proximity. Stress of close management may result in reduced fertility in some rhinos.
"Sanctuary": paddocks under natural forest with attached night stalls, already operational in Indonesia & Malaysia.	Very close monitoring possible (Andrianshah et al, 2013). Suitable food can be harvested from forest. Sub-fertile rhinos can potentially receive treatment. Readily-identified diseases can be treated. Attempts at sperm collection, oocyte harvesting and artificial insemination possible frequently.	Experienced veterinarians may not wish to commit to living out of town for very long periods.
Large enclosure (> 1,000 hectares) under rainforest.	Rhinos can develop their own home ranges and inter-actions with other rhinos. Rhinos choose their own foods. Low stress. Low risk of disease.	Site needs to be flat to allow construction and maintenance of perimeter fence (or, costly and with difficulty, a fence could be built following the boundary of a water catchment in a hill range). Site needs to be accessible by road and daily monitoring of perimeter fence achievable. Close monitoring of rhinos not possible. Supplementary minerals may be needed in case soils of chosen area are sub-optimum. Sub-fertile rhinos would better be managed in zoos or sanctuaries. Attempts at sperm collection, oocyte harvesting and artificial insemination not possible.
Large enclosure (> 1,000 hectares) on private land in Indonesia (e.g. abandoned plantation)	Perimeter fence can be constructed along existing roads or terraces. Site does not need to be flat. Woody weeds can be managed to provide partial food supply. Monitoring easier than in natural forest large enclosure due to road access and better visibility. Responsibility for costs and security shared with land-owner. Rhinos can develop their own home ranges and inter-actions with other rhinos. Relatively low stress and low risk of disease.	Herbicides cannot be used, and fertilizers with caution. Rhinos will need supplementary food from forest source. Piped water supply likely to be needed if natural watercourses not always present and clean. Close monitoring of rhinos not possible. Sub-fertile rhinos would better be managed in zoos or sanctuaries. Attempts at sperm collection, oocyte harvesting and artificial insemination not possible.

natural topography. In the absence of weeding, natural woody growth would provide some of the rhinos' food requirements. Responsibility for costs of developing and maintaining a large enclosure on private land and for security would need to be resolved, and potentially shared with the land-owner, which would most likely be a corporation.

Good and consistent husbandry and veterinary care are essential whichever option or combination of options is chosen. The willingness of experienced veterinarians to live on site, and indeed the availability of such veterinarians, are critical factors which may have a bearing on which model and location is chosen. Security will be a significant issue whatever option is chosen, and site-specific measures will need to be discussed and implemented.

Our suggestion is that the best solution is a combination of either the zoo / sanctuary model and the large enclosure forest or plantation model. All wild SR captured would be allocated to one or the other, based on their reproductive capability and other factors. Healthy, fertile SR could be allocated to the large enclosure, and other SR to the sanctuary or zoo.

We do not underestimate the challenges associated with working to achieve production of SR embryos by means other than natural breeding (Wildt and Wemmer, 1999), but history over the past century is replete with examples of people postulating that something cannot be done, a few years before that something is achieved. We must move purposefully towards making maximum use of assisted reproductive technologies on captive SR. Such experimental work could facilitate cost-sharing and potentially provide a useful conservation role for interested zoo authorities.

Conclusions

Based on our experience to date :

- Preventing the extinction of the SR rhino might not necessarily be achieved in the longer term by protecting wild rhinos.
- The emphasis on preventing poaching of wild SR has not been matched by serious efforts to maximise captive SR births. The latter is as much needed as the former in order to prevent extinction.
- SR can be captured and translocated from the wild with very low risk of mortality.
- SR can be sustained in good health in fenced facilities if veterinary care and dedicated keepers are always present under high quality management.
- SR can be bred in fenced facilities, both in zoos in temperate climates and in tropical rainforest forest paddocks.
- The occurrence of breeding in wild SR may be taken as reason to leave the rhinos in situ or, equally, as a great opportunity to capture and translocate some fertile wild rhinos into fenced facilities in order to increase the genetic diversity of the existing captive population and as part of the need to boost birth rates.
- Some wild SR live in places where capture and, crucially, removal from the forest will be logistically extremely difficult or impossible. The longer a decision to capture rhinos is delayed, the greater the likelihood that remaining rhinos will be in remote areas.
- Wild SRs which are not breeding are likely to be infertile or sub-fertile, and by capturing these rhinos, there is a chance to make use of their gametes for reproduction.
- If a decision is made to follow the African model of concentrating free-ranging rhinos in a large enclosure, the option to establish the enclosure in a plantation on private land is worthy of consideration.
- In general, the key elements of the best decisions can be made at any time, without waiting for better information on wild SRs.

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Biography

Together, the authors of this paper have many years of unique experience of wild and captive SRs in Malaysia. Abdul Hamid Ahmad conducted field work on SR at Danum Valley in 1990 (Ahmad, 1990), when there were breeding female SRs near the Field Centre, and he has subsequently been a lecturer in wildlife biology in Sabah, taking a special interest in SR. Junaidi Payne's interest began with a survey of the SR population in the Endau Rompin forest of Peninsular Malaysia in 1977, guided by the late Nico van Strien. From 1979-86 and then 2005 to present, Junaidi Payne was actively involved in field surveys and conservation proposals for SR in Sabah. From 1980-84, he simultaneously worked on the establishment of Tabin Wildlife Reserve (for SR), and development of a SR captive breeding programme between Sabah and the American Association of Zoo Parks and Aquariums. The latter programme involved US assistance to build a rhino breeding facility in Sepilok, Sabah, with the first two pairs of rhinos to be held there, but the programme was rejected by the State Government in 1985 in favour of a wholly locally managed programme. Zainal Zahari Zainuddin joined the Peninsular Malaysia Department of Wildlife and National Parks in 1986 as a veterinarian, and was subsequently involved in capture, care, husbandry and/or breeding attempts of over 15 SR in Malaysia and Indonesia. In 2010, Zainal left government service and joined Junaidi Payne and Abdul Hamid Ahamd as veterinarian and field manager for the NGO, Borneo Rhino Alliance (BORA), which has as its sole goal the prevention of the extinction of the SR in Borneo (www.borneorhinoalliance.org).

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Contributions

A preliminary test of a prediction from the rafting hypothesis for the presence of non-flying mammals on islands

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Abstrak

Perangkap kamera telah digunakan sejak tahun 2008 sampai 2012 untuk pemantauan satwaliar di dalam area perkebunan kelapa sawit di Kalimantan timur. Sebanyak 40 perangkap kamera digunakan secara bergilir pada seluruh habitat utama pada lebih dari seratus lokasi yang tersebar pada hutan dengan berbagai tingkatan umur yang telah ditetapkan sebagai hutan konservasi, blok perkebunan dengan umur 4 sampai 12 tahun dalam cakupan wilayah kerja PT REA Kaltim. Secara keseluruhan sebanyak 8628 camera-nights dioperasikan selama lebih dari 4,5 tahun (JAnuari 2008 sampai Juni 2012) sepanjang jalur pergerakan satwa atau lokasi sarang orangutan atau tempat dimana ditemui adanya aktivitas satwa. Seabnyak 36 spesies mamalia dari 21 family diidentifikasi dari foto dalam lokasi penelitian. HAmpir 54 % dari species yang tercatat dilindungi oleh perundang-undangan di Indonesia. Spesies yang paling banyak terfoto adalah Monyet beruk (Macaca nemestrina) total 1450 foto, diikuti oleh Babi jenggot (Sus barbatus) dengan foto sebanyak 1126 foto. Beberapa species seperti Artogalidia bivirgata tidak pernah terekam dengan menggunakan kamera yang dipasang pada permukaan Tanah. HAsil yang didaptkan menunjukkan pentingnya konservasi spesies, terutama karena relative besarnya jumlah spesies mamalia yang dijumpai pada sekitar 18n% hutan asli yang terdapat dalam area konsesi perkebunan. Ringkasa umum setiap aksi yang akan dilakukan dibawah manajemen PT REA Kaltim juga ditampilkan dalam tulisan ini.

Abstract

Non-flying mammals are assumed to have reached oceanic islands by raft from islands of water-edge vegetation. From this hypothesis we can infer that oceanic islands should contain a greater proportion of water-edge species than do continental islands. Without a good sample of mammalian fauna on oceanic islands, we test an altered version of this prediction. At the height of the last ice age, sea levels dropped by 120m. Therefore, immigrants to islands separated by water depths of 120m or more (deep-water islands) should have arrived more often over-water than did immigrants separated by seas of less than 120m depth (shallow-water islands), which immigrants could have reached overland. By comparison to shallow-water islands, deep-water islands should be dominiated by water-edge species. We used a multivariate binomial logit generalized linear model accounting for area of island, median body mass of species, predominant habitat of islands, and island region to compare the numbers of water-edge and total species on deep-water islands to the numbers on nearby shallow-water islands (N = 65 species in 42 genera on 16 deep-water islands and 10 shallow-water islands in three regions of Sunda namely Mentawai off the coast of Sumatra, and Palawan and Sulu, north-east of Borneo). The results contradict the rafting hypothesis: if there was a difference between the deep- and shallow-water islands, water-edge species were significantly less common on the deep-water islands instead of more common. We suggest accidental and deliberate transport by humans as a likely means of cross-sea distribution of terrestrial mammals in the Sunda region.

Keywords: Body mass, Habitat, Indonesia, Islands, Mammals, Rafting, Rivers, Sunda

Introduction

"*Hence islands remote from the continent may obtain inhabitants by casualties which … may occur only once in many … thousands of years … it is obvious that powerful tides, winds, and currents, may sometimes carry along quadrupeds capable … of preserving themselves for hours in the sea to very considerable distances …*" (Lyell, 1832, Ch. 6, p. 92).

Terrestrial mammals inhabit several of the many oceanic islands in south-east Asia (Heaney, 1986;

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Meijaard, 2003). Following Lyell, a common assumption is that these species rafted to the islands (Abegg and Thierry, 2002; Brandon-Jones, 1996, 1998). Although a few cases of rafting have been confirmed, for example a correlation of the direction of gene flow among Caribbean island anolis lizards with direction of ocean currents in the region (Calsbeek and Smith, 2003), most suggestions of rafting are hypotheses, especially for terrestrial mammals. The argument is because a terrestrial mammal is on a historically isolated oceanic island, it must have rafted there. Even the Flores Island hominin might have arrived there on the crest of a tsunami (Morwood and Jungers, 2009; Ruxton and Wilkinson, 2012).

In common with several biogeographic patterns (Crisp et al., 2011), the hypothesis of rafting by mammals often remains untested against alternative hypotheses, and few are explicitedly tested for the distribution of terrestrial mammals. The absence of terrestrial non-domestic mammals on central Pacific islands could be evidence of the improbability of rafting as a means of their dispersal across water, at least over long distances (Gillespie et al., 2012). Nevertheless, Houle calculated that ocean currents could have transported the founders of the New World primates across the then 1400 km width of the Atlantic in a period of just two weeks (Houle, 1998).

Rivers are believed to be the main launching-point for rafts (Houle, 1998; King, 1962; Krause et al., 1997; Matthew, 1915). The assumption is that river-edge vegetation is dislodged and swept to sea during floods or storms, carrying with it any animals on what has effectively become a raft (Wallace, 1876, Ch. 2).

With respect to terrestrial mammals, Schüle (1993) noted that ungulates inhabiting offshore islands usually belong to swamp or flood plain species, although he provided no examples, lists or analyses. Abegg and Thierry (2002) developed one of the few quantitative predictions to test the rafting hypothesis. They noted that the widespread crab-eating macaque *Macaca fascicularis* is a water-edge and coastal forests species. It is even found in mangrove forest and is a good swimmer (Rowe, 1996). By contrast, the distribution of pig-tail macaque, *Macaca nemestrina*, is limited to interior forest habitats. Abegg and Thierry hypothesized that the wider distribution of the crab-eating macaque resulted from the greater likelihood that it would drift to sea on a vegetation-raft. Their prediction from this hypothesis was that there should be a preponderance of riverine or mangrove taxa on oceanic islands. They specifically mentioned riverine habitat, as opposed to more general water-edge habitat, because of the idea that rivers might sweep rafts out to sea.

Here we test the Abegg-Thierry prediction using available information on the distribution of the non-flying mammal community of the Sunda region of insular South-east Asia (Meijaard, 2003). Meijaard (2003) listed only two oceanic islands near the Sunda Shelf, Simeulue and Enggano off western Sumatra. Therefore, for the analysis we chose to distinguish between "deep-water" and "shallow-water islands".

We used Voris' (2000) calculations of South-east Asian land extent at various ocean depths to separate deep-water from shallow-water islands. Deep-water islands are separated from a main-continent by ≥ 120m of sea, and shallow-water islands by < 120m. Using this definition, deep-water islands should still receive more immigrants by rafting than the shallow-water islands, even if sea-levels dropped more than 120m, because the deep-water islands will have been separated from sources for longer than the shallow-water islands. With this assumption, we predicted that deep-water islands should have a preponderance of river edge species in comparison with shallow-water islands.

Methods

The islands

To control for origins of island species, we required deep-water and shallow-water islands nearby the same source, and preferably near one another. Three regions in the species-list that we used (Meijaard, 2003) satisfied the criteria. They are the Mentawai islands and Nias off the potential source of western Sumatra, and the Palawan and Sulu islands off North-east Borneo (Table 1; Fig. 1).

Some consider the Mentawai islands and Palawan island were connected to the Sunda mainland during the last glacial maximum (Meijaard, 2003). If so, the connection must have been brief, given the 145m depth of the channel between Borneo and Palawan, and similarly with the shallowest depth between the northern end of the Mentawai island peninsula and Sumatra (Heaney, 1986; Voris, 2000). Furthermore the high degree of endemicity of the Mentawai islands fauna, and to some extent also the Palawan fauna indicates long separation. Nevertheless, we run an analysis excluding Palawan and its neighbouring islands to avoid any biases.

Table 1. Sampled South-east Asian islands and their characteristics. Bracketed areas are estimated from Google maps. Median mass includes *Sus sp*.

Island	Region	Depth	Area (km²)	Vegeta-tion	Median Mass (kg)	Total #species	#water-edge species	
							Nrw	Brd
Enggano	Mentawai	Deep	800	Non-For.	0.23	2	0	0
N. Pagai	Mentawai	Deep	820	Forest	0.30	14	1	3
Sipura	Mentawai	Deep	845	Forest	0.30	16	1	4
S. Pagai	Mentawai	Deep	920	Forest	2.00	12	1	3
Siberut	Mentawai	Deep	4,030	Forest	0.28	14	1	3
Nias	Mentawai	Deep	4,771	Non-For.	5.00	9	3	5
Bankaru	Mentawai	Shallow	(80)	Forest	0.18	6	1	4
Tuangku	Mentawai	Shallow	(220)	Forest	0.23	11	2	4
Pinie	Mentawai	Shallow	790	Forest	1.10	11	4	6
Tana Masa	Mentawai	Shallow	800	Non-For.	0.83	12	3	8
Tana Bala	Mentawai	Shallow	900	Forest	0.40	16	5	10
Cuyo	Palawan	Deep	(50)	Non-For.	0.16	1	0	1
Bangkalan	Palawan	Deep	(50)	Forest	0.53	1	0	0
Balabac	Palawan	Deep	(300)	Forest	3.26	3	1	2
Culion	Palawan	Deep	320	Forest	2.50	12	3	8
Busuanga	Palawan	Deep	(580)	Forest	0.40	11	1	7
Palawan	Palawan	Deep	14,650	Forest	0.97	21	4	10
Malawali	Palawan	Shallow	(25)	Non-For.	0.08	4	0	1
Balembangan	Palawan	Shallow	(70)	Forest	0.06	7	0	3
Jambongan	Palawan	Shallow	(100)	Non-For.	51.0	2	2	2
Banggi	Palawan	Shallow	440	Forest	0.12	13	3	7
Bongao	Sulu	Deep	(15)	Non-For.	2.00	1	0	0
Sanga-Sanga	Sulu	Deep	(60)	Non-For.	2.00	1	0	0
Simunul	Sulu	Deep	100	Non-For.	2.00	1	0	0
Tawitawi	Sulu	Deep	870	Non-For.	46.00	2	1	1
Sebatik	Sulu	Shallow	452	Non-For.	6.50	1	1	1

Simeulue and Enggano are separated from a potential emigration source (Sumatra) by ocean depths twice the estimated 120m sea level during the last glacial maximum, Simeulue by 420m (Meijaard, 2003), and Enggano by more than 1000m (Natawidjaja, 2003). We omitted Simeulue from the analysis, because suspected that humans introduced all its six terrestrial mammalian species. For instance the Sulawesi *Sus celebensis* was definitely introduced; *Macaca fascicularis* is so closely associated with humans that human-mediated introduction is a near-certainty (see Discussion); and *Rhizomys sumatrensis* occurs outside of Sumatra in insular SE Asia on only Simeulue, despite being widespread in mainland Asia. We retained Enggano in the sample.

The test-sample consisted of 26 islands, 16 deep-water, and 10 shallow-water. For the three regions of islands, these three values were respectively: Mentawai, 11 islands (6 deep-water, 5 shallow water); Palawan, 10 islands (6 deep, 4 shallow); Sulu, 5 islands (4 deep, 1 shallow).

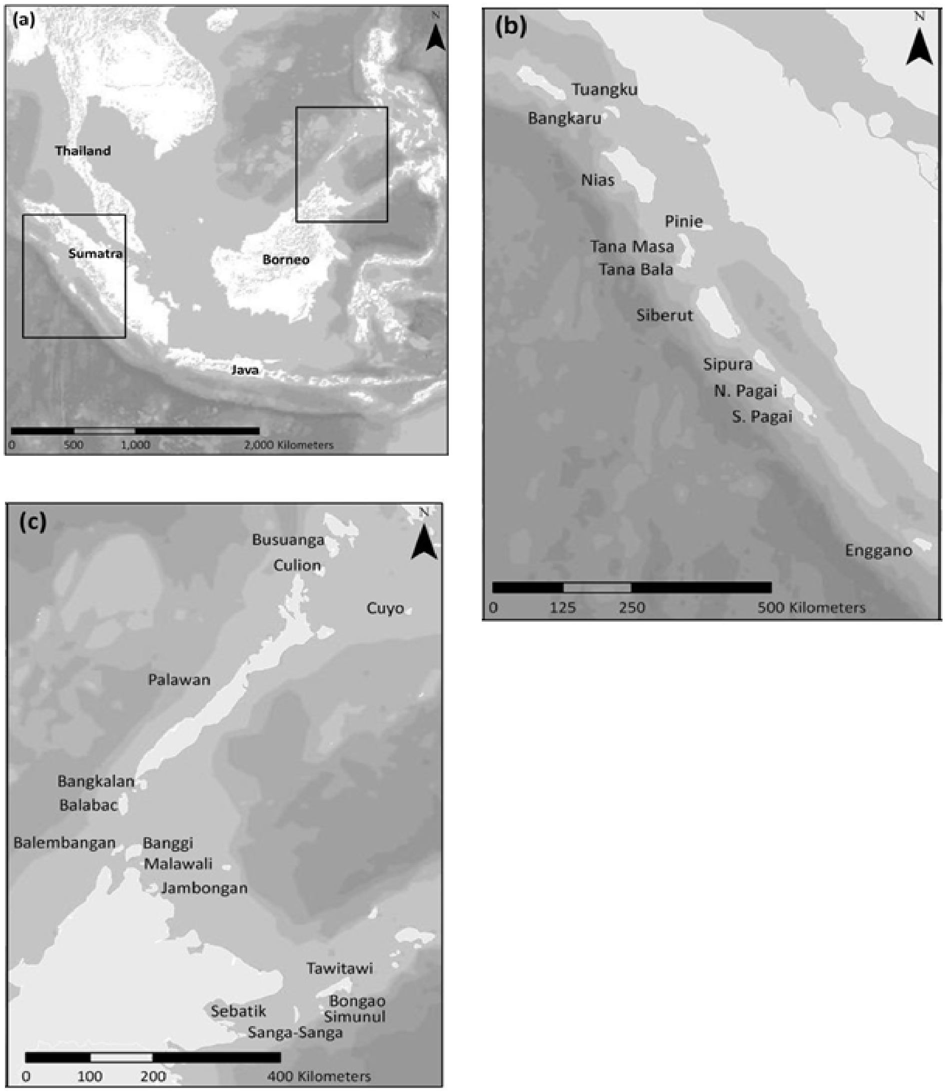

Figure 1. Map of the region analyzed. a) shows regions in map (b), Mentawai (11 islands), and in (c), Palawan (10 islands) and Sulu (5 islands).

Mammals on islands

We used Meijaard's (2003) detailed analysis and compendium to obtain a list of species on each of the islands (Table 2). *Sus barbatus* has since been seen on Tawitawi (E.M. pers. obsv.). However, the number of species was the unit of analysis, because most genera were represented by only one species on each island (slope of 1.1 for species by genera), and analysis by genera would have produced a very similar result.

Meijaard (2003) excluded 18 species from his listing, including both of the region's macaques, *M. fascicularis* and *M. nemestrina*, because of the likelihood that humans brought them to the islands. Similarly, Heaney (1986) omitted commensals. We excluded Meijaard's 18 species, as well as *Rhizomys sumatrensis* on Simeulue, because we assumed that it is a mainland Asia species and probably introduced.

In total, the sample was 65 species in 42 genera. Per island, median = 7 species, range = 1-21; median = 5 genera, range = 1-18. As expected (Harcourt, 1999), number of taxa, whether genera or species, was strongly related to area of island (df = 25, F > 10.0, P < 0.005).

We accounted for body mass because it could affect both probability of rafting as well as survival post-disembarcation. Heaney (1986) remarked that most of the species on the small south-east Asian islands were rodents. Perhaps a relatively larger number of small-bodied individuals could fit onto a raft, thereby increasing the probability of successful establishment upon arrival (Kappeler, 2000). In addition, smaller animals need smaller rafts, effectively increasing the number of available rafts that could transport small animals. Alternatively, larger bodied animals might survive longer rafting journeys, because they can better withstand long periods of inclement conditions, such as lack of food and immersion in water (Houle, 1998). And perhaps if the raft breaks up during the voyage, the larger-bodied species are likely to swim longer distances and better survive risky landings at coastal areas with large surfs (Meijaard, 2005). On small islands, small-bodied animals are more likely to achieve sustainable populations than are large ones (Harcourt 1999). The combined result of all these variables suggests that medium sized animal species may enjoy relatively poor rafting success (Meijaard, 2005).

We obtained information on body mass of species

Table 2. Island genera and their characteristics. If more than one habitat, more common given first; body mass is median of congeners.

Genus (# Species)	Water edge		Median	Authority
	Narrow	Broad	Mass (kg)	
Aeromys	No	No	0.28	Robinson & Kloss, 1915
Aonyx	Yes	Yes	4.05	Lesson, 1827
Arctictis	No	No	8.35	Temmnck, 1824
Arctogalidia	No	No	2.4	Merriam, 1897
Callosciurus	No	No	0.3	Gray, 1867
Chiropodomys (3)	No	No/Yes	0.03	Peters, 1869
Crocidura	No	Yes	-	Wagler, 1832
Cynocephalus	Yes	Yes	1.1	Boddaert 1768
Exilisciurus	No	No	0.02	Moore, 1958
Hemigalus	No	Yes	2.0	Jourdan, 1837
Herpestes	Yes	Yes	1.4	Illiger, 1811
Hylobates	No	No	5.7	Illiger, 1811
Hylopetes (2)	No	No	0.31	Thomas, 1908
Hystrix	No	Yes	4.6	Linnaeus, 1758
Iomys	No	No	0.09	Thomas, 1908
Lariscus (2)	No	No	0.21	Thomas & Wroughton, 1909
Lenothrix	No	Yes	0.18	Miller, 1903
Leopoldamys (2)	No	No	0.37	Ellerman, 1947
Manis	No	Yes	6.0	Linnaeus, 1758
Maxomys (5)	No	No/Yes	0.15	Sody, 1936
Muntiacus	No	Yes	18.0	Rafinesque, 1815
Mydaus	No	Yes	2.5	F.G. Cuvier, 1821
Nasalis	Yes	Yes	7.0	E. Geoffroyi, 1812
Niviventer	No	Yes	0.08	Marshall, 1976
Nycticebus	No	Yes	2.0	E. Geoffroyi, 1812
Palawanomys	No	No	0.08	Musser & Newcomb, 1983
Petaurista	No	Yes	1.8	Link, 1795
Petinomys	No	No	0.37	Thomas, 1908
Presbytis (2)	No/Yes	No/Yes	6.18	Eschscholtz, 1821
Prionailurus	Yes	Yes	5.0	Severtzov, 1858
Ptilocercus	No	No	0.05	Gray, 1848
Rattus (2)	No	No	0.225	G. Fischer, 1803
Ratufa (2)	No	No	0.5	Gray, 1867
Rhinosciurus	No	No	0.25	Blyth, 1856
Simias	No	Yes	7.9	Miller, 1903
Suncus	No	No	-	Ehrenberg, 1832
Sundamys	No	Yes	0.4	Musser & Newcomb, 1983
Sundasciurus (6)	No/Yes	Yes/No	0.18	Moore, 1958
Sus	Yes	Yes	96	Linnaeus, 1758
Tragulus (2)	Yes	Yes	4.25	Pallas, 1779
Tupaia (7)	No	Yes/No	0.135	Raffles, 1821
Viverra	No	Yes	8	Linnaeus, 1758

from 11 sources (Emmons, 2000; Hayssen, 2008; Lekagul and McNeely, 1977; Meijaard and Groves, 2004; Miller, 1905; Nakagawa et al., 2007; Payne et al., 1985; Sody, 1940; Soligo and Martin, 2006; Yasuma, 1994, 1999). If we could not find the body mass of the species, we used values of the closest relative that we could find of a similar size. This approximation was used to estimate the mass of 32 of the 65 species.

We did not account for phylogeny, but assumed that every rafting was effectively an independent event. Phylogeny is a poor predictor of the co-occurrence of pairs of mammals on islands in insular South-east Asia (Cardillo and Meijaard, 2010).

Water-edge habitat of species

We divided species into two categories: water-edge and non-water-edge (Table 2). For habitat designations, we used the IUCN Red List of Threatened Species (2012), Lekagul and McNeely (1977), Payne et al. (1985), and Yasuma and Andau (2000). We used a narrow and a broad classification of water-edge. In the narrow classification, we included species with aquatic habitats described as "water-edge", "occasionally by rivers", and 'mangrove'. We excluded species with habitats described as "streams" or "close to water", assuming that streams and lakes were unlikely sources for ocean-going rafts. If the literature did not highlight "preference for water", we classified the species as "non-water-edge". In the broad definition, we classed all species described to have any preference and association with water as "water-edge", including species with a wide habitat tolerance.

The sample included 11 water-edge species narrowly defined, and 60 non water-edge. Broadly defined, the sample consisted of 32 water-edge species, and 37 non water-edge.

Area of islands

For a water-edge species to survive on an island, we assumed that the island must also have suitable habitat available --- such as water-edge habitat. We did not have information on the vegetation of the islands, but there are plenty of rivers on the islands (Shively, 1997; Whitmore, 1984; Whitten, 1982). As a quantitative measure of potential water-edge habitat, we used area of islands, assuming that larger islands would usually have more coastal perimeter and more rivers, and hence would have a greater area of riverine and water-edge forest. We obtained areas of islands from Harcourt (1999), Heaney (1984), and various online sources, including maps from Google, from which we calculated areas as length by breadth when we could not find text statements of size.

Forest on islands

Assuming that ocean-going rafts are likely to originate from forests bordering rivers, and therefore carry forest-dependent species, we included whether or not an island harbored forest-dependent species in the multi-factorial analysis. We assumed that, if there were no forest dependent species the resident species were less likely to have arrived by rafting than otherwise. The distribution of forest-dependent species in our data set is as in Fig. 2 in Meijaard (2003).

Another reason to include forest-dependent species in the analysis is because regions of the Sunda Shelf were deforested at the height of the last glacial maximum (Brandon-Jones, 1998, 2001; Heaney, 1991; Meijaard, 2003). However, it seems likely that riverine forest could have remained (Colyn et al., 1991; Dupont and Weinelt, 1996), as it does in arid regions nowadays. In the context of probability of successful rafting, the influence of ice-age aridity might be lower than expected. Nevertheless, none of the Sulu islands or their close neighbors have forest-dwelling mammals, perhaps because of recent, near-total clearance of forests on the islands (Stattersfield et al., 1998). Therefore, the Sulu islands should have a significantly different complement of species by comparison to the Mentawai and Palawan island groups.

Analysis

The data were compiled by an assistant who knew of Abegg and Thierry's (2002) prediction, but not any views we might have had on the probability of rafting as a means of arrival on oceanic islands.

We examined the combined influence of all the hypothesized variables with a binomial logit generalized linear model, with number of water-edge species and total number of species as the response variables, and the category of island (deep-water, shallow-water), area of island, median body mass of species on the island, presence-absence of forest species on the island, and island region as potential determinants.

For a sample of N = 26, five potential influences are too many for reliability of the precise resultant values. We used the full model to identify likely and unlikely influences, and then ran the model with only the likely effects to obtain a better idea of their relative strength of influence.

For the multivariate models we provide values for the Akaike Information Coefficient AICc, a measure enabling comparison of how well models performed, i.e. how well the independent variables explain the dependent variable (Burnham and Anderson, 2001). The smallest AICc indicates the best model. AICc, as opposed to AIC, corrects for small samples by penalizing extra parameters. This is important in this case because the number of compared to the sample size.

All statistical tests were performed with JMP 9.0 (SAS Institute Inc., 2011); probabilities are two-tailed; probabilities of 0.1 or more are presented as 'ns'.

Results

Narowly defined water-edge species

The complete model, with five potential effect variables, indicated only nature of island (deep- or shallow-water) and median body mass of species on the islands as obvious significant correlates of the number of water-edge species on islands compared to total number of species (Table 3A; Fig. 2). Contrary to the expectation, deep-water islands had fewer water-edge species compared to non-water edge (Fig. 2).

Table 3a-3d. A) Binomial logit generalized linear model of number water-edge species (NARROW definition) in relation to total number of species as predicted by: deep- or shallow-water islands; median body mass of mammalian fauna on the islands; area of islands; whether islands forested or not, and the island group (Mentawai, Palawan, Sulu). B) Similar to 3A, but results for only significant parameters. C) Similar to 3B, but two outlier islands omitted (one each in Palawan and Sulu groups). D) Similar to 3B, but Palawan group of islands omitted.

A)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole Model			25.1	0.0004	60.1
Deep / Shallow	1.01	0.29	14.2	0.0003	
Log median body mass	0.71	0.22	12.4	0.0005	
Log area (km^2)	0.20	0.19	1.1	0.3	
Forest / Non-forest	0.35	0.36	1.0	0.3	
Island Group			0.9	0.7	

B)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole			21.7	0.0001	53.0
Deep / Shallow	0.69	0.22	11.1	0.0009	
Log median body mass	0.64	0.17	17.7	0.0001	

C)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole			12.9	0.002	51.6
Deep / Shallow	0.62	0.22	8.06	0.005	
Log median body mass	0.57	0.18	10.5	0.002	

D)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole			13.3	0.002	36.6
Deep / Shallow	0.78	0.27	9.36	0.002	
Log median body mass	0.58	0.22	7.26	0.008	

Omitting the three non-significant variables ($P > 0.3$), and reiterating the model with just two variables (a more reasonable number for the sample size) confirms nature of island and average island body mass as statistically significant correlates of the number of water-edge species on islands compared to total number of species, and with a better fit as indicated by the AICc value (Table 3B).

The model had two significant outliers, one Sulu island and one Palawan island, both considered shallow-water islands. If these are omitted, island type and body mass remain as significant predictors, and now with the smallest AICc value (Table 3C)

A reiteration excluding Palawan (e.g. it might not be a true deep-water group of islands) continue to indicate both "type of island" and "body mass" as influential variables, but with island type showing a stronger effect than body mass (Table 3D). Deep-water islands had fewer water-edge species in relation to total number than did shallow-water islands. Island group was not a significant influence ($\chi 2 = 0.1$).

Predictions went both ways in relation to the likely body size of rafting animals, and therefore also to the size of animals on deep-water compared to shallow-water islands. Our results indicated that although narrowly defined water-edge genera were perhaps larger than non-water-edge ($z = 1.7$, $P < 0.09$, $N = 10$, 17, Wilcoxon/Kruskal-Wallis Rank Sums), sample species on deep-water islands were in average larger than those on shallow-water islands (Fig. 3). Water-edge taxa (larger bodied than non-water-edge species) were found on shallow-water islands, whereas large-bodied taxa (water-edge on average) were on found on deep-water islands.

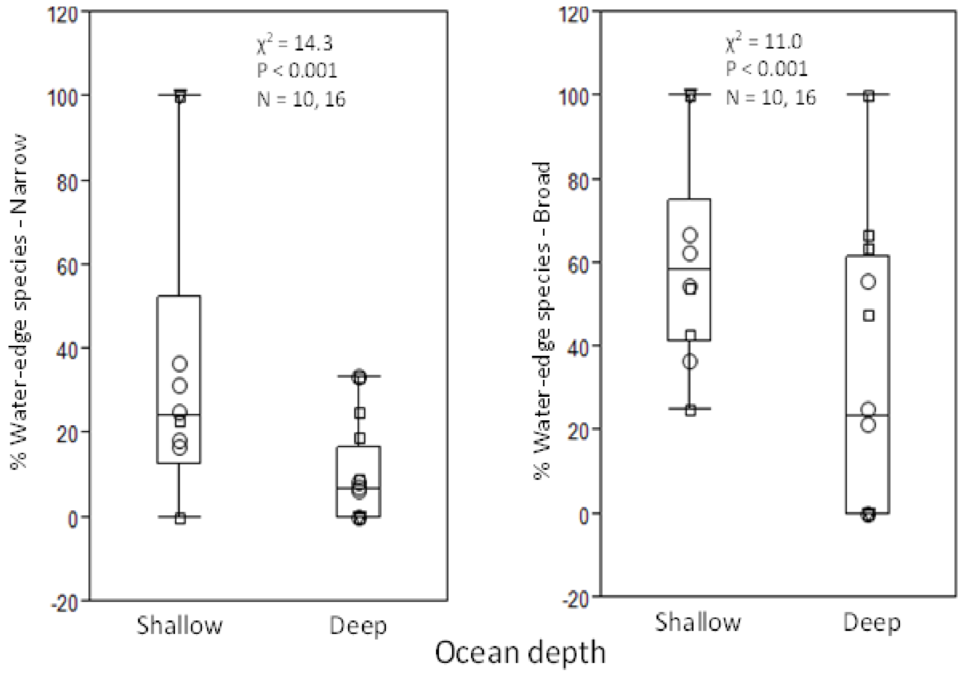

Figure 2. Shallow (N=10) vs Deep (N = 16) islands compared for percentage of "Narrowly" and "Broadly" defined Water-edge species. Circles - Mentawai; triangle - Sulu; square - Palawan. Median, central 50% range and total range shown. Statistics from full model.

Broadly defined water-edge and non-water edge species

Here, the number of the two types is more similar than when narrowly defined, and island type (deep- vs. shallow-water) and body mass were significant correlates (Table 4A). Omitting the non-significant correlates, and reiterating the model reveals a better fit (Table 4B). Contrary to our expectations, water-edge species were more common on shallow-water islands than on deep-water islands, even though water-edge genera were larger than non water-edge ($z = 2.4$, $P < 0.02$, N = 17, 10, Wilcoxon/Kruskal-Wallis Rank Sums), and large-bodied taxa were more common on the deep-water islands (Fig. 3).

With the model's one significant outlier removed from the sample, sea depth and body mass remained significant predictors of presence on deep-water compared to shallow water islands (Table 4C). A preponderance of heavier taxa were on the deep-water islands.

Even though "island group" was not a significant variable, we made another iteration of the model without Palawan, because the Palawan group of islands might have been separated from a source for a shorter time than the Mentawai and Sulu groups of islands. Island type (deep- vs. shallow-water) and body mass remained significant variables (Table 4D): water-edge species were more common in relation to total number of species on shallow-water islands than on deep-water islands, and larger species were most common on deep-water islands.

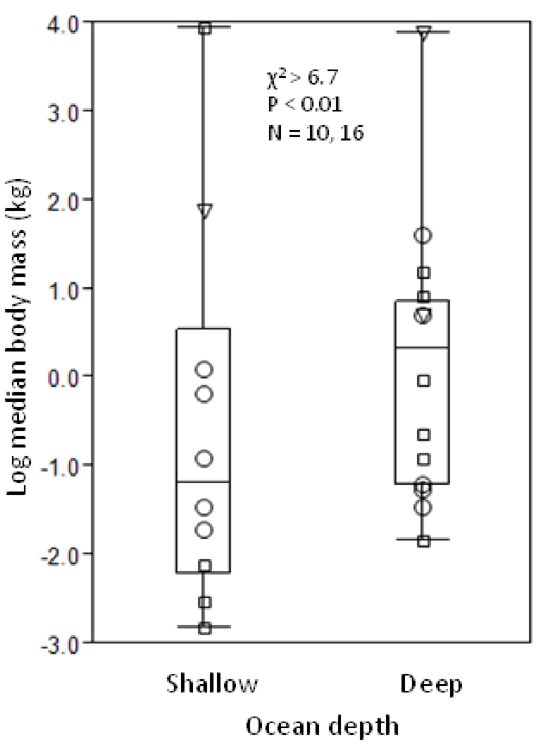

Figure 3. Shallow and Deep islands compared for median body size (kg) of species. Circles - Mentawai; triangle - Sulu; square - Palawan. Median, central 50% range and total range shown. Statistics from full model, for Narrow and Broad definitions of water-edge species.

Table 4a-4d. A) Binomial logit generalized linear model of number water-edge species (BROAD definition) in relation to total number of species as predicted by five variables: deep- or shallow-water islands; median body mass of mammalian fauna on the islands; area of islands; whether islands forested or not, and the island group (Mentawai, Palawan, Sulu). B) Similar to 4A, but results for only significant parameters. C) Similar to 4B, but one outlier island omitted (in Palawan group). Similar to 4B, but Palawan group of islands omitted.

A)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole Model			20.9	0.002	80.9
Deep / Shallow	0.64	0.20	11.42	0.001	
Log median body mass	0.49	0.19	7.93	0.005	
Log area (km^2)	0.03	0.14	0.03	0.9	
Forest / Non-forest	0.003	0.27	0.00	1.0	
Island Group			5.41	0.07	

B)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole Model			15.72	0.0005	77.6
Deep / Shallow	0.53	0.16	10.78	= 0.001	
Log median body mass	0.42	0.14	10.80	= 0.001	

C)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole Model			17.03	0.0003	74.8
Deep / Shallow	0.55	0.17	11.70	0.001	
Log median body mass	0.44	0.14	11.80	0.001	

D)

Model / Predictors	Estimate	$\sigma_{\bar{x}}$	χ^2	P <	AICc
Whole Model			18.67	0.0001	45.3
Deep / Shallow	0.76	0.21	15.36	0.0001	
Log median body mass	0.45	0.18	6.63	= 0.01	

Discussion

Abegg-Thierry (2002) predicted that, if mammals rafted to islands in the Sunda region, there should be a greater proportion of water-edge species on oceanic islands than on continental islands. The prediction was not supported by our hypothesis. Instead, the analyses indicated the opposite i.e. a smaller number of water-edge species by comparison to total number of species existed on deep-water islands than on shallow-water islands. The adequacy of the prediction's test depends on deep water islands being disconnected from the source. Excluding the Palawan group of islands from the analysis changes the results for taxa classified as water-edge or not under the broad classification (body size not significant), which suggests that the Palawan group might be different and perhaps more connected to other sources than the other two island groups.

Our study is, of course, only a preliminary test of the rafting hypothesis, given that deep-water continental islands are not as distantly isolated as are oceanic islands. However, the rafting hypothesis for the distribution of mammals in the Sunda region and elsewhere has rarely been rigorously tested either quantitatively or with novel predictions. Therefore, we suggest that our rejection of the Abegg-Thierry prediction should be considered.

In addition to habitat, body size seemed to affect presence on deep-water compared to shallow-water islands in the multi-variate analyses. Deep-water islands had larger-bodied taxa on average than did shallow-water islands.

These are contradictory results. The taxa on deep-water islands are larger than those on nearby shallow-water islands. Water-edge taxa are larger than are non-water-edge. Yet water-edge taxa are less likely on deep-water islands than are non-water-edge taxa. Among the variety of possibilities by which body size could influence mammals reaching or surviving on islands, this anomaly could be explained by the larger bodied animals' better swimming endurance. This might be the case when considering that *Sus,* by far the largest mammal recorded on the islands, is a strong swimmer and recorded to have swum more than 40km into the ocean (Caldecott et al., 1993). Other factors than those tested might also influence passage to islands.

Over a century ago Wallace (1876, Ch. 13) suggested that humans might have carried Asian species east of what now known as the Wallace Line, a division between the Oriental and the Australian biogeographic regions. Acknowledging the possibility of human agency, both Meijaard (2003) and Heaney (1986) excluded several species from their lists of island species. For instance, Meijaard excluded the long-tailed, *Macaca fascicularis*, and pig-tailed macaques, *Macaca nemestrina*. People in the region use both species to collect fruit from trees (Sponsel et al., 2002), and transported the long-tailed macaque in colonial times to the eastern-most island in its range, Ngeaur in Palau, east of the Philippines, and hence east of the Wallace Line (Wheatley et al., 2002). If primates constituted part of the human diet, as they do in the Mentawai islands (Fuentes, 2002), it would be common practice in the humid tropics to transport them as "live food", however, with the possible risk of loosing some through escapes. These "escapees" have probably founded new island populations. Meijaard (2003) also excluded the Asian palm civet, *Paradoxurus hermaphroditus*, because the local people often keep it as a pet, as Wallace (1876, Ch. 13) reported.

Several non-flying species on islands are endemics, which suggests that they have been isolated for several thousand years. Nevertheless, that duration does not preclude transport by humans. Wild animals have been traded across hundreds of kilometers for centuries (Somerville et al., 2010), and identified domestication of animals began around 10,000ya (Driscoll et al., 2009). The keeping of wild animals could be a far more ancient practice, bearing in mind that it occurs in traditionally-living societies throughout much of the world (Fuentes and Wolfe, 2002).

Accidental transport of small-bodied species is possible too, even if they were not the commensals that Meijaard (2003) and Heaney (1986) eliminated from their counts. It is easy to imagine some wild mice sought refuge in thatching material and were carried to an island. Such accidental transport could easily explain how the <50g skink, *Lipinia noctua*, dispersed so quickly across much of the Pacific (Austin, 1999). A similar explanation could apply to the 80g Polynesian rat, *Rattus exulans*, although it constituted part of Polynesians' stable diet (Matisoo-Smith & Robins, 2004) and could have been transported deliberately.

Humans reached Australia at least 45,000 years ago (Gillespie, 2008; Hudjashov et al., 2007; O'Connell and Allen, 1998; Oppenheimer, 2003; Pope and Terrell, 2008). At that time, Australia was separated by 100km of ocean, measured from any part of South-east Asia from which humans could have arrived. In other words, humans have had sea-going craft for at least 45,000 years - assuming that the Australian continent was not populated by humans swept in by tsunamis (Morwood and Jungers, 2009; Ruxton and Wilkinson, 2012).

Fooden (1995) suggested that the various morphological differences between island forms of the long-tailed macaque were sufficiently significant to exclude the possibility of transport by humans. However, if the first humans in the region brought macaques with them, and if a macaque generation time is 10 years, it follows that a time-period of 45,000 years could result in approximately 4,500 generations of macaques. Under significantly different habitat circumstances this is ample evolutionary time to produce forms specific to each island. Most of the other mammals in the region are smaller bodied than are primates, and have shorter life cycles than primates (Harvey et al., 1987; Read and Harvey, 1989). It is reasonable to expect that their generation time is even less than 10 years. McNab (2002) reviews studies that suggest speciation of an oceanic island duck *Chenonetta* in less than 10,000 years, as well as speciation of a 2kg marsupial, *Spilocuscus*, within 2,000-13,000 years.

Transport by humans may indeed explain the apparent discrepancy between the water edge species domination on shallow-water islands and larger-bodied species on deep water islands. But what if water-edge species are larger than non-water-edge species on average? What if humans were more likely to deliberately transport large-bodied live animals to deep-water islands than shallow-water before domestication? This could be due to the former were less easily reached and so required resident food supply? That is pure speculation, of course, but no more so than natural rafting in the absence of any other evidence than the presence of a terrestrial animal on an oceanic island.

Transportation by humans cannot explain the presence of island endemics that arose before humans (or boating hominids) arrived. Examples include the Mentawai island macaques (Abegg and Thierry, 2002; Ziegler et al., 2007). All older origins are irrelevant to the rafting theory, because sea-levels at origin of the Mentawai 2.5mya were lower than in the Pleistocene (Ziegler et al., 2007).

Humans are not the only non-rafting agents of cross-sea transport. "Owls transport mice alive?" wrote Darwin on page 82 of his Notebook B on transmutation of species (Darwin, 1837-1838). Male merlins, *Falco columbarius*, caching food during the breeding season will sometimes leave live lizards in their cache (Jim Tigan, West Coast Falconry Academy, California, pers. comm.). Is transport across water of live animals by raptors less likely than transport by rafts? Even some of the larger mammals could have been so transported, given that the Philippine eagle, *Pithecophaga jefferyi*, can carry prey weighing more than 10 kg (Birdlife International, 2001), which is larger than all but the bearded pig, *Sus barbatus*, of the species in our dataset.

Our test of the Abegg-Thierry (2002) hypothesis is preliminary. Not only are the deep-water islands in our sample not "true" oceanic islands, but several are very close to the major source islands. The next step should be a comparison of true oceanic islands with shallow-water islands that might have been populated from the same source, or alternatively a comparison of oceanic islands with the adjacent mainland from where the island inhabitants are assumed to have originated from. A good sample might be the mammalian community of the Andaman and Nicobar islands off Thailand in contrast to the community of the shallow-water islands of the Mergui Archipelago along Thailand's coast, or of the past community of the Thai isthmus. Hypotheses of human transport could be tested by relating dates of arrival of humans as judged by archeological evidence to molecular dates of origins of island forms.

Although our comparison offers only a preliminary test of the Abegg-Thierry prediction, the test is a logical extension of their prediction, and has the benefit of being one of the few explicit tests of the rafting hypothesis for the distribution of mammals in insular South-east Asia.

In conclusion, we do not dismiss the fact that terrestrial mammals could have dispersed by rafts across the South-east Asian islands. We believe, however, to explain the distribution of mammals in the region, rafting is often used as a default explanation void of systematic testing, alternative predictions and in need of more analyses similar to the one we have presented in this paper.

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Camera trapping as a conservation tool in a mixed-use landscape in East Kalimantan

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Abstrak

Perangkap kamera telah digunakan dari 2008-2012 untuk survey dan pemantauan satwa liar pada perkebunan kelapa sawit di Kalimantan Timur. Sebanyak 40 kamera dipasang secara berotasi pada habitat utama di lebih dari seratus lokasi hutan yang rusak dengan tingkat usia berbeda, di kawasan yang telah ditetapkan perusahaan sebagai kawasan lindung dan di blok kelapa sawit yang berumur 4-12 tahun. Kesemuanya berada atau berdampingan dengan batas areal operasional PT REA Kaltim. Kamera dipasang selama 8628 hari atau sekitar 4.5 tahun (Januari 2008-Juni 2012) disepanjang jalur hewan atau lokasi adanya sarang orangutan atau bukti lainnya dari aktivitas satwa. Sebanyak 36 jenis mamalia dari 21 famili dapat diidentifikasi dari foto yang diperoleh dalam areal studi. Sekitar 54% diantaranya jenis yang dilindungi hukum Indonesia. Jenis yang paling banyak terfoto adalah Beruk, *Macaca nemestrina,* berjumlah 1.450 foto, diikuti oleh babi jenggot, *Sus barbatus*, berjumlah 1.126 foto. Beberapa jenis, seperti *Arctogalidia bivirgata*, tidak pernah terfoto oleh kamera yang dipasang pada permukaan tanah. Hasil ini cukup menggembirakan untuk kegiatan konservasi satwa, terutama relatif besarnya jumlah jenis mamalia yang ditemukan, menghuni mungkin 18% areal hutan yang berbatasan dengan perkebunan. Berikut disajikan sebuah bahasan singkat mengenai rencana pengelolaan oleh REA Conservation Management Plan.

Abstract

Camera traps were used from 2008-2012 to survey and monitor wildlife within an oil palm plantation in East Kalimantan. A total of 40 trail cameras were rotated through major habitats at over a hundred sites in disturbed forests of various ages of the company's designated Conservation Reserves, and in oil palm blocks from 4-12 years old, all within or adjacent to PT. REA Kaltim operational boundaries. Cameras were set for a total of 8628 camera-nights over approximately 4.5 years (January 2008 - June 2012) along animal trails or at sites with orangutan nests or other evidence of animal activity. A total of 36 species of mammals from 21 families could be identified from photographs within the study area. Approximately 54% of species photographed are legally protected in Indonesia. The most photographed species was the Pig-tailed Macaque (*Macaca nemestrina*), total 1450 photos, followed by the Bearded Pig (*Sus barbatus*), total 1126 photos. Some species, such as Small-toothed Palm Civet, *Arctogalidia bivirgata*, were never photographed by ground-based cameras. The results are encouraging for species conservation, primarily because of the relatively large number of mammal species that have been found to inhabit perhaps 18% of the originally forested area of the plantation boundaries. A brief summary of subsequent actions taken under the REA Conservation Management Plan is provided.

Keywords: Camera trapping, oil palm, wildlife conservation, orangutans, East Kalimantan, Borneo

Introduction

The island of Borneo is one of the most biodiverse units of the Sunda Region (Azlan and Engkamat, 2006), but has undergone rapid agricultural development, especially for the oil palm (*Elaeis guineensis*). Palm oil is one of Indonesia's largest foreign exchange earners, with several million metric tons exported, valued at over ten billion US Dollars in 2011. Oil palm plantations continue to expand across landscapes in Sumatra, Kalimantan and most recently, in West Papua.

The PT. REA Kaltim Estates (REA Kaltim), a foreign-owned but Indonesian operated plantation company, occupies an approximately 30,000 hectare site in the upper region of the Belayan River, a tributary of the Mahakam River in East Kalimantan. Prior to 1970 the upper Belayan watershed was densely forested with

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timber species of commercial diameters ≥ 60cm. Some riparian areas contained regenerating forests derived from old patches of villagers' shifting agriculture plots. Whitmore (Whitmore and McKenzie, 1995) surveyed the area in the mid-1990s and compiled REA Kaltim's earliest environmental impact assessment. They indicated that the forests were rich in both flora and fauna, and he recommended protecting substantial areas within the plantation, along rivers as well as areas too wet (swampy) or steep for productive cultivation (Whitmore and McKenzie, 1995).

The cultivation of oil palm on a large scale is one of the most serious causes of the decline in Southeast Asia's biodiversity in general, with losses of up to 85% by the year 2100 (Koh and Wilcove, 2009; Sodhi, et al., 2010). In 2007 a Conservation Department (REA KON) was activated to address important issues in the area of the PT. REA Kaltim Estates, initially focusing on the conservation of orangutans (*Pongo pygmaeus*). This species was regularly observed in forested areas within the company's land title (Hak Guna Usaha) and had caused damage to palm seedlings, eating the central shoot. In 2007, an adult orangutan allegedly bit an estate worker. The work of REA KON rapidly expanded into a general evaluation, monitoring and assessment of the wildlife of the total plantation area of more than 25,000 hectares, of which just under 20% remained forested, and was subsequently proposed as permanent conservation reserves (CR).

During Whitmore's surveys in 1994, the upper Belayan was still under secondary forests, although substantial damage to the canopy had been caused by intensive timber extraction, particularly along the northern bank. In 1996 oil palm planting began along the south/west bank of the river. By 2007, forest remnants remained only in moist areas of the river's flood plain, as well as peat swamp forests, but even these areas again suffered serious damage in 1983 (Whitmore, 1995) and more extensively during the 1997-1998 El Niño Southern Oscillation (ENSO). Some oil palms were also damaged, but virtually all survived the fire.

REA Kaltim was the first oil palm company to develop extensive plantations the Upper Belayan landscape. Although soil and crop suitability surveys began as early as the late 1980s, the company finally established a presence in 1995 via an office located on a raft at the riverside at a site now known as Pulau Pinang (H.L. Schaefer, Pers. Comm.) Along the banks of the Belayan, its plantations now cover about 30,000 Ha, of which about 18% was set aside for conservation (http://www.rea.co.uk/rea/en/business/history). These CRs consist mostly of riparian forests, areas with unique habitats such as peat swamp or wetlands, and a few steep areas of more than 25° slope. Experience has shown that such formally identified and managed CRs contribute significantly to local species diversity, especially some endangered species still persisting in these forests.

A minimum of 285 mammals species have been identified on Borneo (Earl of Cranbrook, Pers. Com.) of which over half are terrestrial species. A relative modest number are mentioned in environmental reports held by REA Kaltim's management. Since species richness is an important indicator of environmental quality (Kitamura et al., 2010), widespread persistent biodiversity reflects successful conservation management. Loss of original species from the landscape and negative impacts from human disturbance signals significant deterioration in the conservation values of an area.

Mammals are often difficult to detect, even from the most careful walking surveys. Many are cryptic and nocturnal, while others quickly learn to avoid humans. This scenario especially applies to forested habitats outside protected areas.

Rapid development in the use of camera traps over the past decades has improved the ease of detection of both common and cryptic mammal species (Azlan and Sanderson, 2007; Cheyne, et al., 2010). In 1997, WWF-Indonesia introduced the use of camera traps for biological inventories in the hill and submontane forests of Kayan Mentarang National Park in East Kalimantan and, combined with data from walking surveys, reported a total of 94 mammal species (Wulffraat and Samsu, 2000). Research using camera traps at numerous sites in Kalimantan and Malaysian Borneo has been used to inventory mammal species from protected areas (Mohd. Azlan et al., 2003; Kawanishi and Sunquist, 2003, Azlan and Engkamat, 2013) as well as in disturbed areas such as logged forest (Mohd-Azlan and Sharma, 2006, Mohd-Azlan, 2006), tree plantations (Belden, et al., 2007, Giman, et al. 2007; McShea, et al., 2009), and degraded rural habitats occupied by humans (Rustam, et al., 2010).

By implementing long term inventory and monitoring of mammal species within and at the boundaries of REA Kaltim, the purpose of this study was to determine whether the company's permanently forested CRs actually serve their stated purpose as refugia for biodiversity, especially mammal species. This effort also seeks to provide additional information into the ability of an indigenous mammal fauna, especially Rare, Threatened or Endangered species, to persist in mixed-use landscapes. The present inventory was set up to obtain empirical field data concerning the survival of Endangered biodiversity within REA Kaltim's operational area, especially orangutans (*Pongo pygmaeus*). Camera trapping was more intense and repetitive in areas where orangutans were detected because of their conservation status and the need for long-term monitoring of this species. We hope that the value of the conclusions can be validated over a longer period, as data collection through camera trapping continues at these sites.

Study area

The study took place within riparian and dryland areas within the PT. REA Kaltim Plantations land title boundaries (Latitude : 00 9' 30"N – 00 31' 39"N ; Longitude : 1160 3' 24" E – 1160 27' 33" E), mostly within the approximately 5,000 hectares of its CRs (Fig. 1). These patches of secondary forest remnants lie mostly along small rivers, although some are isolated within oil palm blocks. All have undergone several cycles of licensed mechanical logging, illegal timber harvesting, and in some cases ENSO fires. The canopy is often less than 10m high and frequently dominated by pioneers such as *Macaranga gigantea* and *Melicope glabra*. Large remnant trees of the Dipterocarpaceae are widely dispersed, some species now only surviving as saplings. Of the existing trees >50 cm DBH, only few are dipterocarps. Most are non-timber species such as *Irvinia spp.* and other members of the Euphorbiaceae. Multitudinous gaps of new growth or belukar often connect forest patches. Dayak villagers still claim areas for slash-and-burn agriculture away from the main river and up several kilometers of most navigable streams. These disused plots exist in various stages of recovery from less than ten years, to several decades old. Most are rich in both wild and cultivated fruit trees.

Methods

Camera traps by Trailwatcher© 2035 Digital Scouting System, consisting of a SONY Cybershot 7.1 Megapixel (MP) camera equipped with an external infrared sensor, in a Pelican Model 1020 housing, assembled and sold by David Helmly, Monticello, Georgia USA. This heat sensor based camera is durable and reliable, working well in the humid tropics of Kalimantan.

All but two of the Trailwatchers units used a Sony Cyber Shot 7.1 MP, except for two newer Models (W55) equipped with 12.1 MP SONY cameras. All Trailwatcher cameras are triggered by thermal sensors reacting to the presence of a heat source within a distance of 10-12 meters. The cameras were oriented along a generally North-South axis to avoid "ghost" images caused by direct sunlight or its reflection from the surrounding vegetation. All camera trap positions were recorded using a GPS (Garmin 60CSx), and have a time/date stamp for every image.

A total of 40 trail cameras were rotated through the major habitats of the PT. REA Kaltim operational area (Fig. 1). These included oil palm blocks from 4-12 years old, and disturbed forests of various ages that have resulted from episodes of intense logging, and or fires set either to clear areas for planting oil palm, for slash-and-burn farming or related accidental fires occurring during periods of extended drought. We attempted to obtain a general picture of the distribution of the mammal fauna of these areas based on an assessment of species recorded by the camera traps. The cameras were set in forested areas, 50-200m from the edge of streams/rivers that serve as a buffer for small rivers that traverse oil palm blocks. Camera units were strapped to trees ±50cm above the ground flanking wildlife trails, and a scent lure placed into the crevice of a stick ±3m in front of the camera. During the last few months of the study (424 camera days), 17 camera units were set up in trees within the CRs, 10-12m above the ground.

Commercial lures were used to attract animals to the cameras, including, Blackie's Blend Three Meat scent lure, Carman's Magna Glan and Fox Hollow-Coyote Gland lures; Caven's Cat Passion lure; O'Gorman's Powder River Paste, and Cat Call Lures; Marsyada's Midnight Mist; and a home-made Margarine-Honey mix.

Camera images were downloaded, and batteries checked every two weeks, the latter replaced whenever necessary. Cameras were removed after one month and moved to a new location at least 500m away. All sites where orangutans had been photographed were revisited annually.

Cameras were set in pairs in representative habitat types along animal trails in all the REA Kaltim CRs.

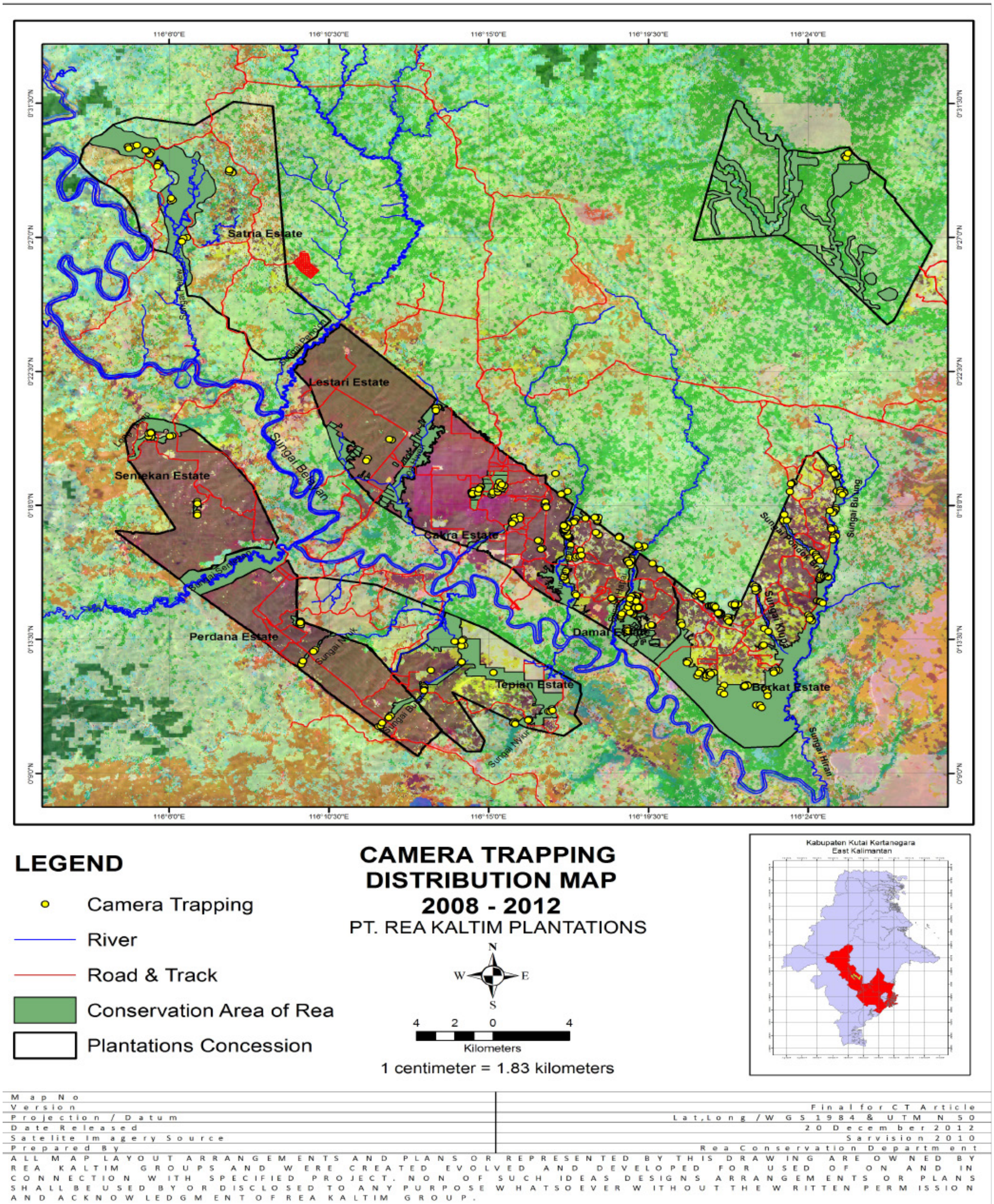

Figure 1. Map of the survey area and camera trap locations. A total of x8628 trap nights over 4.5 years recorded 36 species of mammals from 21 families.

Identifiable habitat types were: Lowland Dry Forests (HDRK), freshwater wetland or Flood Plain Forest (HR), and Peat Swamp Forest (HDRB). Camera traps were installed in oil palm blocks for a total of 19 camera-days. REA KON staff conducted regular surveys for other mammal species to determine their presence and distribution over a majority of the habitats within REA's operational area.

Results

A total of 8628 trap nights over approximately 4.5 years (January 2008 - June 2012) recorded 36 species of mammals from 21 families in the study area (Table 1). Approximately 54% of species photographed are legally protected in Indonesia (Decree 7, 1999). The most photographed species was the Pig-tailed Macaque (*Macaca nemestrina*) total 1450 photos, followed by the Bearded Pig (*Sus barbatus*), total 1126 photos. Carnivora and Pholidota were represented by nine species each (Tab. 1), followed by Primates (seven species) and Artiodactyla (four species) (Tab. 1).

Records of the activity patterns of most mammal species recorded by the cameras were not at variance with any records previously reported. All Primates except for *Tarsisus bancanus* were photographed exclusively during the day (Fig. 2), but were observed to differ in their sleeping habits. *Macaca nemestrina* slept in the low canopy (<10m) of small trees, while *M. fascicularis* slept higher up, in any remaining older emergents. All images of *Manis javanica* were obtained either in the late afternoon, or late at night and *Muntiacus spp*. were mostly photographed in the evening (1700-2100hrs) (Fig. 2), with one pair active just after midnight (0142hrs). *Sus barbatus* was active at virtually all hours of the day or night (Fig. 2).

Orangutans were routinely photographed in the Conservation Reserves of four estates. In Belayan, this species appeared to frequent land with a relatively flat contour containing a variety of freshwater marsh and peat swamp habitat. They were commonly recorded

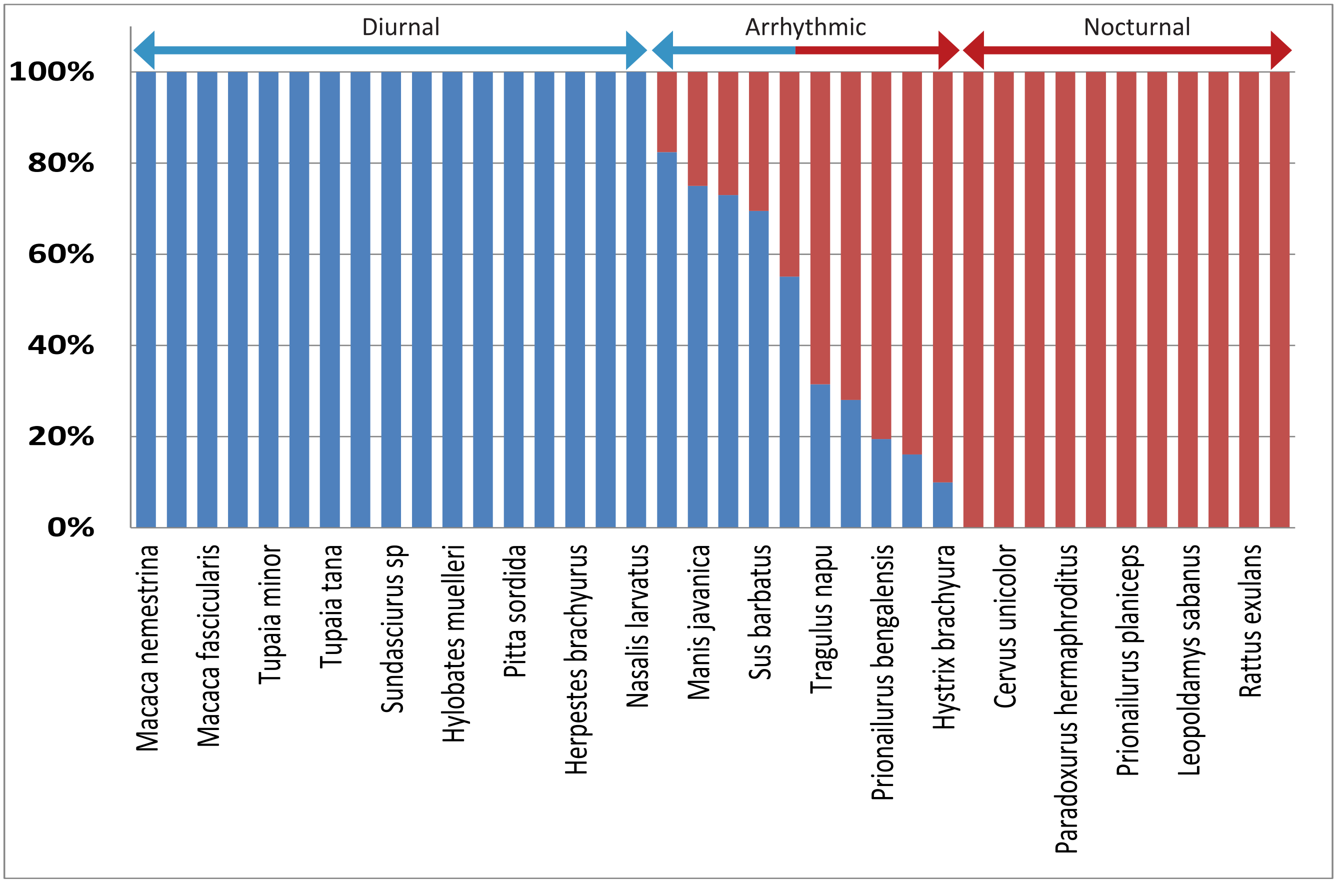

Figure 2. The diurnal rhythm of 19 different species recorded in this study. All primates except for *Tarsisus bancanus* were diurnal, whereas most of the carnivores and rats were nocturnal. The absence of predators like clouded leopard, *Neofelis diardii* may explain why bearded pigs, *Sus barbatus*, were active throughout the day and night.

Table 1. A list of species recorded from the study. DF = dry forest; WF = wet forest; BER =; DAM =; TEP =; etc etc; G = recorded on ground; A = recorded as arboreal.

Family/ Species	Latin name	English name	Num	Estate	Habitat	Pos
Insectivora						
Erinaceidae	*Echinosorex gymnurus*	Moonrat	42	BER, DAM, TEP, SAT	DF, WF	G
Scandentia						
Tupaiidae	*Tupaia gracilis*	Slender treeshrew	21	DAM	DF	A
	Tupaia minor	Pygmy treeshrew	49	BER, CAK	DF	A
	Tupaia tana	Large treeshrew	31	DAM, BER	DF, WF	G
Primates						
Tarsidae	*Tarsius bancanus*	Western tarsier	1	DAM	DF	G
Cercopithecidae	*Presbytis rubicunda*	Red leaf monkey	7	DAM	DF	A
	Nasalis larvatus	Proboscis monkey	1	TEP	WF	A
	Macaca fascicularis	Long tailed macaque	438	TEP, DAM, SEN, PER, BER, SAT, LES	DF, WF	G, A
	Macaca nemestrina	Pig tailed macaque	1450	All estates	DF, WF	G
Hylobatidae	*Hylobates muelleri*	Bornean gibbon	7	BER	DF	A
Pongidae	*Pongo pygmaeus*	Orangutan	178	BER, DAM, CAK	DF, WF	G
Pholidota						
Manidae	*Manis javanica*	Pangolin	8	DAM, CAK, PER, TEP	WF	G
Rodentia						
Muridae	*Leopoldamys sabanus*	Long-tailed giant rat	5	SAT	DF	G
	Rattus exulans	Polynesian rat	1	DAM	DF	A
	Sundamys muelleri	Mueller's rat	4	BER, DAM	DF	A
Sciuridae	*Callosciurus notatus*	Plantain squirrel	978	BER, DAM, CAK, LES, PER, TEP, SEN	DF, WF	G, A
	Callosciurus prevostii	Prevost's squirrel	13	CAK, SAT, SEN	DF	G
Hystricidae	*Hystric brachyura*	Common porcupine	272	BER, DAM, CAK, SEN, SAT	DF, WF	G
	Trichys fasciculate	Long-tailed porcupine	16	SAT	DF, WF	G
	Thecurus crassispinis	Thick-spined porcupine	274	BER, DAM, CAK, LES, SEN, PER	DF, WF	G
Carnivora						
Ursidae	*Helarctos malayanus*	Sun bear	49	BER, DAM, CAK, LES, SAT	DF, WF	G
Mustelidae	*Martes flavigula*	Yellow-throated marten	3	BER	DF	G
Viverridae	*Arctogalidia trivirgata*	Small-toothed palm civet	40	DAM	DF	A
	Hemigalus derbyanus	Banded palm civet	23	BER, SAT, TEP	DF	G
	Paradoxurus hermaphroditus	Common palm civet	39	CAK, DAM, SAT	DF	G
	Viverra tangalunga	Malay civet	239	BER, DAM, CAK, SAT	DF	G
	Herpestes brachyurus	Short-tailed mongoose	4	BER	DF	G
Felidae	*Prionailurus bengalensis*	Leopard cat	113	DAM, BER, CAK, SAT	DF	G
	Prionailurus planiceps	Flat-headed cat	16	TEP, DAM, PER	DF, WF	G
Artiodactyla						
Suidae	*Sus barbatus*	Bearded pig	1126	BER, DAM, CAK, SAT, SEN	DF, WF	G
Tragulidae	*Tragulus napu*	Larger mouse deer	626	BER, DAM, TEP	DF, WF	G
Cervidae	*Cervus unicolour*	Sambar deer	89	BER, DAM, CAK	DF	G
	Muniacus sp	Barking deer	176	BER, DAM, CAK, SAT	DF	G

on the forest floor, although walking surveys indicated that especially younger individuals spend much of their time in the low canopy of the disturbed/logged over or previously farmed regenerating forests.

All four species of the Viverridae were photographed at night only. *Viverra tangalunga* was always recprded on the ground in forested CRs whereas *Paradoxurus hermaphroditus* was photographed in tall oil palm (ca. 12 years old). *Hemigalus derbyanus* were only rarely seen in the study area, based on the number of images acquired, and *P. hermaphroditus* and *Arctogalidia trivirgata* were photographed in trees only.

Prionailurus bengalensis was one of two carnivores (along with *Paradoxurus hermaphroditus*) photographed inside the oil palm blocks. An active predator of rodents, an individual *P. bengalensis* was photographed at the edge of an oil palm block carrying a rat, *Rattus cf. tiomanicus* in its mouth.

Sus barbatus was detected both day and night (24 hours) (Fig. 1), and photographed in all forest types, as well as in the planted blocks. More than 80% of bearded pigs photographed were groups of from two to twelve individuals, on occasion a female with nursing young, or subadult siblings already foraging on their own.

Muntiacus spp. (*Muntiacus muntjac* and *M. atherodes* could not be distinguished) were photographed primarily on the North bank of the Belayan, which is contains larger CRs, and in the at at the time undeveloped and mostly forested Satria Eastate across the rive. Camera images indicated a general activity range as late as 21.00 - 01:00 hrs (Fig. 1), overlapping with that of the sympatric *Sus barbatus*. *Muntiacus* were frequently photographed in pairs. Sambar deer, *Cervus unicolor*, was photographed in forested CRs exclusively on the North bank, and never in the older, more populated and developed estates across the river. Sambar deer were active primarily late at night and during the early morning hours (89 total photos, taken between 2200-0400 hrs (Fig. 1).

Discussion

The objectives of this work have inadvertently gone beyond the original purpose, to survey and monitor a small population of orangutans affected by development of the PT. REA Kaltim Plantations in East Kalimantan. Nevertheless, the results are encouraging for species conservation, primarily because of the relatively large number of mammal species that have been found to inhabit 18% of the originally forested landscape (REA Conservation data, PT. REA Kaltim Plantations, 2012). Several species (*Pongo pygmaeus*, *Helarctos malayanus*, *Prionailurus planiceps*) assumed to be seriously threatened by plantation development and rising human population densities, still persist in the area, and have been routinely recorded on camera from 2008-2012. There was no verifiable loss of species from either the REA Conservation Areas or from the adjacent landscape during the study interval, although several species (*Martes flavigula*, *Herpestes brachyurus*) required a time span of continuous camera trapping of almost four years before their existence could be confirmed.

Camera trapping studies outside protected areas in Borneo have generally been conducted for less than one year, recording from 18–21 mammal species (Azlan and Engkamat 2006; Mohd-Azlan and Engkamat 2013). In some cases, the total number of species has not been mentioned since the targets were specific groups, such as small carnivores (Wells, et al. 2005; Brodie and Giordano 2011; Cheney, et al. 2010; Cheyne and MacDonald, 2011; Mathai et al. 2010). Few studies have extended for more than three years, the longest in Sarawak (Belden, et al. 2007) and another in East Kalimantan (Rustam, et al. 2010). Both of these studies were undertaken in areas of degraded forest with scattered human occupation. Both also demonstrated the existence of many more mammal species than might have been predicted based exclusively on the condition and high level of disturbance of the habitat.

In general, more mammal species in Hulu Belayan were photographed along North/East bank of the Belayan River, compared to those seen on the South/West bank. Species recorded exclusively on the north bank totaled 19, exclusively found on the south bank, only two, while a total of 14 species were photographed on both sides of the river. These results were likely influenced by camera trapping effort, with four times more trapping days in the north bank, compared to the south bank. The south bank is also less forested, and has a higher density of human population compared with the north. In any case, surveys restricted to one or the other side of the Belayan would have provided quite differing outcomes.

Orangutans are confined exclusively to the northern side, except for a single unconfirmed report from the SYB Tepian Estate, an area with some stands of original peat swamp forest across from the Damai Estate, where orangutans are consistently seen.

Orangutans continue to occupy the Damai and Berkat Conservation Reserves, although this population has never been reported in any published survey articles previously on the distribution of the species. Perhaps because of the low canopy in all forests within the operational area, orangutans of all ages, and not just large adults, were photographed on the ground. It has been suggested that the subspecies *Pongo pygmaeus morio* of East Kalimantan spends more time on the ground than other subspecies of orangutan (Ashley Leiman, Pers. Comm.). No orangutans were ever photographed in the heavily forested areas of the Satria estate of the South bank, and little evidence was seen of their presence, possibly because of the proximity of a several villages, and several active coal mining concessions. One encouraging aspect for conservation of this species in the areas adjoining the Damai and Berkat Eastates was that over four years, the cameras photographed four new babies still nursing from their mothers (two in Berkat Estate in 2010, and one in 2011; one in Damai Estate, 2012).

In Lambir Hills National Park, Azlan and Engkamat (2006) identified 11 families and 18 species of mammals. *Macaca nemestrina* was most frequently photographed (63 photos), as was the case in the Belayan study. However, in Lambir Hills photos of large mammals were infrequent, and only a single bearded pig was photographed over 1127 camera trap-nights. Their perceived low densities were attributed to illegal hunting. Such speculations were however not supported by direct evidence (dead animals, carcasses, interviews concerning declining rates of offtake, etc). By comparison, hunting of large mammals (pigs, muntjac and deer) was observable, routine and often intense throughout the REA plantation areas from 2008-2012. Nevertheless, *Sus barbatus* and *Muntiacus spp*. remained abundant. Sambar Deer, *C. unicolor*, were present, though less common. In 1994, deer densities in the old forests of the Lanjak-Entimau Wildlife Sanctuary were low, ironically except in the disturbed areas in the northern portions of the reserve with higher human densities, and where hunting is frequent (Raleigh Blouch, Pers. Comm.). Thus, differences in abundance of large mammals in forested protected areas of Borneo may have less to do with hunting, and more closely tied to the nature of the habitat. For example, bearded pigs in the heavily forested Danum Valley Conservation Area were found emaciated, dead, or in poor condition (ribs showing) in 2000, and this was viewed as related to a dearth of forest fruits (Wong, et al., 2005). Interestingly, in the project area in Hulu Belayan, no emaciated pigs were ever photographed, although ribs were visible in about 20% of the individuals seen in images during an extended month-long drought in 2009. *Sus barbatus* appeared throughout the year in cameras representing all habitats, almost always in groups of two or more, and including sites near human habitation such as worker emplacements and plantation offices.

Carnivores were mostly photographed in low numbers except for *Viverra tangalunga*, which appeared to be especially fond of the scent lures and spent considerable time rubbing itself on the lure stick or on the ground next to the camera. Images of other viverrids and mustelids were low in number, except for photos of *Arctogalidia trivergata* that were obtained quickly upon cameras being set in the tree canopy. *Martes flavigula* photographed in Hulu Belayan in the early morning (6:44), as it was in the Planted Forest Zone near Bintulu Sarawak (Giman, et al. 2007).

Although a subadult *Helarctos malayanus* was killed and eaten by Damai Estate workers in mid 2008, bears were still photographed every year in the estates of the North bank, though never on the south bank of the Belayan. Another photo by the staff of REA KON was provided of a female with two cubs in Damai Conservation Reserve, in mid-2013.

Felids were present, the most common images obtained from *Prionailurus bengalensis* that is widespread, and seen either in forested areas adjacent to estate blocks, or within the planted areas. It is a well-known predator of rats in palm oil plantations (Grassman et al., 2005; Rajaratnam et al., 2007), and its presence was expected. Images of *Prionailurus planiceps* were restricted to wet areas such as the edge of wetlands or from peat swamp forests. *P. planiceps* eats frogs, shrimp and fish (Banks 1949; Erlandson and Moss, 2001).

Identification of most murid rodents is difficult from camera trap images unless certain distinguishing morphological features are clearly apparent. However, it was somewhat startling to have collected 435 images of murid rodents from camera traps set in the tree canopy after 447 camera-nights for 15 months during 2010-2012, employing 18 camera units. Few could be identified to species, but virtually all appeared to be from the Genus *Rattus*.

Whereas none of the recorded species diurnal rhythms differed significantly from what is previously recorded Azlan and Lading (2006) in Lambir Hills, Sarawak (Malaysia) reported that *Tragulus sp* are active only at night and never recorded in daylight, but in Belayan study area, *T. napu* was photographed feeding around noon (12:32hrs). The explanation for *Sus barbatus'* activity patterns throughout the day may imply an absence of large nocturnal predators, specifically *Neofelis diardii* as discussed by Ross et al (2013).

Interestingly, a water or common Monitor Lizard (*Varanus salvator*) investigated a camera on the ground. These images implied that the lizard's body temperature was higher than its surroundings, a situation known from this group (Traeholt, 1996). On the other hand, the small number of photos of pangolins may not reflect the true abundance. It has been suggested that if their scaly surface is not of sufficiently different temperature from the surrounding environment, it is possible that the infrared sensors of some trail cameras will only rarely detect this species.

Mixed use landscapes are rapidly increasing in area across the lowlands of Borneo/Kalimantan, with inescapable impacts on the original flora and fauna. Some researchers (Stevens, 1968; Payne et al., 1985; Mickleburgh et al.,1992; Nowell and Jackson, 1996; Laidlaw, 2000; Fitzherbert, et al., 2008; Koh and Wilcove 2008; Harrison 2011) have suggested that declines observed in many vertebrate species in wildlife surveys must be attributable to forest clearing for plantation agriculture such as oil palm. However, the results of this study suggest that such sweeping conclusions are not necessarily supported by the evidence, at least in some of the semi-forested mixed-use landscapes where many plantations have been developed.

Unfortunately, there is seems to be much more effort expended in hand wringing and decrying the loss of pristine forested habitats to both plantations (*Acacia* and oil palm) and coal mining than there is in seeking practical solutions that business interests will accept and implement. Although there is a place for appeals for an end to deforestation, the reality is that we know little about the relative survivorship of mammal species in these degraded areas. It is imperative that we understand which species can and will survive, which can disappear and perhaps which will become even more abundant. In view of the continuous modification of the landscape, companies such as plantations and mining must be encouraged to view biodiversity conservation as a rational and necessary component of their operational development. The results of this study imply that with attention paid to an intentional design of the landscape to include both planted and natural areas, and the presence of a science-based conservation program, that a significant portion of the mammal fauna – including so-called endangered "flagship" species such as orangutans, can persist (and breed) over relatively large areas, accompanied by perhaps a majority of the previously existing mammal species of the landscape. As the initial destructive impacts of plantation development die down, some species that may have previously been gone missing, may perhaps reappear at a later date. Finally, monitoring and assessment by a permanently resident conservation team with scientifically valid approaches is key to detecting and analyzing species and population trends.

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Short communications

First breeding record of Banded Woodpecker *Picus* (*Chrysophlegma*) *miniaceus* in Indonesian Borneo

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Introduction

The Banded Woodpecker *Picus* (*Chrysophlegma*) *miniaceus* ranges from the Thai isthmus and Burma, south to Sumatra (including Bangka, Belitung and Nias islands), Java and Borneo (Winkler et al., 1995). There are currently four subspecies *P. m. perlutus* found in south Myanmar and the Thai isthmus, *P. m. malaccensis* found in Peninsular Malaysia, Sumatra and Borneo, *P. m. niasensis* found on Nias island, off northwest Sumatra, and *P. m. miniaceus* from Java (Winkler et al., 1995; Winkler and Christie, 2002). The species is common in Peninsular Malaysia, Singapore, Borneo, Sumatra, but rare in Java (MacKinnon and Phillips, 1993; Winkler and Christie, 2002).

For a species to be considered as "breeding" observation of nest-building, nests, eggs, fledging or young being fed must have been recorded (Davison, 1988). The ability to construct holes for nest sites is one of the key features of woodpeckers (Winkler et al., 1995). Nesting holes are often made in hollow tree-trunks or trunks with a rotten core at any height from the ground (Smythies, 1999). Usually, two or three white eggs are laid in a tree hole nest (Hellebrekers and Hoogerwerf, 1967; MacKinnon & Phillips, 1988). Nesting success is generally high among woodpecker species that typically raise more than 70% offspring successfully (Winkler and Christie, 2002), and in certain cases some pairs may even have produced two broods in a season in Malaysia (Wells, 1999). The high nesting success rate is attributed to these species' ability to excavate their own nests (Winkler and Christie, 2002).

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Fledglings that have vacated the nest are known to be persistently begging for food by uttering loud squeaking calls. The parents remain protective of the young for an extended period of time, and family members may even remain together when the parents begin the next reproductive cycle (Winkler and Christie, 2002)

Compared to Malaysian Borneo, records of breeding woodpeckers in Indonesian Borneo remain limited, despite being considered a resident species (Mann, 2008). Recent reports confirms the limited information on breeding records of Banded woodpecker in Kalimantan (Balen et al., 2011; Balen et al., 2011, 2013; Kamsi and Balen, 2012; Posa 2011; Posa et al., 2011; Posa and Marques, 2012; Wielstra et al., 2011; Wielstra and Pieterse, 2009, 2011; Woxvold and Noske, 2011).

Until recently, there were no breeding records of the Banded woodpecker, *P. m. malaccensis*, in Kalimantan (Mann 2008; Smythies, 1999). To our knowledge, this paper describes the first breeding record of the Banded woodpecker in Indonesian Borneo.

Study area and methodology

The study site is located in Tarjun, Kelumpang Hilir subdistrict, Kotabaru district (03^{o}16.1"S/ 11^{o}608"E), South Kalimantan Province, Indonesia. The area consists of agriculture, settlements and small disturbed patches of forests <50m above sea level. The incident that confirms that the species breeds in Kalimantan was recorded on the 29th September, 2013, during a bird-watching trip. The bird was observed and photographed for identification and documentation.

Results and Discussion

On 29th September 2013, an incidental observation of an adult Banded woodpecker, *P. m. malaccensis*, feeding a juvenile took place. The birds were observed for approximately two minutes and identified as an adult male Banded woodpecker by its reddish-rufous ear-coverts, red crown extending to nape-sides, distinctly scaled mantle and scapulars and barred primaries (MacKinnon and Phillips, 1993; Robson, 2011; Winkler and Christie, 2002). The juvenile was identified by its duller overall colouration and having yellow-orange sides in the mouth. The feeding material is not clearly seen, but was presumed a caterpillar.

The record of fledging Banded woodpecker in Kotabaru on 29th September 2013 corresponds with the peak breeding season of Banded Woodpecker in Peninsular Malaysia and Greater Sunda (Wells, 1999; Winkler et al., 1995). The breeding season is reported to be March-April in Java and Sumatra (Hellebrekers and Hoogerwerf, 1967; MacKinnon and Phillips, 1988) with chicks emerging in May-June in Sumatra (van Marle and Voous, 1988).

It is our hope that researchers and birdwatchers in Kalimantan will put more effort into recording information about the breeding season and behaviour of the Banded woodpecker and other woodpecker species in Kalimantan.

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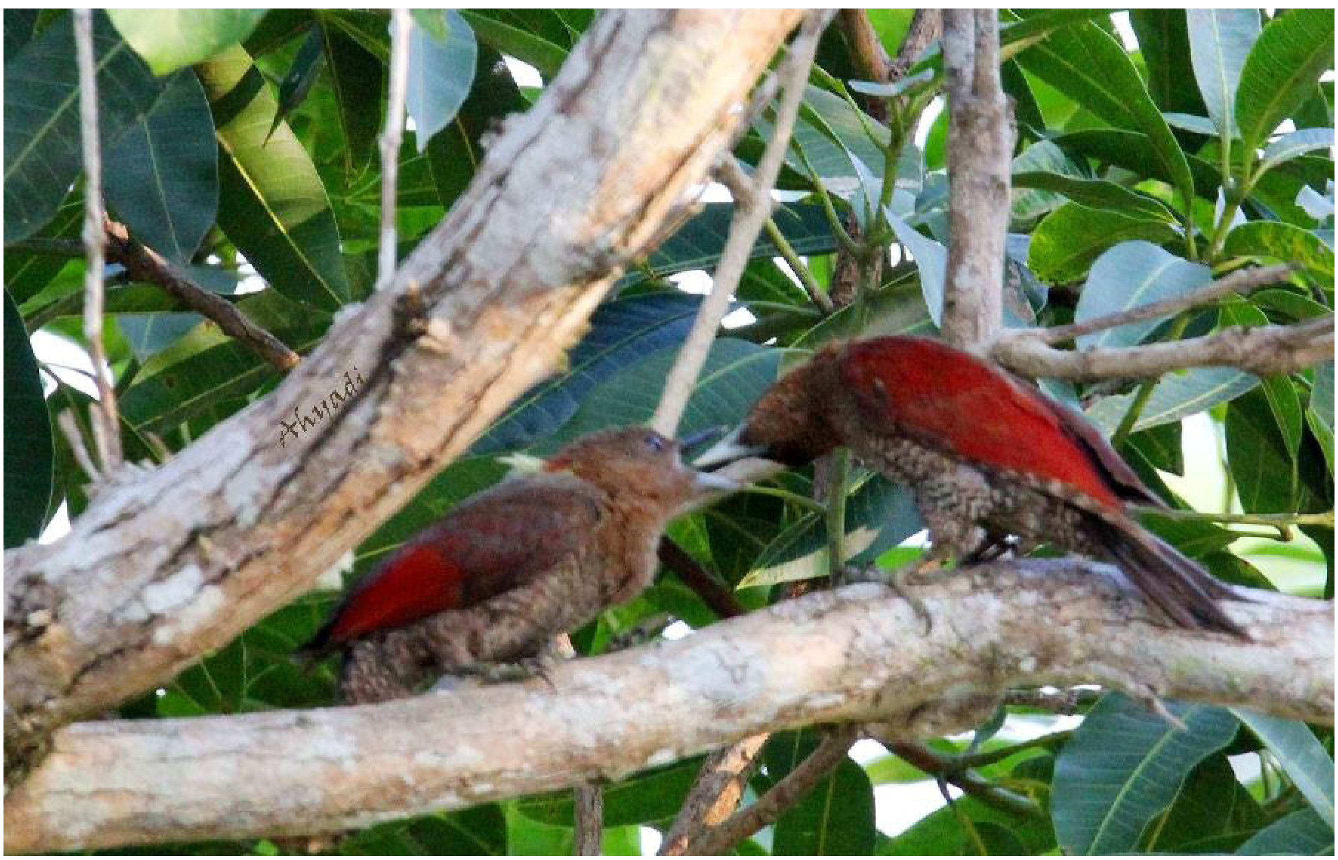

Figure 1. Banded Woodpecker feeding a juvenile in Kotabaru, South Kalimantan, on 29th September 2013. ©Ahyadi Hasyim.

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Students' research projects

Microchiroptera community in oil palm plantation

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Palm oil palm is largest vegetable oil commodity in the World and the most lucrative. The rapid expansion of oil palm plantations in Indonesia have had an adverse effect on fauna and flora, particularly *Microchiropterans* that are dependent on intact understorey habitat. To date there are very few studies on *Microchiropterans* in oil palm plantation. This study focused on species richness and diversity, distribution, abundance and demographic structure of *Microchiropteras* in three habitat types of the oil palm plantation PT Kencana Sawit Indonesia (KSI) along with community composition, food available, potential habitat for *Microchiropteras* and source-sink dynamic between the three types of habitat. The field study took place from October 2010 until October 2011 in KSI, West Sumatra. A total of 180 trapping nights were conducted, using harp traps at 20 locations in three habitat types (forest block, riparian forest and oil palm plantation). Trapping took place from 18.00 until 06.00 and the traps were checked twice a day - evening and morning. TA light trap was deployed adjacent to the harp traps to attract insects. *Microchiropteras* were identified using Payne (2000), Struebig & Sujarno (2006) and Kunz & Parsons, eds. (2009). A total of 1085 individuals from 21 species and five families were captured. Of this 17 species were caught in forest block, 10 species in riparian forest and only thee species in oil palm plantation. An analysis using EstimateS (Win 8.20) returned a total species richness in oil palm as 27 species. *Hipposideros cervinus* was the most common species in PT KSI area followed by *H. bicolor* but was only found in forest blocks and riparian forests and absent in oil palm habitat. In contrast *H. bicolor* was common in oil palm habitat. Similarity was moderate between forest block and riparian forests, and low between forest block and oil palm habitat as well as between riparian and oil palm. The age composition of the *Microchiropteran* community in the study area was dominated by adults (83.60%), followed by young (16.13 %) and only 0.27 infants. Adults individual were caught in all habitat types, whereas young/infant individuals were caught in forest block and riparian forests only. A total of 66.40% of adult females were lactating, with 30.78% non-reproductive and pregnant, recent post lactating and post lactating 0,80%, 1,61% and 0,40% respectively. Based on the study results it can be concluded that forest blocks within an oil palm plantation can act as an important source habitat for *Microchiropterans*.

The effect of ungulates on forest floor vegetation

Mohd Sanusi (Malaysia), MSc candidate
National University of Malaysia/Copenhagen Zoo, Denmark

The ecological function of large ungulates in a tropical rainforest is poorly understood. For my Master-programme, I intend to study the browsing pressure of Malayan tapirs, *Tapirus indicus*, in a tropical rainforests. The study site is Krau Wildlife Reserve, a 67.000ha undisturbed tropical rainforests habitat in the state of Pahang, Peninsular Malaysia. Malayan tapirs are abundant in Krau Wildlife Reserve. I will chose 10 sites, and setup 10 "double plots" i.e. one fenced area of 5x5 meters, and one "open" area of 5x5m adjacent to the fenced area. Measuring the ungulate browsing pressure will be undertaken by recording the species composition, growth rate and regrowth of plants in the fenced and unfenced plot. Each plant within each plot will be recorded, measured and marked every two months for comparison over time. Two video camera-traps will be deployed at each plot to determine what species frequent the area and if they forage. It is well-known that some ungulates such as elephants are considered to be good seed-disperser, whereas Malayan tapirs are not. With this study, I hope to cast more light on the ecological function of large ungulates in a tropical rainforest.

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Keywords: From five to eight pertinent words, in alphabetical order.

Literature cited in text: Enclose citations in text in parentheses e.g. "Asian tapirs are no elephants when it comes to seed dispersal (Campos-Arceiz et al., 2011)."

Use an ampersand (&) between author surnames when the citation is parenthetical: (Traeholt & Idris, 2011).

When a citation is not parenthetical, use "and": "Our results agree with the predictions of Wolf and Rhymer (2001)."

For citations with more than two authors, use et al.: (Campos-Arceiz et al., 2011). Do not italicize et al.

List parenthetical citations in alphabetical order and chronologically from oldest to most recent and separate entries with a semicolon: (Campos-Arceiz et al., 2011; Geissman, 2009, 2010).

Separate the years with commas when citing multiple papers by the same author: (Corlett, 2007, 2010; Geissman, 1984, 1995, 1999, 2000).

"**In press**" means the cited paper has been accepted unconditionally for publication. Provide the year of publication in the text (Bird, 2010) and in Literature Cited section provide the volume number, and substitute "in press" for page numbers (Bird, I.M. 2010. Nesting success in arid lands. Conservation Biology 24: in press.).

Papers in review must be cited as unpublished and should not appear in the Literature Cited section.

Use an initial for the first (given) name and spell out the last name (surname) for other sources of unpublished data or information: (R. Fowler, unpublished data; M.E. Soulé, personal communication).

Software: capitalize the first letter only if the name of the program is a word (e.g., Vortex, ArcGIS). If the name of the program is not a word, use all capital letters (e.g., SAS).

The following are examples of Literature Cited house style:
Campos-Arceiz, A. and R.T. Corlett (2011). Big animals in a shrinking world—studying the ecological role of Asian megafauna as agents of seed dispersal. Innovation 10: 50–53.

Campos-Arciez, A., Larringa, A.R., Weerasinghe, U.R., Takatsuki, S., Pastorini, J., Leimgruber, P., Fernando, P. and L. Santamaria (2008). Behavior rather than diet mediates seasonal differences in seed dispersal by Asian elephants. Ecology 89: 2684–2691.

MacArthur, R.H. & Wilson, E.O. (1967). The Theory of Island Biogeography. Princeton University Press, Princeton, USA.

Sutherland, W.J. (ed.) (1998). Conservation Science and Action. Blackwell Science, Oxford, UK.

Beck, B.B., Rapaport, L.G. & Stanley Price, M.R. (1994). Reintroduction of captive-born animals. In Creative Conservation: Interactive Management of Wild and Captive Animals (eds P.J.S. Olney, G.M. Mace & A.T.C. Feistner), pp. 265-286. Chapman & Hall, London, UK.

Traeholt, C., Bonthoeun, R., Rawson, B., Samuth, M., Virak, C. and Sok Vuthin (2005). Status review of pileated gibbon, *Hylobates pileatus* and yellow-cheeked crested gibbon, *Nomascus gabriellae*, in Cambodia. Fauna & Flora International, Phnom Penh, Cambodia.

Sun H. (2000). Status of the tiger and its conservation in Cambodia. MSc thesis, University of Minnesota, Minneapolis, USA.

IUCN (2010). 2010 IUCN Red List of Threatened Species. Http://www.redlist.org [accessed 1 February 2011].

Biography: This should describe the main research interests of all authors (<150 words total), apart from what is obvious from the subject of the manuscript and the authors' affiliations.

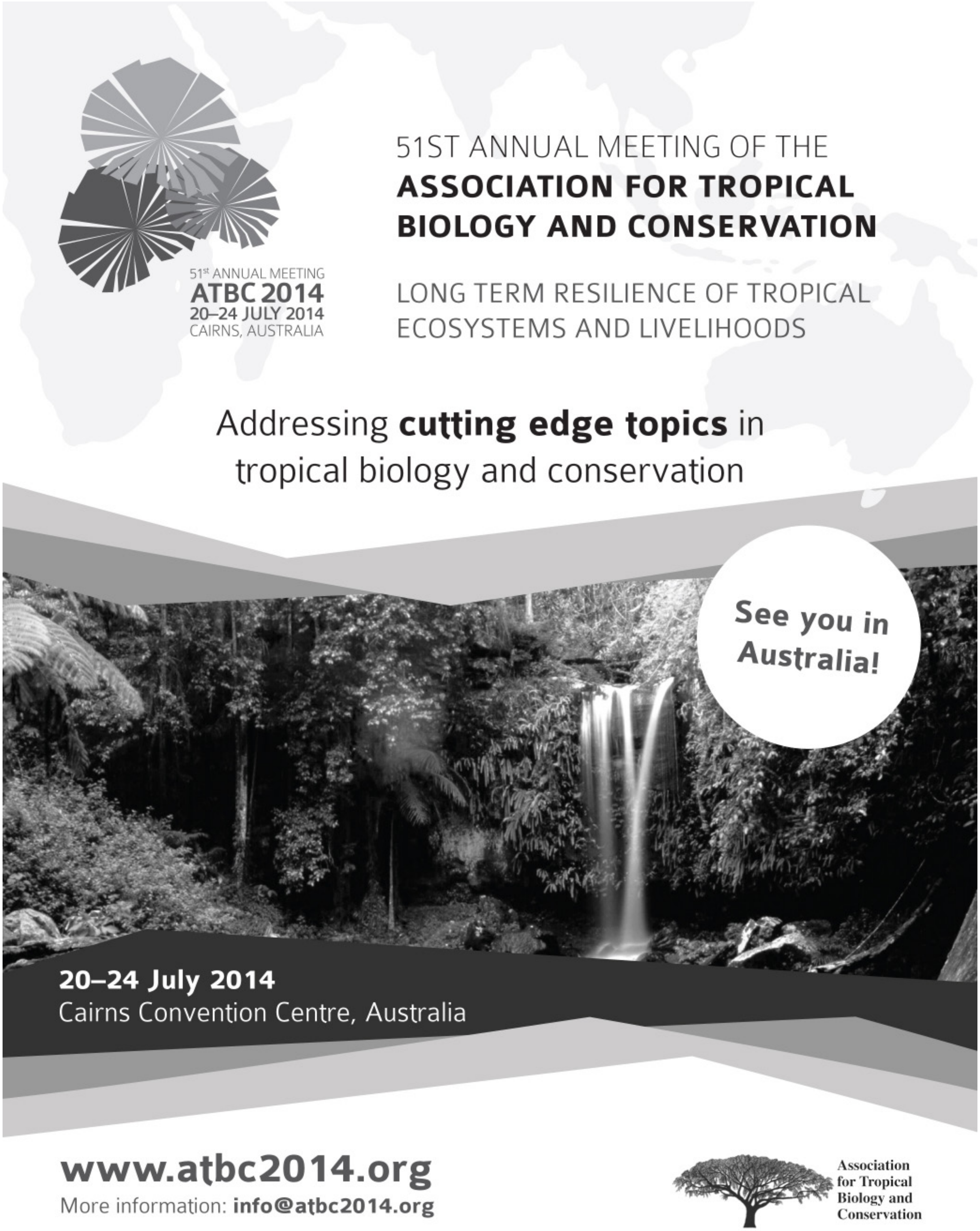
Tables, figures and plates: These should be self-explanatory, each on a separate page and with an appropriate caption. Figures can be submitted in colour as well as in black and white. The Editorial Team may decide to convert coloured figures into black and white should it be necessary due to printing cost and without diluting the message. Plates (black and white only) will only be included in an article if they form part of evidence that is integral to the subject studied (e.g., a photograph of a rare species), if they are of good quality, and if they do not need to be printed in colour.

Appendices: Lengthy tables, and questionnaires are discouraged. In special circumstances these may be made available for viewing online.

Species names: The first time a species is mentioned, its scientific name should follow in parenthesis and in italics: e.g., Asian elephant (Elephas maximus). English names should be in lower case throughout except where they incorporate a proper name (e.g., Asian elephant, Cookson's wildebeest, long-billed vulture).

Abbreviations: Full expansion should be given at first mention in the text.

Units of measurement: Use metric units only for measurements of area, mass, height, etc.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