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Sabah Wildlife Department and 10 years of research: Towards a better conservation of Sabah's wildlife

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Abstract

In this paper, we present an update on the current wildlife research undertaken by the Sabah Wildlife Department (SWD) and its partners. For the last ten years, SWD has been extremely active in developing research programmes on all Sabah's flagship species including the Bornean orangutan, the proboscis monkey, the Sumatran rhinoceros, the Bornean elephant, the Bornean banteng, the Malayan sun bear, and the Sunda clouded leopard. This has been facilitated by: (1) the setting up of their own field research centre located in the Lower Kinabatangan Wildlife Sanctuary, the Danau Girang Field Centre, in collaboration with Cardiff University; (2) the development of strong collaborations with different overseas institutions such as Leibniz Institute for Zoo and Wildlife Research, University of Indiana, Kyoto University, Oxford WildCRU, EcoHealth Alliance, Houston Zoo, and many others; and (3) the collaboration with several NGOs such as HUTAN-Kinabatangan Orangutan Conservation Programme, Borneo Conservation Trust (BCT), WWF-Malaysia, Borneo Rhino Alliance (BORA), UK Appeal, and many others. Recently, some of the research carried out by SWD and partners has received funding from the palm oil industry through the Malaysian Palm Oil Council, Sime Darby Foundation, and others. The main aim of the research carried out by SWD and partners is to contribute to the conservation and management of the species and ecosystems, which are under their responsibility.

Preamble

Sabah is at the forefront of wildlife conservation in South-East Asia, facing one of the biggest conservation challenges: finding a balance between sustainable development, species survival and achieving a shift towards green economy. To our knowledge, Sabah is the only place in Borneo that is still harboring all Bornean larger mammals: the Bornean orangutan (*Pongo pygmaeus morio*), the proboscis monkey (*Nasalis larvatus*), the Bornean elephant (*Elephas maximus borneensis*), the Bornean banteng (*Bos javanicus lowi*), the Sumatran rhinoceros (*Dicerorhinos sumatrensis harrissoni*), the Sunda clouded leopard (*Neofelis diardi*) and the Malayan sun bear (*Helarctos malayanus*).

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The Bornean Orangutan *(Pongo pygmaeus)*

Image 1: Bornean orangutan female and her offspring in the forest of the Lower Kinabatangan Wildlife Sanctuary, Lot 6 (Photo courtesy: Rudi Delvaux)

Orangutan research in Sabah in the last 10 years has been mainly carried out by the NGO HUTAN and its two directors, Dr Marc Ancrenaz and Dr Isabelle Lackman. In 2005, Ancrenaz *et al.* estimated the distribution and size of the orangutan populations living in Sabah using a combination of ground and helicopter surveys (Ancrenaz *et al.* 2004; Ancrenaz *et al.* 2005). It appeared that the state was harboring a total estimated population size of about 11,000 individuals, making it one of the main strongholds for orangutans. However, this publication also showed that 60% of orangutans living in Sabah occur outside protected areas, mainly in production forests that are still exploited for timber (Ancrenaz *et al.* 2005). It raised the importance of granting protection status to these forests and led to the decision by the Sabah government to stop logging activities in two forest reserves, Ulu Segama and Malua, to set aside them for the conservation of orangutans and other charismatic species. To date, the PLoS Biology paper published in 2005 on the orangutan surveys carried out in the whole state of Sabah is one of the best examples of "science helping conservation". More recently, HUTAN conducted additional aerial and ground surveys of orang-utan nests in the Ulu Segama Malua (USM) forest complex. Their data showed that orang-utan populations could be maintained in forests that have been lightly and sustainably logged. On the other side heavily logged - following conventional logging strategies - areas exhibited a decline in orang-utan numbers, which could eventually result in localized extinction (Ancrenaz *et al.* 2010). Nest distribution in the forests of USM indicated that orang-utans leave areas undergoing active disturbance and take momentarily refuge in surrounding forests that are free of human activity, even if these forests are located above 500 m asl (these higher elevations are usually not the best habitat for orang-utans). Displaced individuals will then recolonize the old-logged areas after a period of time, depending on availability of food sources in the regenerating areas. These results indicated that diligent planning prior to timber extraction and the implementation of reduced-impact logging practices can potentially be compatible with great ape conservation.

Starting in 2000, Cardiff University, Sabah Wildlife Department, Universiti Malaysia Sabah and the NGO HUTAN investigated the genetic structure within and among Bornean orang-utans in forest fragments of the Lower Kinabatangan floodplain (Goossens *et al.* 2005, 2006a; Jalil *et al.* 2008). DNA was extracted from hair and faecal samples for 200 wild individuals collected during boat surveys on the Kinabatangan River. Fourteen nuclear genetic markers were used to characterize patterns of genetic diversity. We found that genetic diversity was high in the set of forest fragments and that genetic differentiation was significant between these fragments. We also confirmed the role of the river as a natural barrier to gene flow, with genetic differentiation higher between the Northern and Southern sides of the river than between the fragments from the same side of the river. Statistical tests confirmed the overall picture that gene flow was limited across the river, and that was also confirmed by mitochondrial DNA analyses carried out by Jalil *et al.* (2008), showing that orangutan samples on either side of the river were strongly differentiated and that large rivers act as barriers to gene flow in this long-lived, solitary arboreal ape, something that was also showed by Warren *et al.* (2001) in Kalimantan. However, we found that migration between forest fragments from the same side of the river had a high probability indicating that orang-utans used to move relatively freely between neighbouring areas. This strongly suggested that there was a need to maintain migration between isolated forest fragments by restoring forest corridors alongside the riverbanks and between patches. However, genetic management of fragmented populations poses logistical and theoretical challenges to conservation managers. Therefore, we simulated changes in genetic diversity and differentiation within and among fragmented population units under different management scenarios using the molecular marker data collected from the Kinabatangan (Bruford *et al.* 2010). We examined the genetic implications of management options for the highly fragmented yet globally significant orang-utan population in the Lower Kinabatangan Wildlife Sanctuary. We simulated the effects of non-intervention, translocation, corridor establishment and a mixture of the latter two approaches on future genetic diversity in this population using the stochastic simulation software VORTEX and a well-described molecular dataset for 200 individuals (Goossens *et al.* 2005) from within the Sanctuary. We found that nonintervention resulted in high extinction risks for a number of subpopulations over short demographic timescales (<5 generations). Furthermore, the exclusive use of either translocation or corridor establishment as a management tool was insufficient to prevent substantial levels of inbreeding using demographically and logistically feasible translocation rates and was insufficient to prevent inbreeding and extinction in the most isolated subpopulations using conservative corridor establishment rates. Instead, a combination of modest translocation rates (one individual every 20 years) and corridor establishment enabled even the most isolated subpopulations to retain demographic stability and constrain localised inbreeding to a very low level. Our simulations suggested that this mixed management approach was both a pragmatic and potentially successful course of action and that this combination may be useful in other species and fragmented populations in the future. However, establishing corridors can be very costly and will take time to happen. Following the results published by Goossens *et al.* (2005) and Bruford *et al.* (2010), Sabah Wildlife Department, the NGO HUTAN, Danau Girang Field Centre and Borneo Conservation Trust embarked in a large operation of building orangutan bridges over tributaries and drains in the Kinabatangan. After a few years, these bridges appeared to be successful and orangutans have been observed using them, as well as other wildlife such as proboscis monkeys, pig-tailed and long-tailed macaques, silvered langurs, gibbons, civets and squirrels. This was another example of science helping conservation.

In another publication (Goossens *et al.* 2006a), using the so far largest-ever dataset from wild orang-utan populations, we showed strong evidence for a recent demographic collapse in North Eastern Borneo and demonstrated that this signature was independent of the mutation and demographic models used. That was the first demonstration that genetic data could detect and quantify the effect of recent, human-induced deforestation and habitat fragmentation on an endangered species. Because current demographic collapses are usually confounded by ancient events, this suggested a much more dramatic decline than demographic data alone and emphasised the need for major conservation efforts.

The genetic data produced in the Kinabatangan by our team were also used in a paper led by members of the Institute of Anthropology at the University of Zürich, Switzerland (Nater *et al.* 2011). The Southeast Asian Sunda archipelago harbors a rich biodiversity with a substantial proportion of endemic species. The evolutionary history of these species has been drastically influenced by environmental forces, such as fluctuating sea levels, climatic changes, and severe volcanic activities. Orangutans are well suited to study the relative impact of these forces due to their well-documented behavioral ecology, strict habitat requirements, and exceptionally slow life history. The team investigated the phylogeographic patterns and evolutionary history of orangutans in the light of the complex geological and climatic history of the Sunda archipelago. The study was based on the most extensive genetic sampling to date, covering the entire range of extant orangutan populations, including populations in Sabah (Kinabatangan and Danum Valley). Using data from three mitochondrial DNA (mtDNA) genes from 112 wild orangutans, we showed that Sumatran orangutans, *P. abelii*, are paraphyletic[1] with respect to Bornean orangutans, the only other currently recognized species within this genus. The deepest split in the mtDNA phylogeny of orangutans occurs across the Toba caldera in northern Sumatra and, not as expected, between both islands. Until the recent past, the Toba region has experienced extensive volcanic activity, which has shaped the current phylogeographic patterns. Like their Bornean counterparts, Sumatran orangutans exhibit a strong, yet previously undocumented structuring into four geographical clusters. However, with 3.50 Ma, the Sumatran

[1] A taxon is said to be *paraphyletic* if the group consists of all the descendants of some ancestor minus one or more monophyletic groups of descendants. For example, the group of reptiles is paraphyletic: it contains the last common ancestor of extant reptiles, mammals, and birds and all descendants of that ancestor, except for mammals and birds.

haplotypes have a much older coalescence[2] than their Bornean counterparts (178 kya). In sharp contrast to the mtDNA data, 18 Y-chromosomal polymorphisms showed a much more recent coalescence within Sumatra compared with Borneo. Moreover, the deep geographic structure evident in mtDNA was not reflected in the male population history, strongly suggesting male-biased dispersal. We concluded that volcanic activities have played an important role in the evolutionary history of orangutans and potentially of many other forest-dwelling Sundaland species. Furthermore, we demonstrated that a strong sex bias in dispersal can lead to conflicting patterns in uniparentally inherited markers even at a genus-wide scale, highlighting the need for a combined usage of maternally and paternally inherited marker systems in phylogenetic studies.

In another paper published by Arora *et al.* (2010), also involving a member of Sabah Wildlife Department/Danau Girang Field Centre, the authors looked at the effects of Pleistocene glaciations and rivers on the population structure of Bornean orangutans. Sundaland, which is a tropical hotspot of biodiversity comprising Borneo and Sumatra among other islands, the Malay Peninsula, and a shallow sea, has been subject to dramatic environmental processes. Thus, it presented an ideal opportunity to investigate the role of environmental mechanisms in shaping species distribution and diversity. We investigated the population structure and underlying mechanisms of the endemic Bornean orangutan. Phylogenetic reconstructions based on mtDNA sequences from 211 wild orangutans covering the entire range of the species (and including Kinabatangan and Danum Valley populations from Sabah) indicated an unexpectedly recent common ancestor of Bornean orangutans 176 ka (95% highest posterior density, 72–322 ka), pointing to a Pleistocene refugium. High mtDNA differentiation among populations and rare haplotype sharing was consistent with a pattern of strong female philopatry. This was corroborated by isolation by distance tests, which showed a significant correlation between mtDNA divergence and distance and a strong effect of rivers as barriers for female movement. Both frequency-based and Bayesian clustering analyses using as many as 25 nuclear microsatellite loci revealed a significant separation among all populations, as well as a small degree of male-mediated gene flow. The study highlighted the unique effects of environmental and biological features on the evolutionary history of Bornean orangutans, which are particularly vulnerable to future climate and anthropogenic change as an insular endemic.

[2] *Coalescence* is the merging of genetic lineages backwards to a most recent common ancestor.

Another application of non-invasive genetics is to investigate individual relationships (paternity, relatedness between members of a community, etc) (see Utami *et al.* 2002). Behavioural observations suggest that orang-utans are semi-solitary animals with females being philopatric and males roaming more widely in search of receptive partners, leading to the prediction that females are more closely related than males at any given site. In Lot 2 of the Lower Kinabatangan Wildlife Sanctuary, where HUTAN's study site is located, we showed evidence for male and female philopatry (Goossens *et al.* 2006b). We examined patterns of relatedness and parentage using noninvasively collected DNA samples from animals observed to defecate, and microsatellite markers to assess dispersal and mating strategies. Surprisingly, resident females in Lot 2 were equally as related to other resident females as resident males were to other resident males. Moreover, resident females were more related to each other and to the resident males than they were to nonresident females, and resident males were more related to each other (and resident females) than they were to nonresident males. We assigned genetic mothers to 12 individuals in the population, while sires could be identified for eight. Both flanged males and unflanged males achieved paternity, similar to findings reported for Sumatran orang-utans (Utami *et al.* 2002).

However, Nietlisbach *et al.* (2012) assessed the sex-specific population structure in orang-utans, using a combination of paternally transmitted Y-chromosomal genetic markers and maternally transmitted mitochondrial DNA sequences. Markers transmitted through the more philopatric sex were expected to show stronger differentiation among populations than the ones transmitted through the dispersing sex. They studied these patterns using 70 genetic samples from wild orangutans from seven Bornean (including Kinabatangan and Danum Valley) and two Sumatran populations. The authors found pronounced population structure in haplotype networks of mitochondrial sequence data, but much less so for male-specific markers. Similarly, mitochondrial genetic differentiation was twice as high among populations compared to Y-chromosomal variation. They also found that genetic distance increased faster with geographic distance for mitochondrial than for Y-linked markers, leading to estimates of male dispersal distances that are several-fold higher than those of females. Therefore, contrary to Goossens *et al.* (2006b), these findings provide evidence for strong male-biased dispersal in orang-utans.

Most of the results described above were used in the State Orangutan Action Plan (2012-2016) launched by the Sabah State Government in January 2012 during the Sabah Wildlife Conservation Colloquium organised in Kota Kinabalu.

The Proboscis Monkey (*Nasalis larvatus*)

Image 2: A proboscis male jumping from one tree to another on the riverbank of the Kinabatangan river (Photo courtesy: Rudi Delvaux).

In 2008, Sha *et al.* published results of a Sabah-wide survey of proboscis monkey (*Nasalis larvatus*) to establish its population status and to assess threats to its survival. They found a minimum population size of *c.* 5,907 individuals, mainly along major coastal river systems in Sabah. However, the distribution of the species appeared highly fragmented, with only five major centers of continuous distribution and a large number of small isolated populations. The main concern of the authors was the clearing and conversion of important riparian and coastal mangrove habitats to plantations and human habitation, resulting in fragmentation of otherwise continuous populations along rivers, which could lead to local extinction of remnant populations trapped in small forest fragments.
More recently, Stark *et al.* (2012) conducted a Population Viability Analysis (PVA), which is a predictive procedure that uses different modeling approaches to estimate species vulnerability to extinction, on proboscis monkey populations in Borneo. Using the stochastic modeling software VORTEX, they assessed the status of the species in three fully or partially protected areas in the island, one in Sabah (Kinabatangan population) and two in the Indonesian province of Kalimantan (Balikpapan Bay in East Kalimantan and Danau Sentarum National Park in West Kalimantan). Species-specific life-history parameters were used when possible, and missing parameters were taken from other populations or species. They tested the sensitivity of final predicted population size to 20% variation around the possibly inaccurate parameter estimates. The model they used predicted that in the absence of any management, the Kinabatangan population would remain fairly stable, whilst the two Indonesian populations would decrease by more than half, the smallest going effectively extinct in 30 years. They also investigated whether management strategies, such as reforestation, corridors to reconnect sub-populations, harvesting, reduction of deforestation and controlling fires, might help avoiding population extirpation at each site. Fire had the greatest impact on the Indonesian populations, although hunting was also likely to play an important role. Remedial action to reduce the frequency and extent of fires, perhaps by regulated land clearing for agriculture, should slow proboscis monkey population decline and provide more time to collect the data necessary to evaluate other management decisions. The authors concluded that because information regarding mortality, the effect of fire, and hunting rates on proboscis monkeys is limited, further research should concentrate on these areas to improve PVAs for this species. However, for Sabah, urgent mitigating strategies are necessary to ensure the long-term survival of proboscis monkeys. Immediate actions are needed to prevent small isolated populations from local extinction, and long-term efforts must be undertaken to protect important proboscis monkey habitats and re-establish connectivity between fragmented populations.

Currently, the Sabah Wildlife Department and Danau Girang Field Centre embarked in a large proboscis monkey conservation programme, fully funded by Sime Darby Foundation, as part of their Corporate Social Responsibility programme. Their Big 9 programme is an effort to conserve animal species that are classified as endangered or vulnerable and it includes: the sun bear, orangutan, Bornean elephant, clouded leopard, banteng, proboscis monkey, Sumatran rhinoceros, Malayan tiger and hornbill. For more information check the following web page: http://www.yayasansimedarby.com/. Capacity building and training of one local PhD student (Dr Senthilvel Nathan, SWD) at Cardiff University and two master students (Dr Rosa Sipangkui and Dr Diana Ramirez) from Sabah Wildlife Department/Widlife Rescue Unit at Universiti Putra Malaysia are the main outputs of the programme. We also established collaboration with EcoHealth Alliance to work on emerging and zoonotic diseases in proboscis monkeys. During the project, about 200 proboscis monkeys will be caught (and released) in different populations in Sabah and blood (for DNA analyses), saliva (for disease and virus analyses), parasites, bacteria, morphological and hematological data will be collected. Moreover, nine proboscis monkey males in the Kinabatangan will be set up with satellite collars to understand the ranging patterns and the factors influencing their movements and density in order to determine the adequate amount of habitat available in order to sustain a continuous viable population in the Kinabatangan region. This part of the programme is led by a Cardiff PhD student, Danica Stark.

Additional work has been carried out by Japanese scientists from Kyoto University, in collaboration with Sabah Wildlife Department and Universiti Malaysia Sabah. This work focused on a population of proboscis monkeys inhabiting the forest along the Menanggul river, a tributary of the Kinabatangan river, near Sukau. They worked on feeding ecology and. activity budget (Matsuda *et al.* 2009a), revealing that their dietary diversity in the riverine forest is extremely higher (188 plant species eaten) than that of previous studies. In addition, they clarified the exact home range size (ca. 138 ha) and the factors affecting their ranging behaviours including their sleeping site selection, in a group of proboscis monkeys; food availability, especially unripe fruits (Matsuda *et al.* 2009b), and predation threats by Sunda clouded leopards and estuarine crocodiles (*Crocodylus porosus*) (Matsuda *et al.* 2008a, 2008b) may be the most important factors to explain their ranging patterns. In any case, the riverine forest of at least 800 m from both river banks may be needed for the survival of proboscis monkeys (Matsuda *et al.* 2010, 2011). Social behaviour, female transfer between one-male groups (Murai 2004; Murai *et al.* 2007), which may be related to the environmental factors such as food availability and predation pressure were also investigated in the Menanggul area.

The Bornean Elephant (*Elephas maximus borneensis*)

Image 3: Bornean elephant in the Lower Kinabatangan Wildlife Sanctuary, fit with a satellite collar by Danau Girang Field Centre and Sabah Wildlife Department, providing information on movement patterns in fragmented landscape (Photo courtesy: Rudi Delvaux)

The origin of the Bornean elephant is still controversial; despite the publication of a molecular study indicating the genetic distinctiveness of the Bornean elephant and its derivation from Sundaic stock (Fernando *et al.* 2003). The authors also claimed independent evolution of the Bornean elephant for some 300,000 years since a postulated Pleistocene colonization and recognized it as native to Borneo and as a separate evolutionary significant unit. However, it seems unlikely that a taxon assumed to be present in Borneo for more than 300,000 years, and therefore subject to evolutionary pressures, presents only one maternal lineage as compared with, for example, orang-utans (Jalil *et al.* 2008), proboscis monkeys (Jalil 2007, Munshi-South & Bernard 2011), and Sunda clouded leopards (Wilting *et al.* 2011) which harbour several maternal lineages and are also present on the island since the Pleistocene. More strikingly, there have been no authenticated or confirmed finds of Asian elephant in any controlled excavation, including the Niah cave (Sarawak) or the Madai cave (Sabah, within the species' present range) although other large ungulates (*Rhinocerus sondaicus* and *Dicerorhinus sumatrensis*, *Tapirus indicus*) were excavated. Cranbrook *et al.* (2008) took into account such facts and postulated a different theory: elephants from Java were sent to Sulu at the end of the 14th century as a gift between Sultans, proliferated on the island and subsequently provided the founder members of the existing population of northeast Borneo. However, it remains unclear when and how many founders were translocated to Borneo by the Sultan of Sulu. Elephants were reported to be present on Sulu until the beginning of the 19th century but they were finally exterminated by 1850 (Cranbrook *et al.* 2008). Therefore, Borneo may have been the refuge of the Javan elephant and *E. m. borneensis* is the synonum of *E. m. sondaicus*. If this scenario holds true, elephants have only inhabited Sabah for less than 600 years. But this is still something that needs to be clarified, and the only way would be to compare ancient DNA from the extinct Javan sub-species (that could be extracted from bones, for example) with DNA from the current elephant population in Borneo and see whether they share the same haplotype. However, the debate on the origin of the Bornean elephant should not let us astray from the fact that the Bornean population is evolutionarily unique and that it deserves conservation efforts. Indeed, the Bornean elephant harbours many distinctive characteristics such as smaller size, larger ears, straight tusks and a long tail that can hit the ground. Here additional work is necessary to understand their social behaviour and be able to compare it with the mainland Asian elephant.

Bornean elephants have a limited distribution range and are confined to northeastern part of the island (Malaysian Sabah and the northern part of Indonesian East Kalimantan). Most important for the conservation of Bornean elephants was an estimate of their distribution and their population size. Previous estimations for the population in Sabah have ranged between 500-2,000 elephants. These estimations were carried out through a non-systematic approach, either via interview or from direct sightings or extrapolating population count data from limited sites. Alfred *et al.* (2010) developed and established relative distribution and spatial density of the Bornean elephant using a systematic line transect survey and a long term monitoring of dung decay rates. They conducted an elephant population census in Sabah between July 2007 and December 2008. Using a line-transect dung-count methodology, they surveyed 216 line transects; with a total distance of 186.12 km, in five main elephant managed ranges: (i) Tabin Wildlife Reserve, (ii) Lower Kinabatangan, (iii) Central Sabah, (iv) North Kinabatangan and (v) Ulu Kalumpang. They then estimated the elephant density in those areas using a long-term monitoring of dung decay rates. In each range, the elephant's density varied depending on the size of the suitable habitat. The survey indicated that approximately 2,040 (95% CI: 1,184-3,652) elephants remain in the five main ranges in Sabah, with the largest population being in the unprotected central forests. Elephant density was highest in ranges where habitat has been removed and elephants were concentrated in remaining forest areas.

In 2012, Alfred *et al.* published a paper investigating the home ranging of Bornean elephant females using satellite tracking of five individuals in different regions of Sabah. Studies of African and Indian elephants in landscapes of largely open habitats have indicated that the sizes of the home range are determined not only by the food supplies and seasonal changes, but also by numerous other factors including availability of water sources, habitat loss and the existence of man-made barriers. The home range size for the Bornean elephant had never been investigated before. In 2005, WWF-Malaysia initialised the first elephant satellite tracking programme to study their movement patterns. Five adult female elephants were immobilized and neck collars were fitted with tracking devices. The sizes of their home range and movement patterns were determined using location data gathered from a satellite tracking system and analyzed by using the Minimum Convex Polygon and Harmonic Mean methods. Home range size was estimated to be 250 to 400 km^2 in non-fragmented forest and 600 km^2 in a fragmented forest. The ranging behavior was influenced by the size of the natural forest habitat and the availability of permanent water sources. The movement pattern was influenced by human disturbance and the need to move from one feeding site to another. The authors concluded that home range and movement rate were influenced by the degree of habitat fragmentation. Once habitat was cleared or converted, the availability of food plants and water sources were reduced, forcing the elephants to travel to adjacent forest areas. Therefore movement rate in fragmented forest was higher than in the non-fragmented forest.

Sabah Wildlife Department, the NGO HUTAN and Danau Girang Field Centre are currently investigating the social behaviour and mating strategies of the Bornean elephant using a combination of satellite tracking, behavioural observations and non-invasive genetic

analyses of paternity and relatedness in the Kinabatangan elephant population. The work is part of the PhD of Nurzhafarina Othman, a Malaysian national registered at Cardiff University, who has been working on elephant with the first author (BG) for more than seven years now.
Finally, Sabah Wildlife Department, with the financial support of the Malaysian Palm Oil Council and Borneo Conservation Trust, is planning to set up an elephant sanctuary in Lot 8 of the Lower Kinabatangan Wildlife Sanctuary.

The Sumatran rhinoceros (*Dicerorhinus sumatrensis harrissoni*)

Image 4: Tam Tam, a Sumatran rhino that was rescued from a plantation near Tabin Wildlife Reserve and which is now part of a captive breeding program run by Sabah Wildlife Department and BORA (Photo courtesy: Chris Bray)

Research on the Sumatran rhinoceros has been very limited in Sabah for the last 10 years, for a very sad reason, the number of rhinos in the wild is extremely low (maybe less than 30) and time and money should be spent for conservation rather than research. With as little as about 200 wild individuals worldwide, the Sumatran Rhinoceros (*Dicerorhinus sumatrensis*) is on the brink of extinction. Following the recent report by the World Wildlife Fund on the fate of the Javan rhinoceros (*Rhinoceros sondaicus*) in Vietnam, we are close to witness the loss of another rhinoceros species. During the current Sixth Extinction crisis, genetic studies have played an intense role identifying conservation priorities and they have not been the exception for rhinoceroses species. We have lost time and money in a debate on how genetically different the subspecies from Borneo and Sumatra are. Sabah feels that, in a species where time is pressing, such as the Sumatran rhinoceros, genetic (extremely low between the two subspecies) and geographic distances should not be taken into account and proposed to consider the populations of Sumatra and Borneo as a single management unit (Goossens *et al.* submitted). However, more research is needed in terms of reproduction. At least half of the females caught between 1985 and 1995 had reproductive tract pathology, a phenomenon associated with lack of breeding and carrying of fetuses to successful birth that appears to particularly affect rhinos (Rhinoceros Action Plan 2012-2016). With the financial help of the State Government, the palm oil industry (Sime Darby Foundation) and other funders (WWF-Germany, US Fish and Wildlife Service, etc), and of scientific institutions such as Universiti Malaysia Sabah (UMS) and the Leibniz Institute for Zoo and Wildlife Research (IZW), a local NGO (BORA which stands for Borneo Rhino Alliance - http://www.borneorhinoalliance.org) dedicated to save the Borneo's Sumatran rhinoceros from extinction was created. A Borneo Rhino Sanctuary (BRS) was then set up in Tabin Wildlife Reserve with the idea of bringing wild rhinoceroses together and successfully breed them. The work at BRS is ongoing, with so far two individuals (one male and one female) that have been brought from the wild.

The Bornean Banteng (*Bos javanicus lowii*)

Image 5: Camera trap picture of banteng taken in Malua Forest Reserve during our Banteng Conservation Programme (Photo courtesy: Penny Gardner/DGFC/SWD)

Bos javanicus lowi is one of the rarest endangered large mammals in Sabah - yet very little is known of their ecology or exact population size. There have been no attempts to accurately quantify their population size or to study the dynamics of their population structure, range and dispersal patterns, whether they purposefully enter oil palm plantations and to what extent, or their behavioural ecology. Species-specific information is crucial to their conservation however the elusive behaviour, remote inhospitable forest habitat and small population size preclude investigations. To overcome these problems Sabah Wildlife Department, the NGO HUTAN and Danau Girang Field Centre proposed to study the population in two forest reserves (Malua Forest Reserve and Tabin Wildlife Reserve) by using a multidisciplinary approach of satellite telemetry, molecular analysis and remote camera traps. Funding was obtained from the Malaysian Palm Oil Council, Houston Zoo, Mohamed bin Zayed Species Conservation Fund and Woodland Park Zoo and the project started in October 2010, led by a Cardiff University PhD student, Penny Gardner. In 2012, we intent to place satellite radio-tracking devices on 4 to 6 individuals to monitor their movement and collate information on their range size, dispersal distances and distribution, use of habitat, and also provide insights into their behaviour and herd dynamics. To establish the frequency of visits and the importance of mineral licks and water sources we have been employing remote camera traps. These traps also provided photographic evidence of individuals useful for identification and provided information on the activity of specific individuals. Finally, to determine the integrity and relatedness within and between banteng populations we will examine their genetic structure through analysis of faecal and tissue samples collected in the field. This will also provide a basis for suggesting appropriate management techniques abetting the long term viability and sustainability of *B. j. lowi*, and also mitigating the risks of inbreeding and hybridisation with domestic cattle. This project is the first comprehensive research on banteng in Sabah. Hopefully, with additional funding, we will attempt to locate and survey the remaining banteng populations across Sabah with camera traps. The starting point for this study forms the "faunal survey of Sabah" conducted in the early 80s by WWF. Within this survey the banteng population size was estimated to be 1,980 and a provisional distribution map was shown. Recognition of remnant banteng populations is critical for identifying the extent of the decline, which has probably occurred over the past 30 years as a result of deforestation, conversion to oil palm plantations and human population expansion. It is also crucial for identifying connectivity issues compromising the genetic integrity of the species. The main output of these two projects, mainly funded by the palm oil industry, will be the drafting of a Sabah Banteng Action Plan that will be launched at an international workshop on banteng conservation that we plan to organise in about 3-4 years from now. Further information on the banteng programme can be found in this interesting article published on Mongabay web site: http://news.mongabay.com/2012/0131-hance_fs_banteng.html

The Malayan Sun Bear (*Helarctos malayanus*)

Image 6: Camera trap picture of a sun bear female and her cub taken in Lot 6 of the Lower Kinabatangan Wildlife Sanctuary, near Danau Girang Field Centre (Photo courtesy: DGFC/SWD)

Most of the research carried out in Sabah on sun bears for the last 10 years was by a Malaysian scientist, Siew Te Wong, in Ulu Segama Forest Reserve, central Sabah. Wong published several papers on the ecology, biology, home ranging and behaviour of the sun bears. In 2002, Wong *et al.* published a paper on the sun bear food habits in the Ulu Segama Forest Reserve, by analyzing scats, examining feeding sites, and directly observing bears. Invertebrates such as termites (Isoptera), beetles (Coleoptera), and beetle larvae (Coleoptera) were the predominant food items, occurring in 57% of the scat samples. Figs (*Ficus* sp.) were the most common fruit consumed (in 61% of the samples) during the non-fruiting season. Vertebrates were also consumed but less commonly. Most feeding sites (60%) were in decaying wood, where sun bears foraged for termites, beetles, and beetle larvae. They concluded that sun bears were opportunistic omnivores consuming a wide variety of food items. Furthermore, from June 1999 to December 2001, Wong captured and radio-collared six sun bears in Ulu Segama Forest Reserve, to study their home-range characteristics, movement patterns, activity patterns, population density, and bedding sites (Wong *et al.* 2004). They recorded a total of 343 locations and found bears in both primary and logged forests. The home range size averaged 14.8 ± 6.1 (SD) km^2 and the daily movement distances averaged 1.45 ± 0.24 (SD) km. According to Wong *et al.* (2004), these movements were affected by food availability, especially availability of figs. Male sun bears were primarily diurnal, but a few individuals were active at night for short periods. The majority of the 26 bedding sites consisted of fallen hollow logs. Other bedding sites included standing trees with cavities, cavities underneath fallen logs or tree roots, and tree branches high above the ground. Wong *et al.* (2004) concluded that well-designed logging practices, maintenance of large trees with cavities, protection of fig trees, and strict control of poaching should be incorporated into forest management practices in logged forests. The last paper published by Wong and collaborators (Wong *et al.* 2005) showed that the six sun bears that were captured and radio-collared were in poor physical condition, and two were later found dead, following a prolonged scarcity of fruit during an intermast interval in the study area. Lowland tropical rainforest trees of Borneo display supra-annual synchronized general fruiting. Wong *et al.* (2005) believed that the starvation they observed and the generally low density of large animals in Borneo forests is a consequence of a history of prolonged food scarcity during non-general-fruiting years, but may be accentuated by anthropogenic factors such as forest fragmentation, selective logging, and reduced density of fig trees in logged forests.

Following all his hard work in the forest, Wong founded the Bornean Sun Bear Conservation Centre (BSBCC) to provide for the care, rehabilitation and release of orphaned and captive sun bears, as well as address the lack of knowledge and awareness of the species. The BSBCC is a joint project with the Sabah Wildlife Department, the Sabah Forestry Department and Land Empowerment Animals People (LEAP). BSBCC is supported by the Sabah State Government and other partners such as, once again, Sime Darby Foundation and their Big9 Programme, and many other sponsors. For more information, check the following link: http://sunbears.wildlifedirect.org/bornean-sun-bear-conservation-centre-bsbcc/

The Sunda Clouded Leopard (*Neofelis diardi*)

Image 7: Camera trap picture of a clouded leopard female and her cub taken in Lot 5 of the Lower Kinabatangan Wildlife Sanctuary (Photo courtesy: DGFC/SWD)

Most of the research on clouded leopard in Borneo has been focusing on the taxonomic status of the species. In 2006, Buckley-Beason *et al.* used molecular genetic methods to re-evaluate subspecies partitions and quantify patterns of population genetic variation among 109 clouded leopards of known geographic origin. They found strong phylogeographic monophyly and large genetic distances between *N. n. nebulosa* (mainland) and *N. n. diardi* (Borneo; n = 3 individuals) with mtDNA (771 bp), nuclear DNA (3100 bp), and 51 microsatellite loci. Thirty-six fixed mitochondrial and nuclear nucleotide differences and 20 microsatellite loci with nonoverlapping allele-size ranges distinguished *N. n. nebulosa* from *N. n. diardi*. Along with fixed subspecies-specific chromosomal differences, this degree of differentiation was equivalent to, or greater than, comparable measures among five recognized *Panthera* species (lion, tiger, leopard, jaguar, and snow leopard). These distinctions increased the urgency of clouded leopard conservation efforts, and if affirmed by morphological analysis and wider sampling of *N. n. diardi* in Borneo and Sumatra (see Kitchener *et al.* 2006), they would support reclassification of *N. n. diardi* as a new species (*Neofelis diardi*). In the same issue and parallel to Buckley-Beason *et al.* (2006), Kitchener *et al.* (2006) carried out a detailed examination of geographical variation. They describe the results of a morphometric analysis of the pelages of 57 clouded leopards sampled throughout the species' range. They concluded that there are two distinct morphological groups, which differ primarily in the size of their cloud markings. These results are supported by the genetic analysis above (Buckley-Beason *et al.* 2006). On that basis, the authors gave diagnoses for the distinction of two species, one in mainland Asia (*N. nebulosa*) and the other in Sumatra and Borneo (*N. diardi*). Following these two publications from 2006, a more recent genetic study published by Wilting *et al.* (2011) re-evaluated the proposed subspecies differentiation using additional molecular (mainly historical) samples of eight Bornean and 13 Sumatran clouded leopards, a craniometric analysis of 28 specimens, and an examination of pelage morphology of 20 museum specimens and of photographs of 12 wild camera-trapped animals. Molecular (mtDNA and microsatellite loci), craniomandibular and dental analyses strongly supported the differentiation of Bornean and Sumatran clouded leopards, but pelage characteristics failed to separate them completely, most probably owing to small sample sizes, but it may also reflect habitat similarities between the two islands and their recent divergence. However, some provisional discriminating pelage characters presented in the paper need further testing. According to Wilting *et al.*'s (2011) estimates both populations diverged from each other during the Middle to Late Pleistocene (between 400 and 120 kyr). The authors presented a discussion on the evolutionary history of *Neofelis diardi* sspp. on the Sunda Shelf, a revised taxonomy for the Sunda clouded leopard, *N. diardi*, and formally described the Bornean subspecies, *Neofelis diardi borneensis*, including the designation of a holotype (BM.3.4.9.2 from Baram, Sarawak) in accordance with the rules of the International Code of Zoological Nomenclature. The subspecies description was covered by BBC news and you can check the following link for more information: http://news.bbc.co.uk/earth/hi/earth_news/newsid_9369000/9369238.stm

Previously to that, Wilting *et al.* (2006) utilized a rigorous track classification method to estimate population size and density of Sunda clouded leopards (*N. diardi*) in Tabin Wildlife Reserve. They also extrapolated their local-scale results to the regional landscape level to estimate Sunda clouded leopard population size and density in all of Sabah's reserves, taking into account the reserves' conservation status (totally protected or commercial forest reserves), their size and presence or absence of Sunda clouded leopards. The population size in the 56 km^2 research area was estimated to be five individuals, based on a capture-recapture analysis of four confirmed animals differentiated by their tracks. Extrapolation of these results led to density estimates of nine per 100 km^2 in Tabin Wildlife Reserve. Applying a 95% confidence interval they calculated in total a very rough number of 1,500–3,200 Sunda clouded leopards to be present in Sabah. However, only 275–585 of these animals inhabit the four totally protected reserves that are large enough to hold a long-term viable population of > 50 individuals. More recently, Wilting *et al.* (2012) published one of the first density estimates calculated with spatial capture–recapture models using camera-trap data. In two commercial forest reserves in Sabah (both certified for their sustainable management practices) the density of the Sunda clouded leopard was estimated to be c. 1 per 100 km^2 (0.84 ± SE 0.42 and 1.04 ± SE 0.58). The presence of the Sunda clouded leopard in such forests was encouraging for its conservation but additional studies from other areas, including protected forests, are needed to compare and evaluate these densities. Today, in collaboration with SWD, Andrew Hearn, a PhD student from the WildCRU of the Oxford University is carrying out a state-wide population survey of Sunda clouded leopards in several protected forests including Danum Valley Conservation Area, Ulu Segama Forest Reserve, Kuamut Forest Reserve, Kalabakan Forest Reserve, Kinabatangan Wildlife Sanctuary and Crocker Range National Park. Previously to that, he completed camera trap surveys in Malua Forest Reserve and Tabin Wildlife Reserve. If you want to know more about this fantastic project, check out the following link: http://borneanwildcat.blogspot.com/

Check out the following link for the first video of the Sunda clouded leopard taken into the wild in Deramakot Forest Reserve by Wilting and Mohamed: http://news.bbc.co.uk/earth/hi/earth_news/newsid_8505000/8505785.stm

Sabah Wildlife Department, Danau Girang Field Centre and WildCRU are currently embarking in a Sunda clouded leopard satellite tracking programme that will be carried out in the Kinabatangan Wildlife Sanctuary to understand how that carnivore copes with a mosaic of oil palm plantations/highly degraded forest. The main output of this programme will be a Sunda Clouded Leopard Action Plan for the state of Sabah.

Conclusion

Most of the research described above is meant to assist the Sabah Wildlife Department and its partners to protect charismatic mammal species in Sabah. We hope that more research applied to conservation can be carried out in the future, with the support of the oil palm industry. From the industry, the Malaysian Palm Oil Council and Sime Darby Foundation are currently the two main funding partners to conservation. The future of wildlife in Sabah is not only in the hands of conservationists, NGOs, government agencies but also in the hands of the industry. Palm oil owners and industries can help reconnecting forest so that animals can meet and breed naturally. Forest connectivity and protection are the key issues for wildlife conservation and the industry needs to help Sabah achieving this. It is only together that we will be able to harmonise wildlife and biodiversity conservation with national development.

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