Danau Girang Field Centre

The Bornean Banteng Programme: Conservation and management of the endangered wild cattle *Bos javanicus lowi* in Sabah.

Survey of bantengs in Segaliud-Lokan Forest Reserve

Penny C. Gardner[1*], Benoit Goossens[1,2,3]

[1]Danau Girang Field Centre, C/O Sabah Wildlife Department, 5th Floor, Wisma Muis, Kota Kinabalu. 88100. [2]Cardiff University, Sir Martin Evans Building, School of Biological Science, Cardiff, Wales, U.K. [3]Sabah Wildlife Department, 5th Floor, Wisma Muis, Kota Kinabalu 88100.

***pennygardner14@hotmail.com**

The Bornean Banteng Programme is an initiative of Danau Girang Field Centre and the Sabah Wildlife Department, in collaboration with the Sabah Forestry Department.

This programme is kindly sponsored by Yayasan Sime Darby. Field survey work commenced in October 2012. The programme will culminate in the first international workshop for Bornean bantengs in Sabah in 2017, during which the first Conservation Management Action Plan will be formulated for this species.

Introduction

Taxonomy

Three subspecies of bantengs (*Bos javanicus*) are widely recognised and this is based on phylogenetic analysis of mitochondrial DNA and inferences of their evolutionary history: the Burma or Burmese bantengs (*B. j. birmanicus*) in mainland Southeast Asia, the Java bantengs (*B. j. javanicus*) in Java and possibly Bali, and the Bornean bantengs (*B. j. lowi* or *lowii*), (hereon referred to as *B. j. lowi*) which is endemic to the island of Borneo (Figure 1). The banteng is likely to be a monophyletic species that dispersed across the Sunda shelf (land bridges) connecting the Malayan and Indo-Malayan sub-region during the last glacial period (maximum 22,00-19,000 years ago (Yokoyama et al., 2000). Prehistoric cave paintings in Kalimantan (Indonesia) that date >10,000 years old depict zoomorphic figures, including one animal which is thought to be the Bornean banteng (Chazine 2005; Chazine 2009). Bone fragments of wild cattle, believed to be bantengs, were also found in a cave in Sarawak and were dated to the late-Pleistocene period (Medway 1964), suggesting that the Bornean banteng naturally occurs in Borneo. Phylogenetic reconstruction of bantengs by Matsubayashi et al. (2014), Ishige et al. (2015) and Gardner (2015) indicate the Bornean banteng is most closely related to the wild Indian bison or gaur (*B. gaurus*). This evidence amplifies the importance of conserving the Bornean bantengs separately to other banteng subspecies. The Bornean banteng is morphologically similar to gaur, having starkly white lower legs or stockings with a muscular compact body, however Bornean banteng are smaller in stature than the gaur, they have white buttocks, and a smaller less-pronounced hump between the shoulders (Gardner 2015). Subtle pelage differences are also evident between the three banteng subspecies: *B. j. javanicus*, *B. j. birmanicus* and *B. j. lowi* (Figure 2).

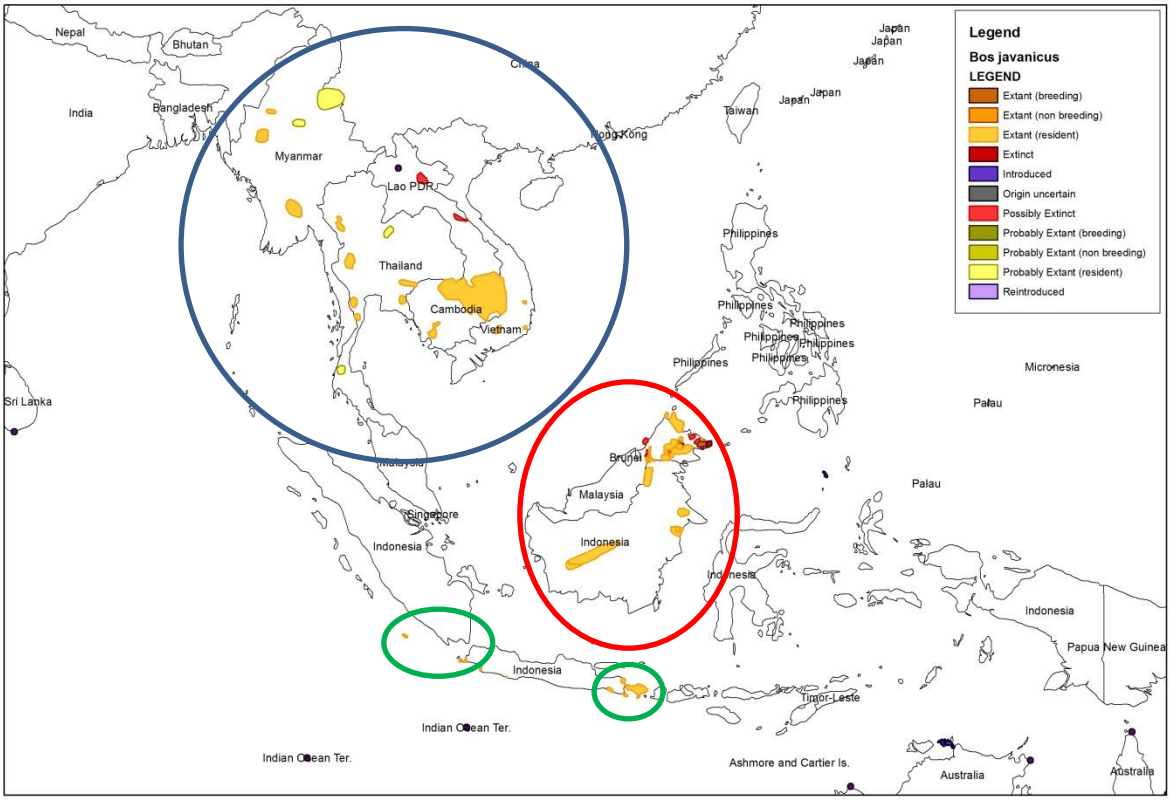

Figure 1: The world-wide distribution of banteng subspecies: Burma or Burmese banteng (*B. j. birmanicus:* blue circle), Java banteng (*B. j. javanicus:* green circle), and the Bornean banteng (*B. j. lowi;* red circle) (Gardner et al. 2016)

Hybridization with domestic cattle remains a serious threat to the genetic integrity of the Bornean banteng. Past observations of abandoned cattle and/or supposedly wild bantengs matching the description of a hybrid (i.e. pronounced dewlap, straight horns and white spotted pelage) have been reported in forest reserves and in agricultural land across Sabah (Deramakot Forest Reserve, Sipitang Forest Reserve, Kalabakan Felda plantation) however genetic introgression has not yet been proven. The use of domestic cattle and buffalo in plantations and within villages inside the forest reserves is not uncommon, and careful management of livestock will ensure interbreeding does not occur. At present, no captive populations of Bornean bantengs persist, and no tissue samples from wild-caught individuals have been obtained. Therefore, establishing the taxonomic description of suspected hybrids using molecular analysis has not been possible during the first study of Bornean bantengs (years 2011-2013) or the state-wide survey of the Bornean bantengs (2013-2016) by the Bornean Banteng Programme/Danau Girang Field Centre.

Figure 2: Photographs of bantengs bulls of the three subspecies with subtle variations in pelage colour and body size: Top left: The Bornean banteng (*B. j. lowi)* with very dark pelage colouration and a stout compact body size, photographed in Segaliud-Lokan Forest Reserve in the Malaysian state of Sabah as part of this study (© Bornean Banteng Programme/Danau Girang Field Centre). Top right: A banteng bull in Thailand (*B. j. birmanicus)* with a brown pelage and heavy-set facial features (© D. Kohn). Bottom: A herd of Java bantengs (*B. j. javanicus)* photographed on the Indonesian island of Java with the bulls evident by their dark brown/black pelage colour. The facial structure of the Java bantengs shows subtle differences in their elongated facial structure (© S. Pudyamtoko).

Legislation

In accordance with the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of threatened species, the banteng is classified as 'Endangered' due to their collective small population size and declining trend across their distribution (Gardner et al. 2016). Under the Sabah Wildlife Conservation Enactment 1997, the banteng is listed in Schedule 1 as 'Totally Protected' therefore no hunting is permitted. The possession of a live wild banteng, or of banteng meat or body parts carries a penalty of 50,000RM or imprisonment for five years, or both. Despite repeated evidence of banteng hunting (carcases,

police report, photographic evidence, and first account accounts by government staff) as recently as January 2015, no convictions have been made to-date.

Past population trends

The past global population size of the Bornean banteng is difficult to assess due to a lack of research, lack of collaboration between stakeholders within and between the three countries in Borneo, and logistical issues associated with conducting large-scale surveys of a low-density mammal. Within Sabah, reports from the late 19th and early 20th centuries indicated that bantengs were present and perhaps common wherever shifting cultivation was practiced (Davies & Payne 1982). Following World War II, when the use of firearms for hunting increased, the bantengs suffered declines. They were eradicated in multiples areas of Sabah (Davies & Payne 1982). Widespread timber harvesting, followed by the conversion of land for agriculture increased the access to previously remote forest, thereby facilitating armed hunting within banteng habitat and the removal of large carcasses. In 1982 the first non-quantitative survey was conducted by Davies and Payne (1982), which estimated the population to be between 300-550 individuals. Actions to mitigate against the activities that threaten the population were outlined in the report. In 1997, the first quantitative survey of bantengs was conducted in forested areas in the state using sign surveys and camera traps, however despite the use of 127 transects, totalling 62 km in 12 forest reserves, only 20 tracks of bantengs were recorded (Boonratana 1997). The low encounter rate precluded density estimates, and the bantengs were found to be rare in areas where they were previously considered as common by Davies and Payne (1982). The report by Boonratana (1997) highlighted their deteriorated status and outlined actions to prevent further loss. Despite these two reports documenting the endangered status of the Bornean banteng and the immediate threats that have caused their decline, no known actions were ever taken to conserve them or their habitat. In terms of subpopulation sizes, within Sabah, the largest subpopulation can reportedly be found in Kulamba Wildlife Reserve, which is thought to contain over 100 individuals (Gardner et al. 2016). However, quantitative survey methods and data to substantiate this figure are not available or in circulation, and this population size should be considered a crude approximation only (Gardner et al. 2016). The most recent and extensive survey of bantengs in Sabah included the Segaliud-Lokan Forest Reserve (SLFR) and was conducted in the year 2015 by the Bornean Banteng Programme. This survey used 30 non-invasive paired camera trap stations positioned inside SLFR, along abandoned logging roads,

in open areas and along forest trails in closed forest. A total of 2,685 camera trap nights were surveyed between 11st September 2015 to 22th December 2015.

Ecology

Activity patterns

Activity patterns of bantengs and ambient temperature in KMTFR were estimated from 15 of the 30 camera trap stations, which captured 253 events of bantengs. One of these was discounted due to violation of independence assumption, therefore 103 independent camera trap events of bantengs were captured over a survey period of 2,685 nights. Independence of camera trap events was defined geographically and chronologically; a minimum distance of 100m was maintained between camera trap stations, and multiple events per station were discounted if they occurred within the same hour. Where possible, all individuals were identified using a combination of natural marks (e.g. scars, horn morphology, and cow-calf associations), and multiple events of the same individuals during the same hour were discounted even if arising from different stations, to minimise pseudo-replication. To estimate 95% confidence intervals around activity and temperature data, activity and associated temperature data was aggregated to two-hour intervals and bootstrapped with replacement following the procedure of Gardner et al. (n.d.). Activity was then stratified into activity budgets according to three behaviours (foraging, travel and resting/fighting) and three locations (abandoned logging road, open area and forest trail).

Observations of temperature data was captured by camera traps and revealed average ambient temperatures started increasing around 08:01-10:00 hours and reached 30°C (CI = 28-33°C) during the midday period (12:01-16:00 hours). During the night and early morning, temperatures dropped to ~24°C (CI = 23-25°C) (Figure 3). Maximal temperatures were slightly elevated from ambient temperatures and were approximately ~1°C higher, extending from midday until 18:00 hours (average 31°C, CI = 29-33°C). Compacted soils following logging activity present unfavourable conditions for seedling recruitment (Pinard et al., 1996), and heavily and extensive logging in the 1990s probably slows rejuvenation of the canopy. Consequently, logging roads and stumping grounds may experience higher ambient temperatures and restricted succession, however an absence of banteng observations in all locations prevents closer examination of this relationship.

Banteng activity was elevated over sunrise and in the two hours preceding it, between 04:01-08:00 hours (Figure 4). Activity then decreased and bantengs were less frequently

active until midday. After 12:00-14:01 hours, activity increased in frequency and bantengs remained active throughout the night. A Spearman's rank correlation between the bootstrapped activity patterns and ambient temperature indicated a negative response, whereby activity frequency decreased when ambient temperatures increased (r_s = -0.57, t = -2.17, 95% CI -0.01 - 0.86, p=<0.05).

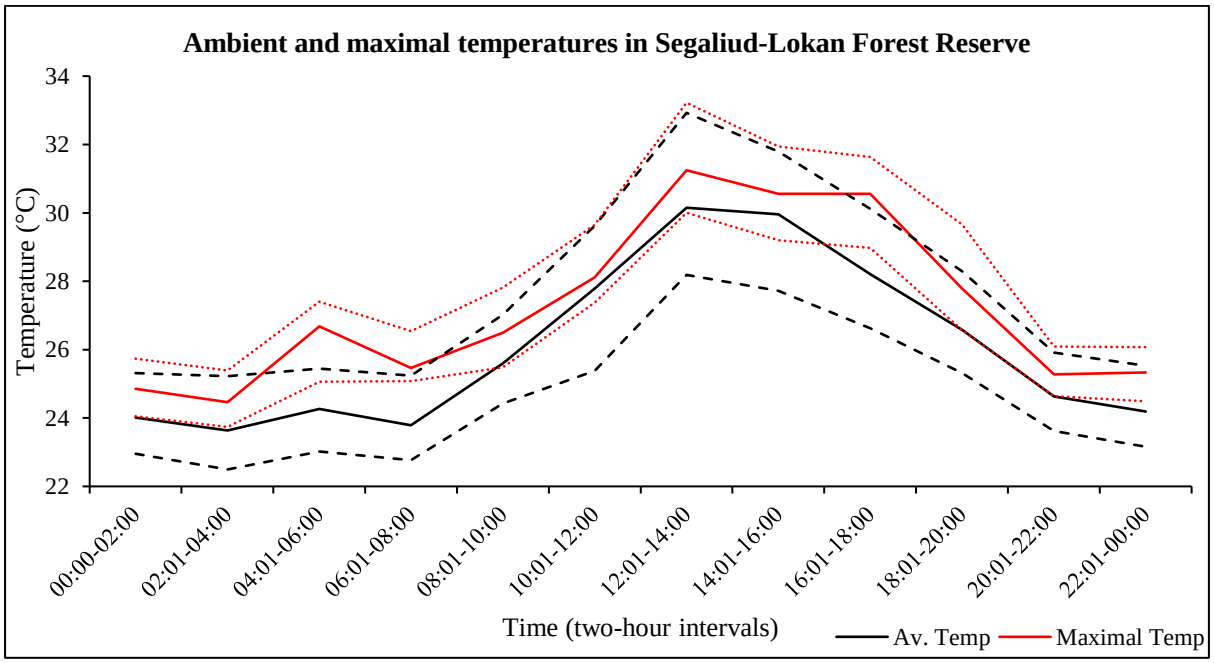

Figure 3: Ambient temperatures and maximal temperatures recorded in Segaliud-Lokan Forest Reserve (SLFR), plotted according to two-hour intervals across the 24-hour period and estimated using non-parametric bootstrapping to estimate 95% confidence intervals.

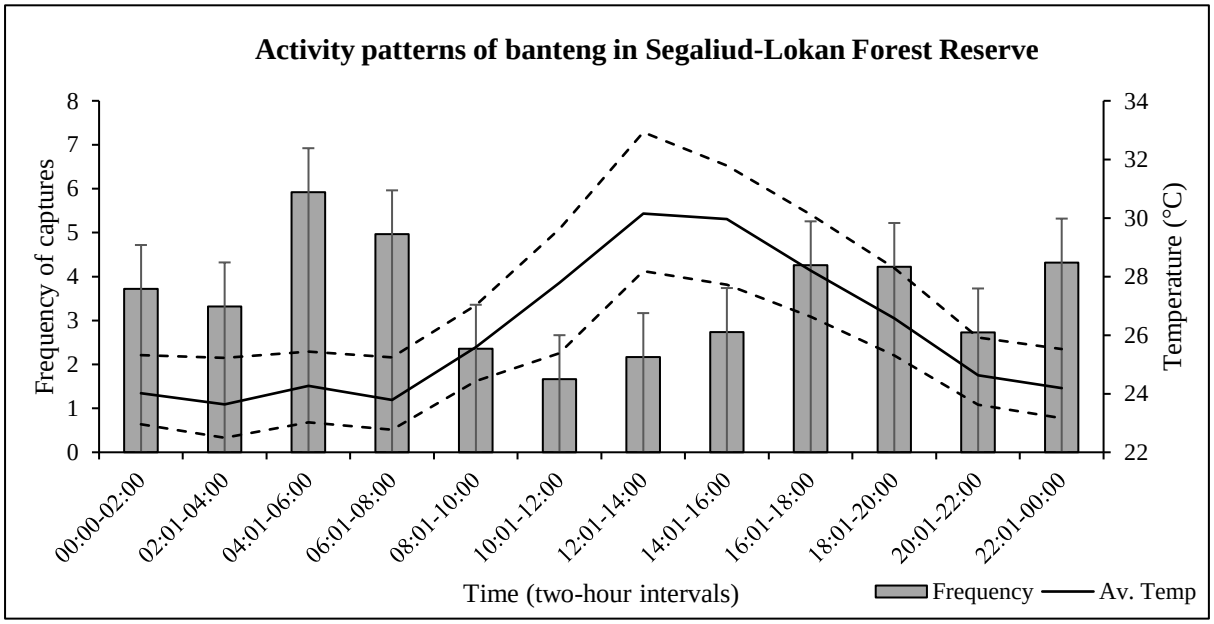

Figure 4: Ambient temperature and activity patterns (all locations combined) of Bornean banteng in Segaliud-Lokan Forest Reserve (SLFR) plotted according to two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals.

Activity budgets

Segregation of activity patterns into three behavioural categories revealed travelling and foraging were the primary behaviours performed throughout the day. Other (resting/fighting) was recorded at very low frequency (<1 min) at all hours except during the midday hot hours. During the midday hours (12:01-16:00 hours) categorised by high ambient temperatures, banteng continued to travel and forage however only foraging was negatively associated with an increase in ambient temperature (r_s= -0.58, p= <0.05, t=-2.24, 95% CI= -0.01 - -0.87). Compared to four other forest reserves, bantengs in Segaliud-Lokan spent half their time travelling (52%) and half their time foraging (48%) (Figure 6).

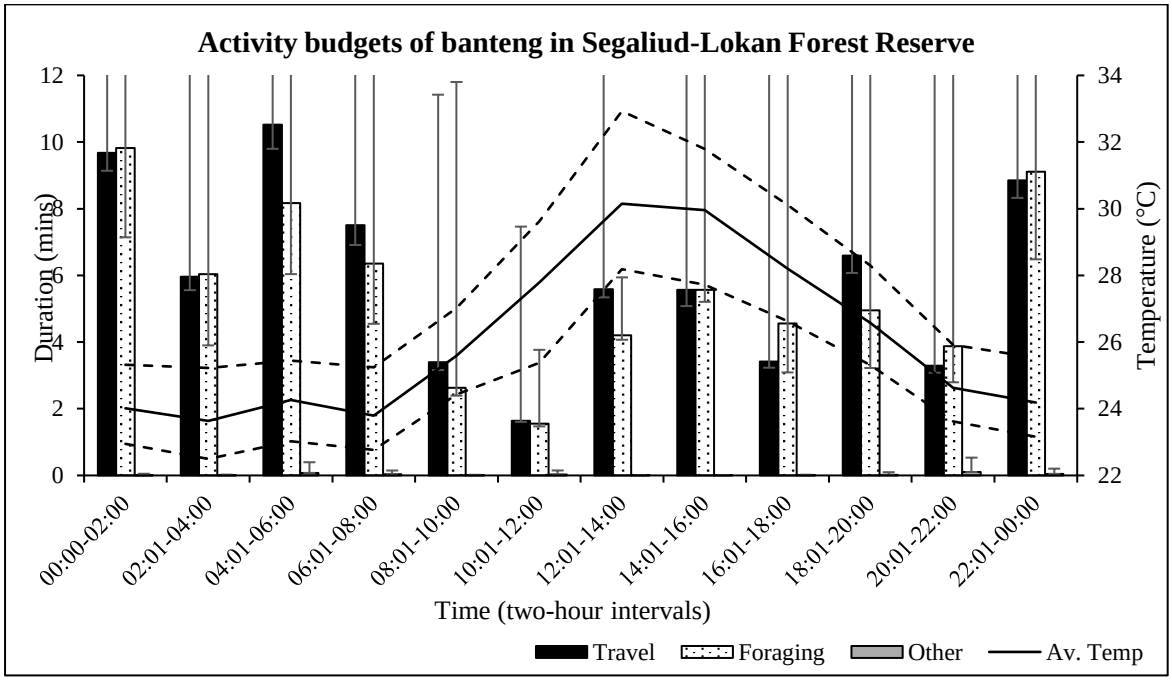

Figure 5: Diel energy budgets of bantengs in Segaliud-Lokan Forest Reserve (SLFR) and ambient temperature plotted according to two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals.

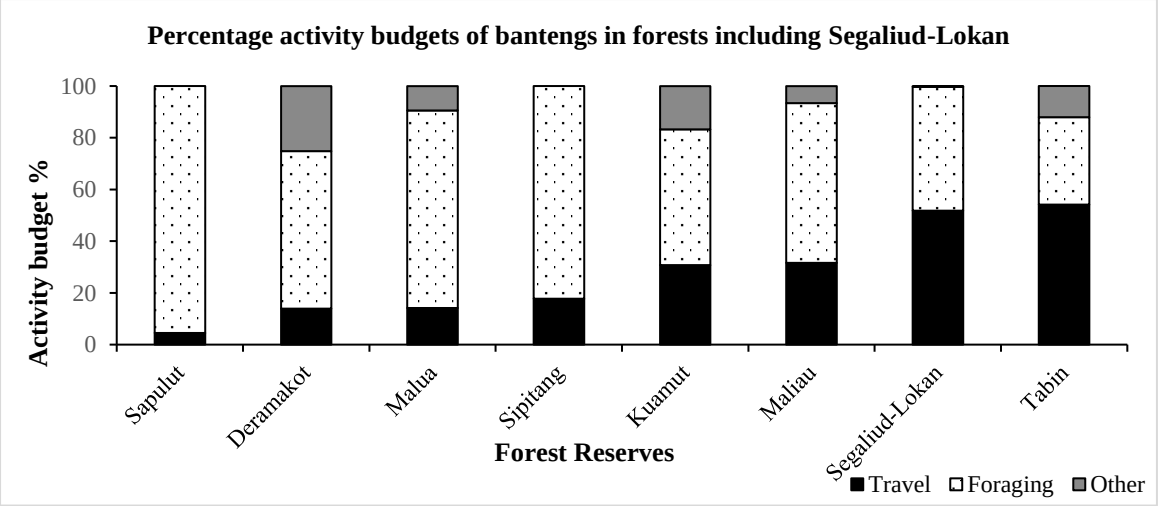

Figure 6: The activity budgets of bantengs expressed as percentage frequencies in eight different forests including Segaliud-Lokan Forest Reserve. The three behaviours which comprised the activities were Travel, Foraging and Other (Resting/Fighting).

Habitat use

Camera traps were established along old logging roads, in open areas and along trails and segregation of activity budgets into these three locations revealed that abandoned logging roads were predominantly used, followed by a small proportion of time spent in open areas (Figure 7). Bantengs in Segaliud-Lokan spent long durations utilising abandoned logging roads in the morning, afternoon and at night but reduced their use of this area between the hours 08:01-16:00 with high temperatures (26-30°C CI 24-33°C). Use of abandoned logging roads and open areas were negatively associated with an increase in ambient temperature (r_s= -0.58, p=<0.05, t=-2.24, 95% CI= -0.87 - -0.01, and r_s= -0.72, 0.01, -3.28, CI = 0.92- -0.25, respectively). Compared to other forests, bantengs' use of abandoned logging roads in Segaliud-Lokan was the second highest (97% of their time), whereas open areas were used the second least (3%) (Figure 8).

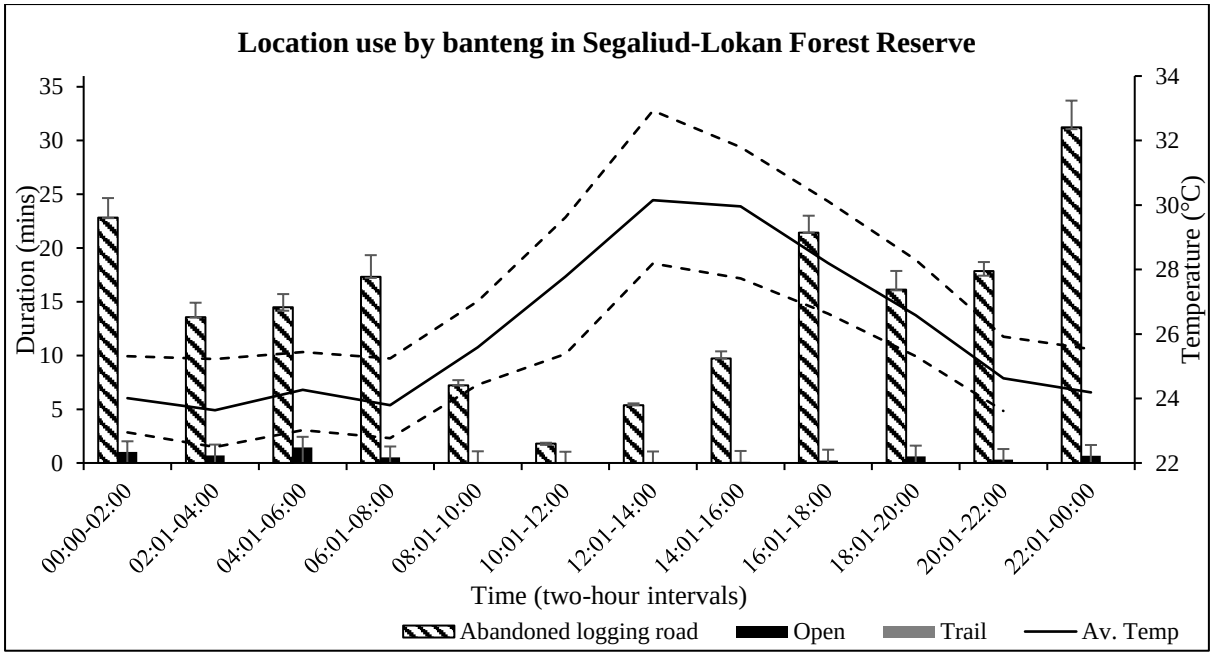

Figure 7: Diel habitat use of bantengs in Segaliud-Lokan Forest Reserve (SLFR) and ambient temperature plotted according to three locations and two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals. Note, active access roads were not monitored due to theft risk.

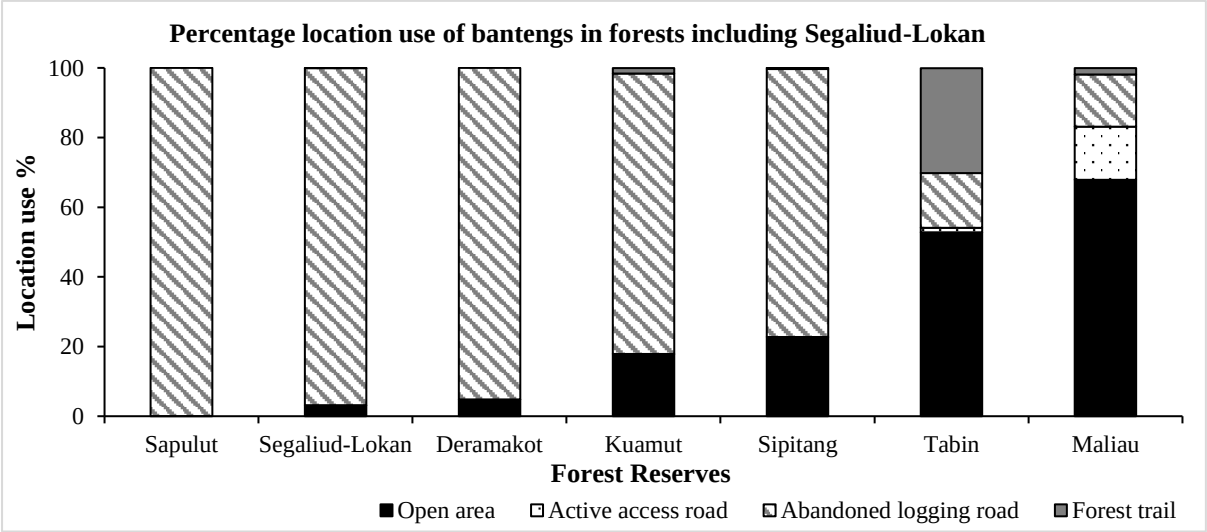

Figure 8: The habitat use budgets of bantengs expressed as percentage frequencies in eight different forests including Segaliud-Lokan Forest Reserve. The three locations were Open area, Abandoned logging road and Forest trail. Forests are ranked according to frequency of use of abandoned logging roads.

Diet and foraging ecology

There is no information pertaining to the diet and foraging ecology of bantengs within Segaliud-Lokan. For information on the foraging ecology of bantengs in other forests, please refer to an unpublished a report entitled ‘Foraging behaviour and forage choices of the Bornean banteng (*Bos javanicus lowi*) in Sabah, Malaysia by S. Ridge.

Population status

Distribution

Bantengs were captured at 15 (50%) of the 30 camera trap stations deployed by the Bornean Banteng Programme across Segaliud-Lokan during the year 2015 (Figure 9). Their distribution was recorded in the east of the reserve (Figure 10) across the reserve but compartments were unknown.

Within Segaliud-Lokan, bantengs were observed congregating in herds of up to 11 individuals comprising bulls, bullocks or juvenile bulls, mature cows, heifers or juvenile cows, and young calves. Photographic captures suggested the presence of possibly six calves, approximately <5 months old, born at different times (three possibly in July-August 2015).

Based on individual identification using natural marks and scars, a recapture history of recognised individuals captured in 2015 indicated that the maximum (straight-line) distance moved within Segaliud-Lokan was 11.7km by one cow and 4.6m by a bull.

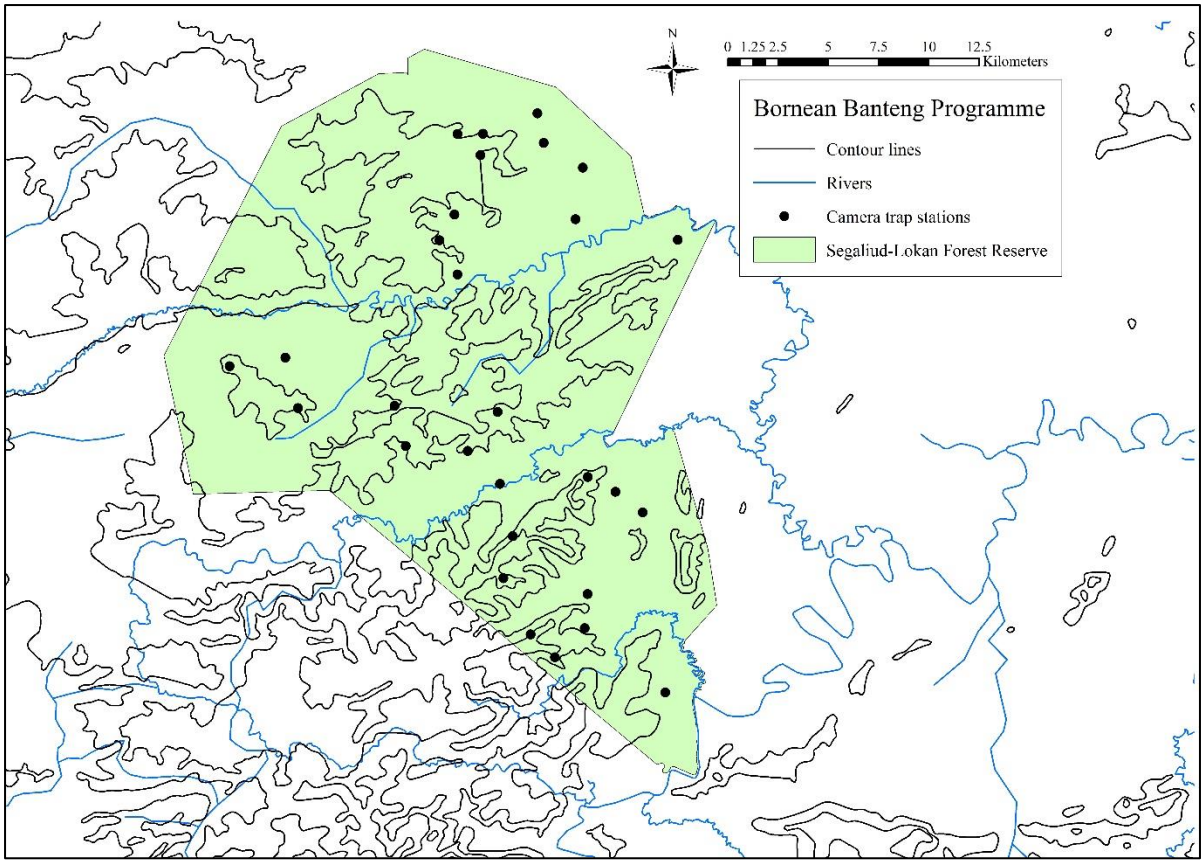

Figure 9: Camera traps deployed by the Bornean Banteng Programme in Segaliud-Lokan Forest Reserve during the year 2015 to collect data on bantengs behaviour and to identify individuals. The population size estimate of bantengs represents these survey points only.

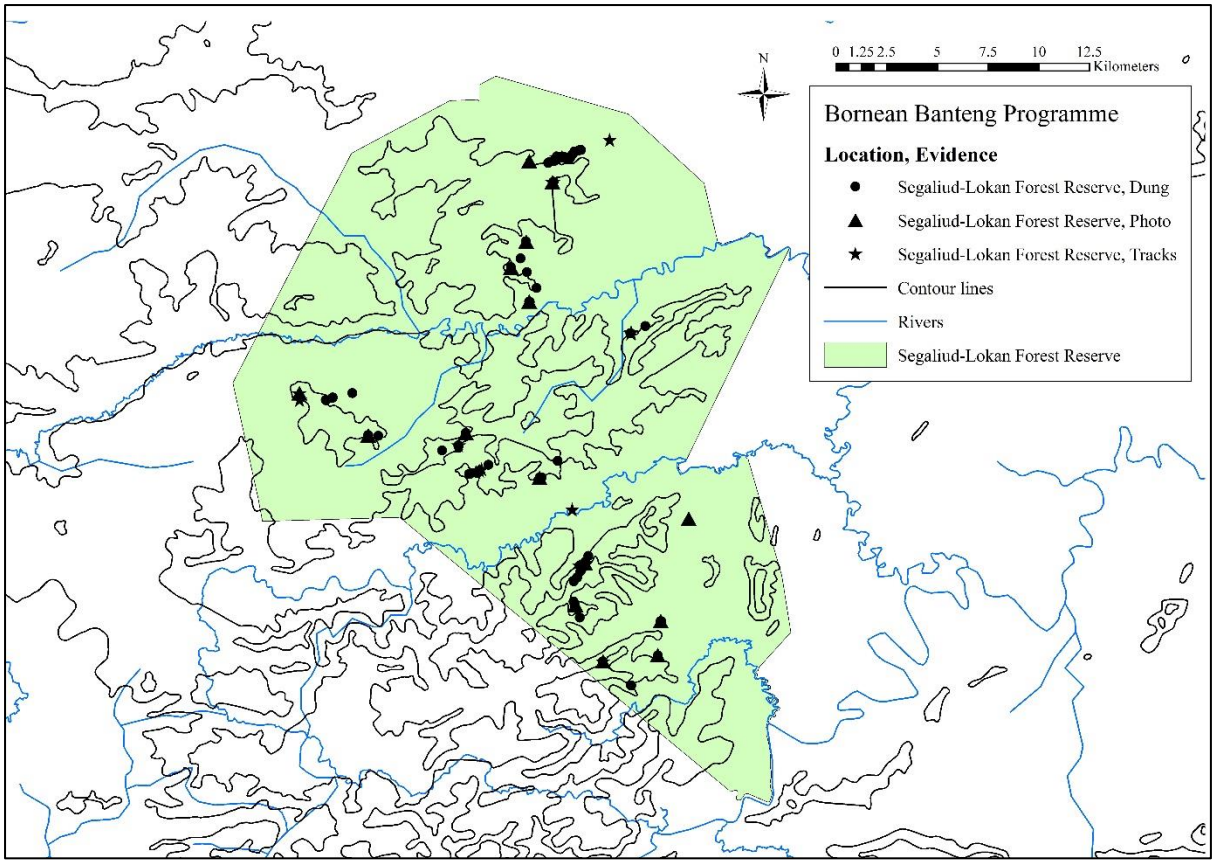

Figure 10: The distribution of banteng signs across Segaliud-Lokan Forest Reserve using camera traps and encounters of tracks and faecal deposits during surveys conducted by the Bornean Banteng Programme during the year 2015. Note, signs are only representative of the survey area and routes covered by the team during the survey.

Population size

Based on recaptures of identified individuals from camera trap data within the Bornean Banteng Programme study areas, 46 individuals were recognisable using scars (Figure 11), markings and cow-calf associations where markings were absent, and many of these were recaptured in multiple areas. At least 26 bulls and bullocks, 15 cows and heifer, and 5 calves were identified, whilst the number of unidentified individuals was ~15 due to poor lighting, visibility and insufficient angles to detect unique scars. The bantengs formed herds, comprised up to 11 individuals. A number of captures were not possible to identify due to poor visibility, lack of scars or insufficient coverage of multiple features and angles. The population size estimate of the areas survey is a crude estimate and does not represent the genetic diversity or their health and body condition.

Figure 11: A mature cow recognisable by a large discoloured patch on the right side of her body. This individual was recaptured on multiple occasions and at two different camera trap stations.

Breeding activity

Evidence of breeding and survival of calves was observed in Segaliud-Lokan using the camera trap data. At least 5 calves were observed in the duration of the study, one was very young <2 months old and probably born late August/early September 2015 (Figure 12). Two other calves, which were probably born to the same herd and around the same time were estimated to have been born around June/July 2015.

Figure 12: Calves captured on camera trap in 2015 within Segaliud-Lokan Forest Reserve.

Population genetic structure

During camera trap surveys, a total of 52 faecal samples were collected for DNA extraction. Samples and molecular analysis using mtDNA on this subpopulation are currently in progress at the Lok Kowi Laboratory in Kota Kinabalu following the same procedures as those outlined in the PhD thesis of P. Gardner (2015). The distribution of faecal samples collected from Segaliud-Lokan can be found in Figure 13.

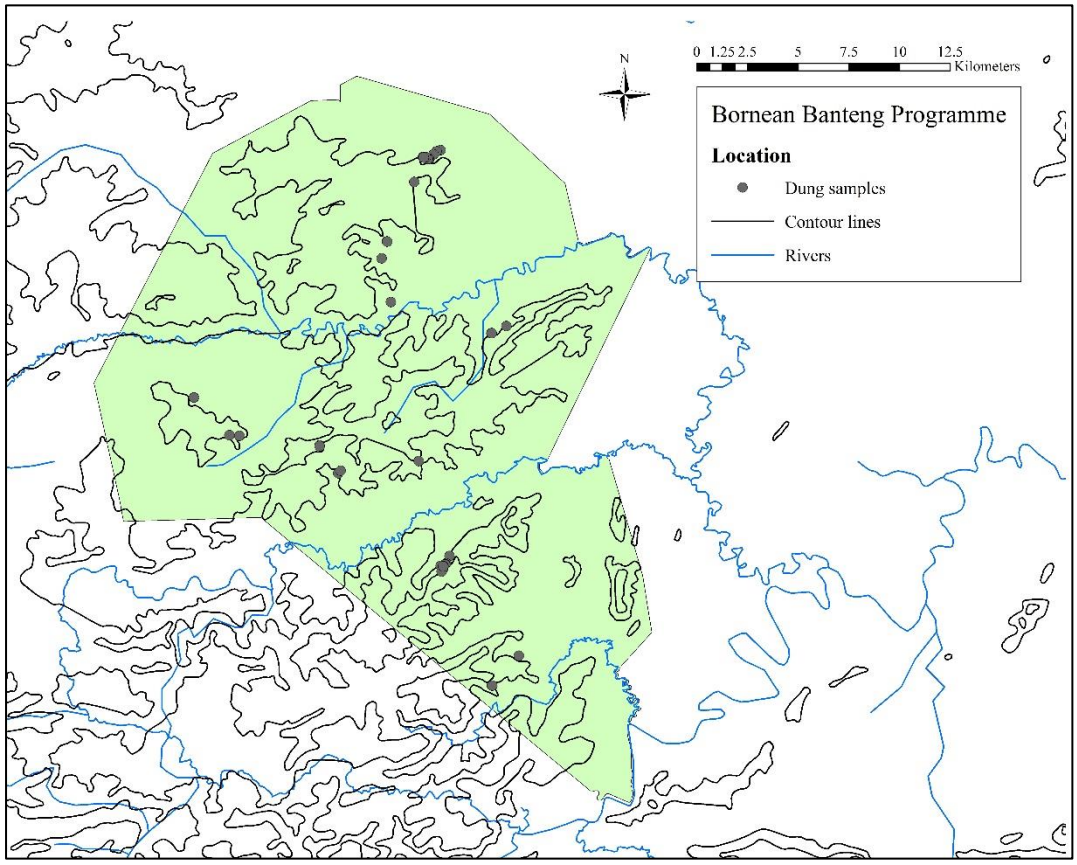

Figure 13: The distribution of dung samples collected for molecular analysis in Segaliud-Lokan Forest Reserve during field work in 2015.

Major threats

Illegal activity recorded in Segaliud-Lokan

The number of illegal activity events recorded using camera traps and direct observations were relatively low in Segaliud-Lokan (19), and comprised (10) events capturing hunting activity including hunters with firearms, (4) stolen camera traps, and (1) encroachment events with unknown purpose, and (4) events capturing fishing activity. See Figure 14 for the distribution of this activity across the reserve. See Appendix 2 for images of illegal activity. In addition to these activities, a banteng bull was captured on camera trap with a missing hoof that has almost certainly been removed by snare. The snare was probably set for a smaller mammal and not the banteng however the resulting effect was catastrophic and the bull will be immeasurable pain and may suffer infection and death. See Figure 15 for an image of the bull missing a hoof.

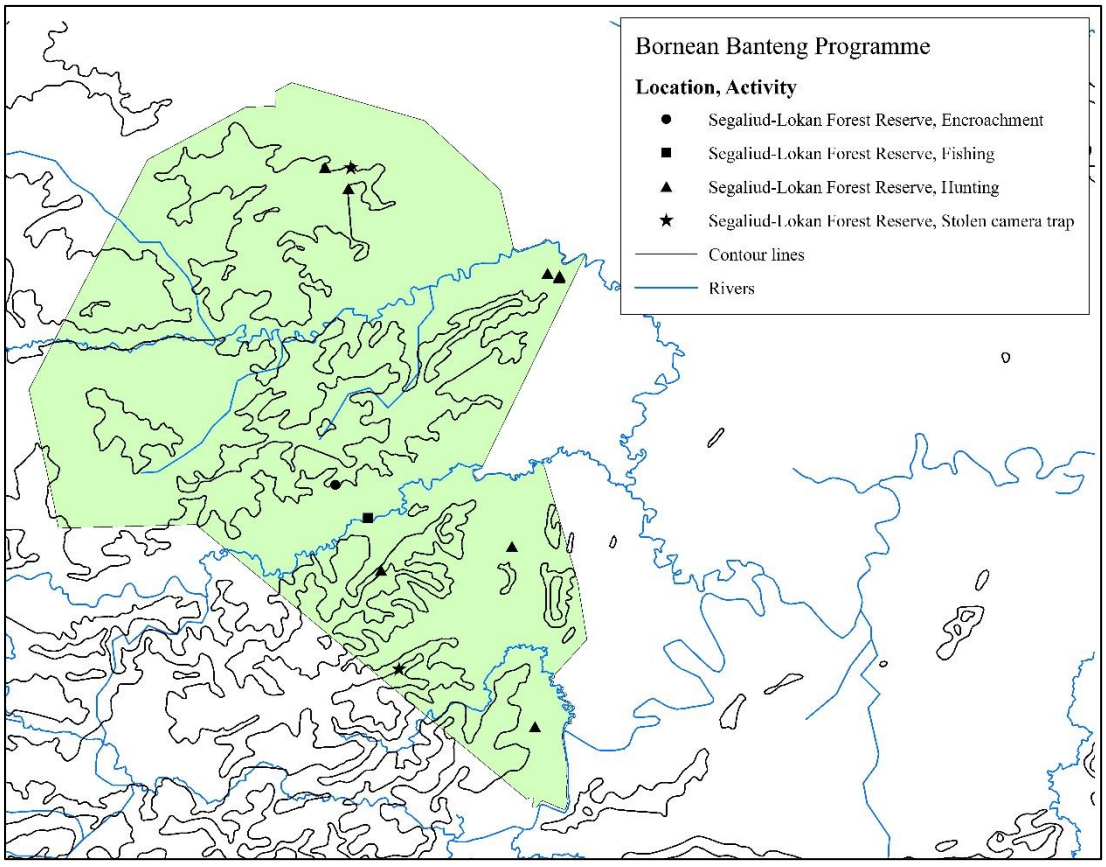

Figure 14: The distribution of illegal activity in Segaliud-Lokan Forest Reserve displayed according to the nature of the activity recorded.

Strengths and weaknesses of the reserve

Based on the information and observations collected during the banteng survey, the perceived strengths and weaknesses in the security of Segaliud-Lokan in respect to security of banteng are detailed in Table 1.

Table 1: The security weakness and strengths of Segaliud-Lokan Forest Reserve as perceived during field work conducted in 2015, which threatens the protection of wildlife including the bantengs but also other game and bird species.

Security weaknesses of Segaliud-Lokan	Security strengths of Segaliud-Lokan
Armed poachers operating inside the reserve during the day and night, and are potentially contracting staff originating from KTS/Segaliud-Lokan itself. Snares set for smaller species are having a clear negative effect on the banteng, which are trapped and/or extensively injured as a bi-product.	PCG unaware of occurrence and regularity of anti-poaching patrols conducted within Segaliud-Lokan by Sabah Forestry Department or KTS Plantation. The main check point was always staffed and vigilant.
Large area and boundary including riparian reserve, making encroachment problematic to monitor.	A relatively large staff and well-established facility with operation bases in different regions of the reserve to conduct patrols from.
Old logging roads were accessible and visible, and facilitated access by poachers. As wildlife, particularly banteng, heavily utilise logging roads for foraging, they are subject to increased human-wildlife conflict in these areas.	Logging roads provide relatively easy access when bridges are not collapsed and staff could easily patrol these on foot or establish ambushes. Could utilise a monitoring tool like SMART to strengthen and motivate wildlife patrols.
Lack of comprehensive data of illegal activity to identify poaching hotspots and patterns in hunting activity to inform enforcement and patrols within Segaliud-Lokan, and theft of camera traps inside the reserve so not	Data on illegal activities may serve to inform anti-poaching patrols by departments in the future, and provide a basis for conducting further investigations over vehicular access and the activities by contractors and villagers within the reserve.
Segaliud-Lokan was frequently used as a hunting ground for banteng over the past few decades, and this reputation is still upheld by some within the forest industry.	KTS has the capacity to reinforce a zero-tolerance to hunting by taking a pro-active approach by increasing signage, random checks and anti-poaching patrols.

Other species records

Species diversity

Including banteng, a total of 21 mammals and 2 bird species were observed in Segaliud-Lokan using camera traps and by direct observations (Table 2). Refer to Figures 15 for images of banteng and Figure 16 for images of other fauna. Due to the height and positioning of the camera traps, many other species could have been missed, therefore our list is not thought to be exhaustive. There is scope for contributing to KTS's wildlife monitoring programme and interpretation material used to educate both staff and visitors to Segaliud-Lokan Forest Reserve.

Figure 15: Bantengs in Segaliud-Lokan Forest Reserve caught on camera trap. Note, the bottom image of a bull with a missing foot, which is almost certainly lost due to a snare set within the reserve. Such injuries will result in immeasurable pain and suffering, and potentially lead to infection and death.

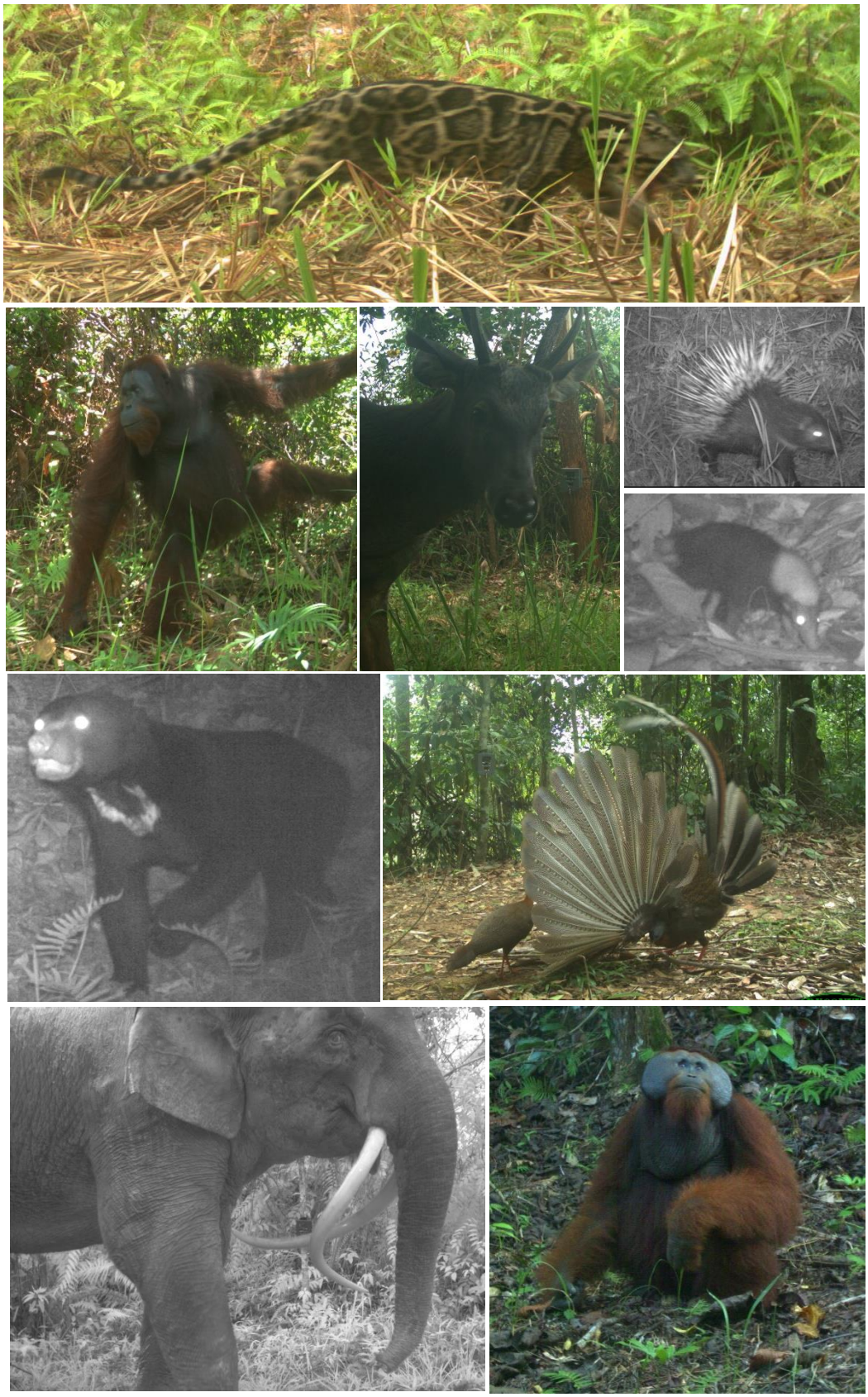

Figure 16: Species captured on camera trap in Segaliud-Lokan Forest Reserve. From top left to right: Bornean clouded leopard, orangutan, sambar deer, porcupine and Malay badger, sun bear, great argus pheasant, elephant and flanged male orangutan.

Table 2: List of species recorded in Segaliud-Lokan Forest Reserve using camera traps an direct observations by the Bornean Banteng Programme in 2015. * Heard calls but no direct observations.

Common name	Latin name
Mammals	
Banded civet	*Hemigalus derbyanus*
Bearded pig	*Sus bartbatus*
Bornean clouded leopard	*Neofelis diardi bornensis*
Bornean gibbon*	*Hylobates funereus*
Bornean porcupine	*Thecurus crassispinis*
Bornean pygmy elephant	*Elephas maximus borneensis*
Bornean sun bear	*Helarctos malayanus*
Bornean yellow muntjac	*Muntiacus atherodes*
Borneo banteng	*Bos javanicus lowii*
Horse-tailed squirrel	*Sundasciurus hippurus*
Leopard cat	*Prionailurus bengalensis*
Long-tailed macaque	*Macaca fascicularis*
Malay badger	*Mydaus javanensis*
Malay civet	*Viverra tangalunga*
Malayan porcupine	*Hystrix brachyura or common porucpine*
Masked palm civet	*Paguma larvata*
Mousedeer	*Tragulus spps*
Orangutan	*Pongo pygmaeus*
Pig-tailed macaque	*Macaca nemestrina*
Sambar deer	*Cervus unicolor*
Sunda pangolin	*Manis javanica*
Unknown squirrel	NA
Yellow -throated marten	*Martes flavigula*
Birds	
Bornean crested fireback	*Lophura ignita*
Great argus pheasant	*Argusianus argus*

References

Boonratana, R., 1997. *A state-wide survey to estimate the distribution and density of the Sumatran rhinoceros, elephant and banteng in Sabah, Malaysia*, New York.

Davies, G. & Payne, J., 1982. *A faunal survey of Sabah*, World Wildlife Fund - Malaysia.

Gardner, P.C., 2015. *The natural history, non-invasive sampling, activity patterns and population genetic structure of the Bornean banteng Bos javanicus lowi in Sabah,*. Cardiff University.

Gardner, P.C., Goossens, B., Goon Ee Wern, J., Kretzschmar, P., Bohm, T. & Vaughan, I.P., *Behavioural adaptations of an endangered ungulate in response to tropical forest degradation in Sabah*,

Gardner, P.C., Hedges, S., Pudyatmoko, S., Gray, T.N.E. & Timmins, R.., 2016. *Bos javanicus*. *The IUCN Red List of Threatened Species*. Available at: http://www.iucnredlist.org/details/2888/0 [Accessed September 12, 2016].

Ishige, T., Gakuhari, T., Hanzawa, K., Kono, T., Sunjoto, I., Sukor, J.R.A., Ahmad, A.H. & Matsubayashi, H., 2015. Complete mitochondrial genomes of the tooth of a poached Bornean banteng (*Bos javanicus lowi*; Cetartiodactyla, Bovidae). *Mitochondrial DNA*, 0(0), pp.1–2. Available at: http://www.tandfonline.com/doi/full/10.3109/19401736.2015.1033694.

Matsubayashi, H., Hanzawa, K., Kono, T., Ishige, T., Gakuhari, T., Lagan, P., Sunjoto, I., Sukor, J.R.A., Sinun, W. & Ahmad, A.H., 2014. First molecular data on Bornean banteng Bos javanicus lowi (Cetartiodactyla, Bovidae) from Sabah, Malaysian Borneo. *Mammalia*, 78, pp.1–9. Available at: http://www.degruyter.com/view/j/mamm-ahead-of-print/mammalia-2013-0052/mammalia-2013-0052.xml [Accessed June 21, 2014].

Appendices

Appendix 1

Appendix 1: Top two images: Two armed hunters working together at night inside Segaliud-Lokan and using a motorbike to hunt. Middle two images: Two different armed hunters on a different day searching the forest together at night. Bottom two images: A 4x4 vehicle with three men spot-lighting (unknown if hunting or conducting a night patrol from KTS Plantations Sdn Bhd).

Appendix 1 continued: Top two images: Fishermen. Middle two images: Two men hunting together using spears and four dogs. Bottom image left: Two armed hunters searching the forest together in daylight around 5pm, right: old wire snare found during the banteng survey in 2015.