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 Deramakot Forest Reserve

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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.

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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).

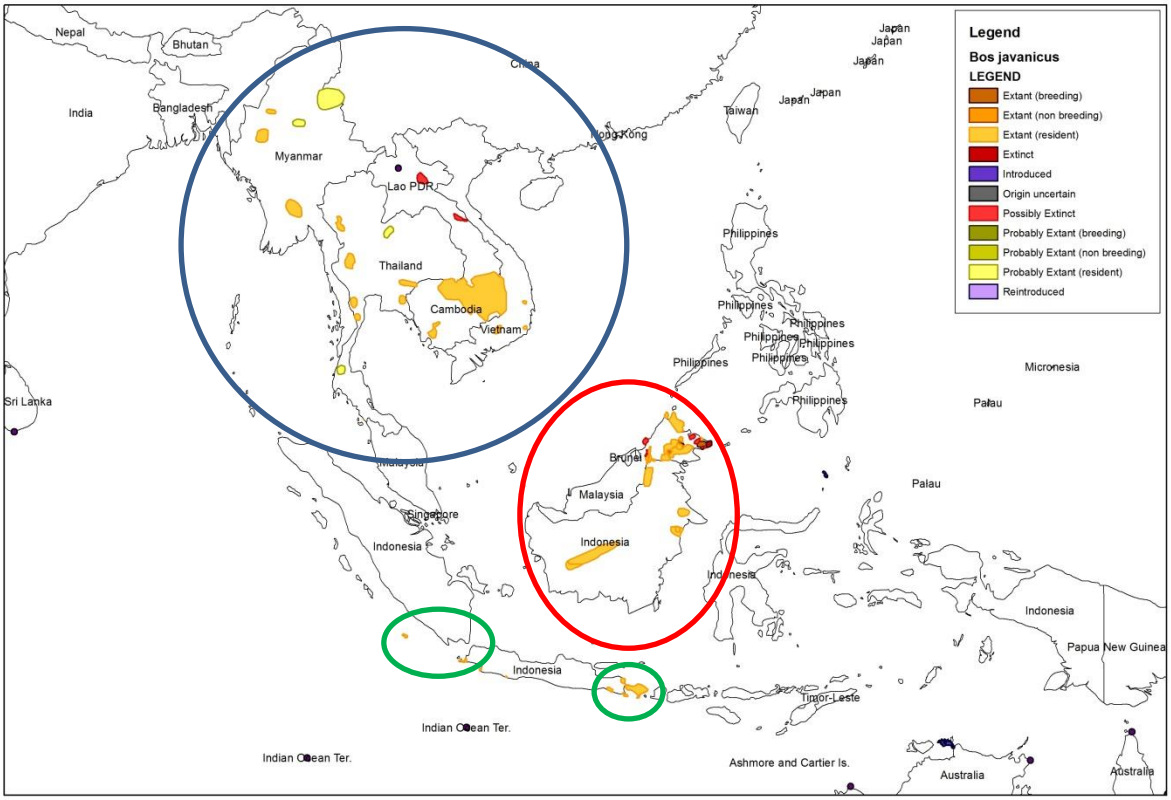

Figure 1: The world-wide distribution of banteng subspecies: Burma or Burmese banteng (*B. j. birmanicus:* blue circle), Java banteng (*B. j. javanicus:* green circle), and the Bornean banteng (*B. j. lowi;* red circle) (Gardner et al. 2016)

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 Deramakot 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 Deramakot Forest Reserve (DFR) and was conducted between the year 2015 by the Bornean Banteng Programme. This survey used 30 non-invasive paired camera trap stations positioned inside DFR, along abandoned logging

roads, in open areas, and along forest trails in closed forest. A total of 2,752 camera trap nights were surveyed between 3rd July 2015 to 12th October 2015.

Ecology

Activity patterns

Activity patterns of bantengs and ambient temperature in DFR were estimated from 14 of the 30 camera trap stations, which captured 48 events of bantengs. One of these was discounted due to violation of independence assumption, therefore 47 independent camera trap events of bantengs were captured over a survey period of 2,752 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 other: resting/fighting) and three locations (abandoned logging road, open area and forest trail).

Deramakot was certified by the Forest Stewardship Council in September 1997, with its 5th certificate expiring in October 2019, with a total of 49,711 ha of the area allocated for log production and 5,778 ha for conservation, and the remaining 18 ha under community forestry (Sabah Forestry Department. 2017). Prior to 1997, Deramakot was logged at least once leaving only 20% of the forest 'well stocked' and 30% in very poor condition with virtually no mature trees remaining (Sabah Forestry Department. 2017).

Observations of temperature data was captured by camera traps and revealed average ambient temperatures started increasing around 06:01-08:00 hours and reached 31°C (CI = 27-33°C) over the middle of the day (12:01-16:00 hours), however dropped to ~24°C (CI = 23-25°C) during hours of darkness and the early morning (Figure 3). Maximal temperatures were slightly elevated during the later afternoon/early evening - remaining at 30°C (CI = 26-24°C) until 18:00 hours but were otherwise comparable for all other hours.

Banteng activity was elevated over sunrise, between 04:01-08:00 hours (Figure 4). Activity then decreased and bantengs were less frequently active until after midday. After 14:00 hours, activity increased in frequency, intensifying between the hours 16:01-20:00, with bantengs remaining active throughout the night. A Spearman's rank correlation between the bootstrapped activity patterns and ambient temperature indicated activity did decline when temperatures were warmer but was not a significant relationship.

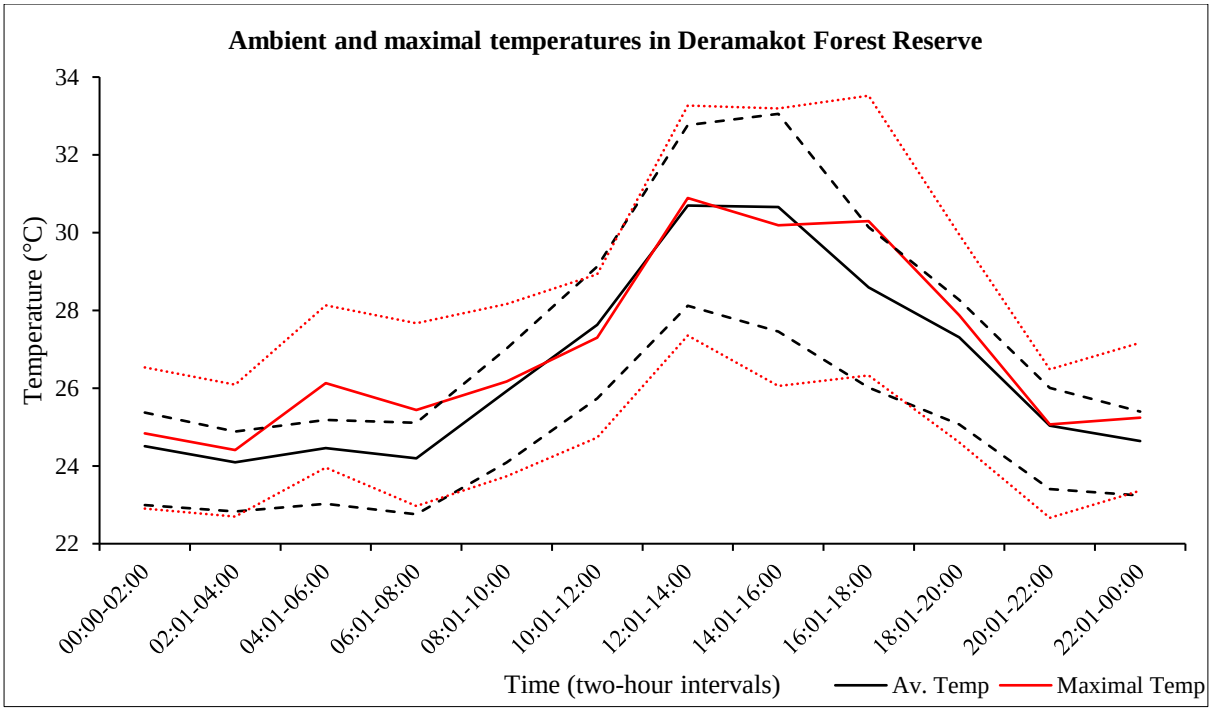

Figure 3: Ambient temperatures and maximal temperatures recorded in Deramakot Forest Reserve (DFR), plotted according to two-hour intervals across the 24-hour period and estimated using non-parametric bootstrapping to estimate 95% confidence intervals.

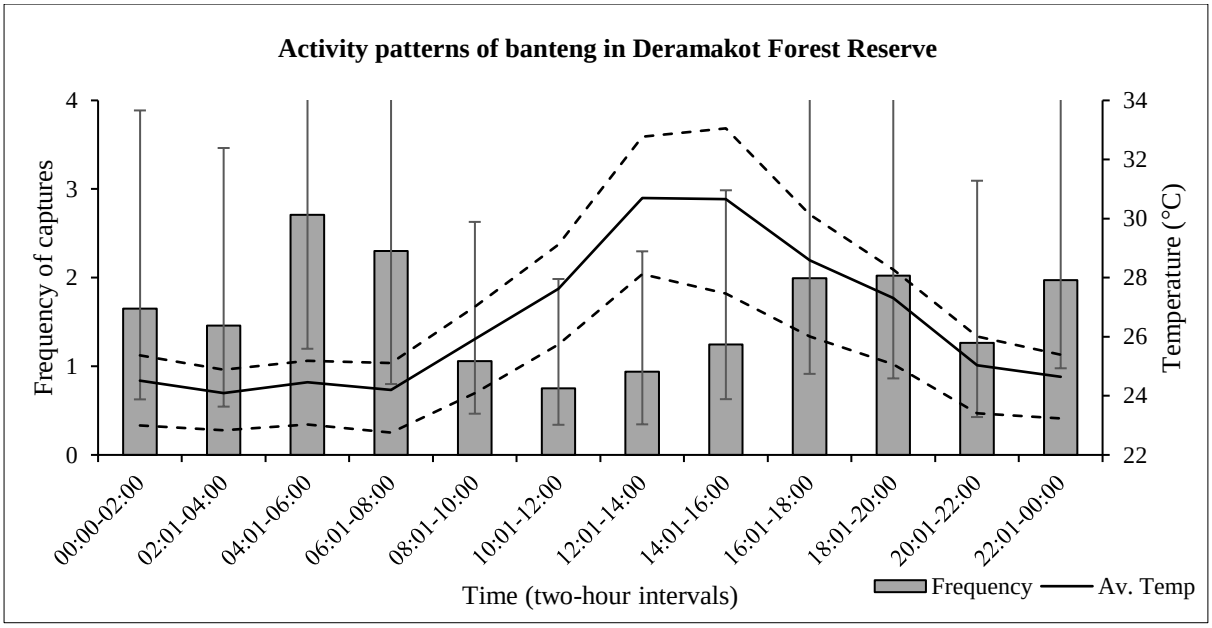

Figure 4: Ambient temperature and activity patterns (all locations combined) of Bornean banteng in Deramakot Forest Reserve (DFR) plotted according to two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals.

Activity budgets

Segregation of activity patterns into three behavioural categories revealed foraging and other: resting and ruminating were the primary behaviours performed throughout the day. Foraging was recorded for long durations in the morning and afternoon, but with depressions during the middle of the day when temperatures were elevated. Other: resting/ruminating was frequently recorded across the 24-hour period, however was conducted for longer durations during and after sunrise (04:01-08:00 hours), and during hours of darkness (20:01-22:00 hours). During the midday hours (08:01-16:00 hours) that experienced high ambient temperatures, all behaviours decreased, and only after 16:00 hours began to resume (Figure 5). Foraging behaviour was negatively associated with an increase in ambient temperature (r_s= -0.67, p= <0.05, t=-2.87, 95% CI= -0.9 - -0.16). Bantengs in Deramakot spent the majority of time foraging (61% of their time) and, followed by other: resting and ruminating (25% of their time), and only 14% of their time travelling (31%) (Figure 6).

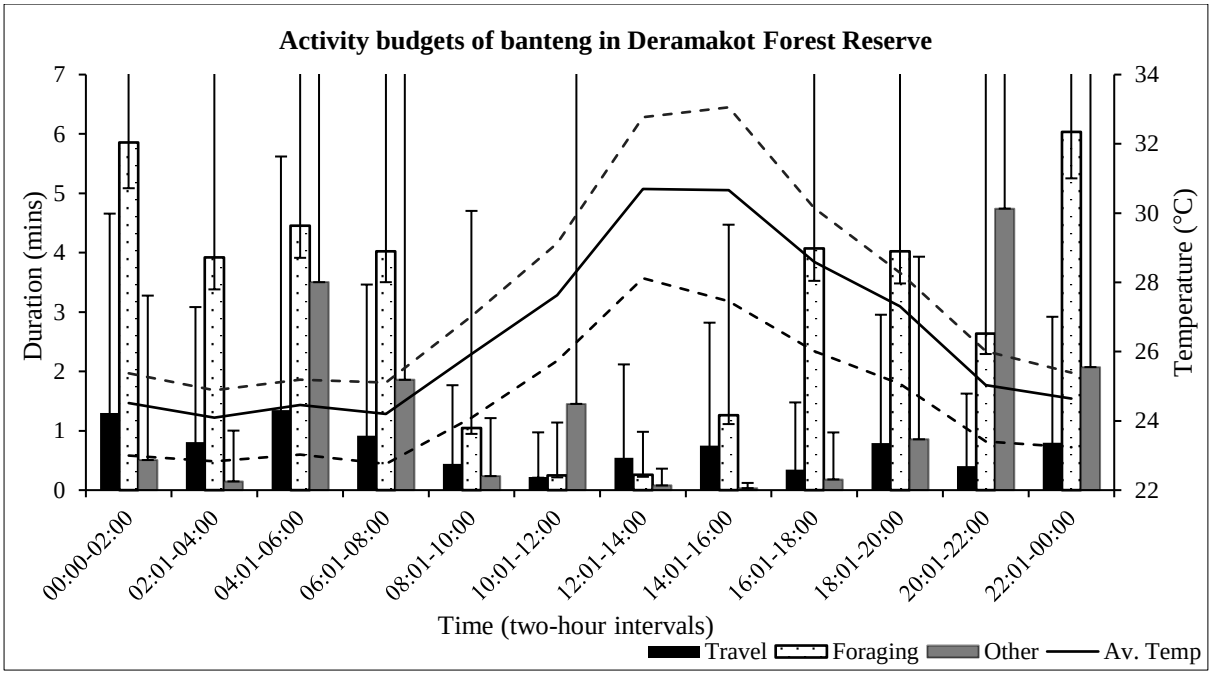

Figure 5: Diel energy budgets of bantengs in Deramakot Forest Reserve (DFR) and ambient temperature plotted according to two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals.

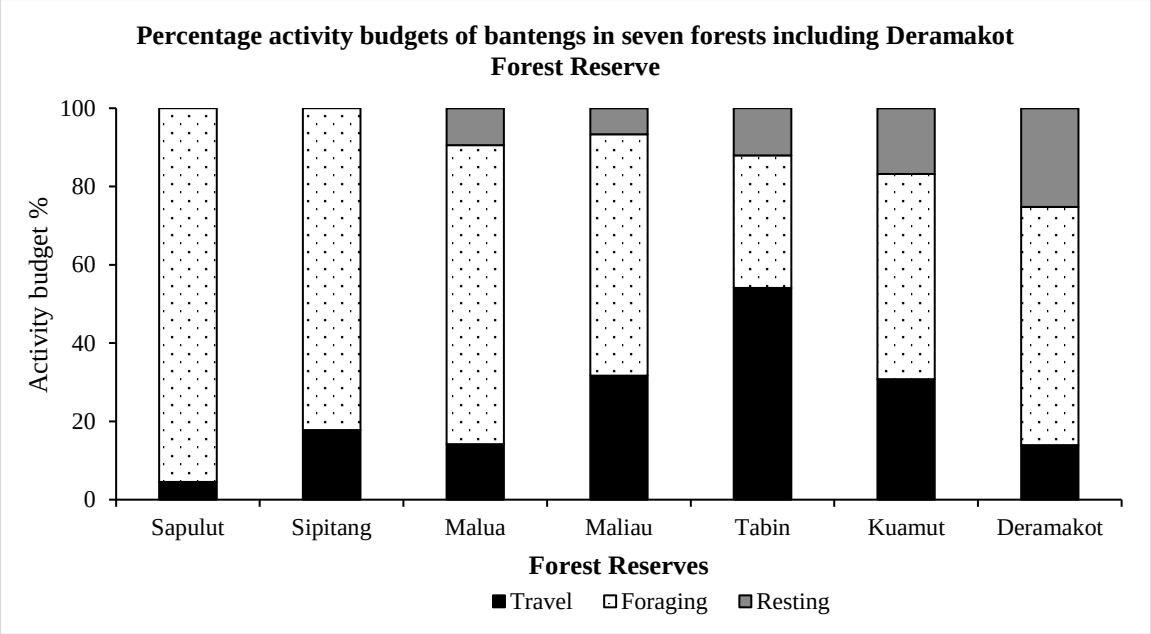

Figure 6: The activity budgets of bantengs expressed as percentage frequencies in seven different forests including Deramakot Forest Reserve. The three behaviours which comprised the activities were Travel, Foraging and Other: Resting, ruminating and fighting (on seldom occasions).

Location use

Compared to other forest reserves, camera traps were established along old logging roads, in open areas and along trails, but not along active access roads. Segregation of activity budgets into three locations revealed that abandoned logging roads were predominantly used for long durations throughout the day but with depressions during hours 08:01-16:00 hours. A small proportion of time was spent in open areas in the early morning and evening/night but no captures of bantengs were obtained along trails in closed forest (Figure 7).

Bantengs in Deramakot spent long durations utilising abandoned logging roads in the morning and afternoon/evening but reduced their use of these areas during hours 10:01-14:00 with high temperatures (26-29°C CI 25-32°C). Use of open areas and abandoned logging roads were negatively associated with an increase in ambient temperature (r_s= -0.63, p=<0.05, t=-2.56, 95% CI= -0.09 - -0.88 and r_s= -0.058, 0.05, -2.23, CI = 0.00 - -0.86, respectively). Compared to other forests, bantengs' use of abandoned logging roads in Deramakot was the second highest (80% of their time), whereas open areas were used the second least (18%) (Figure 8).

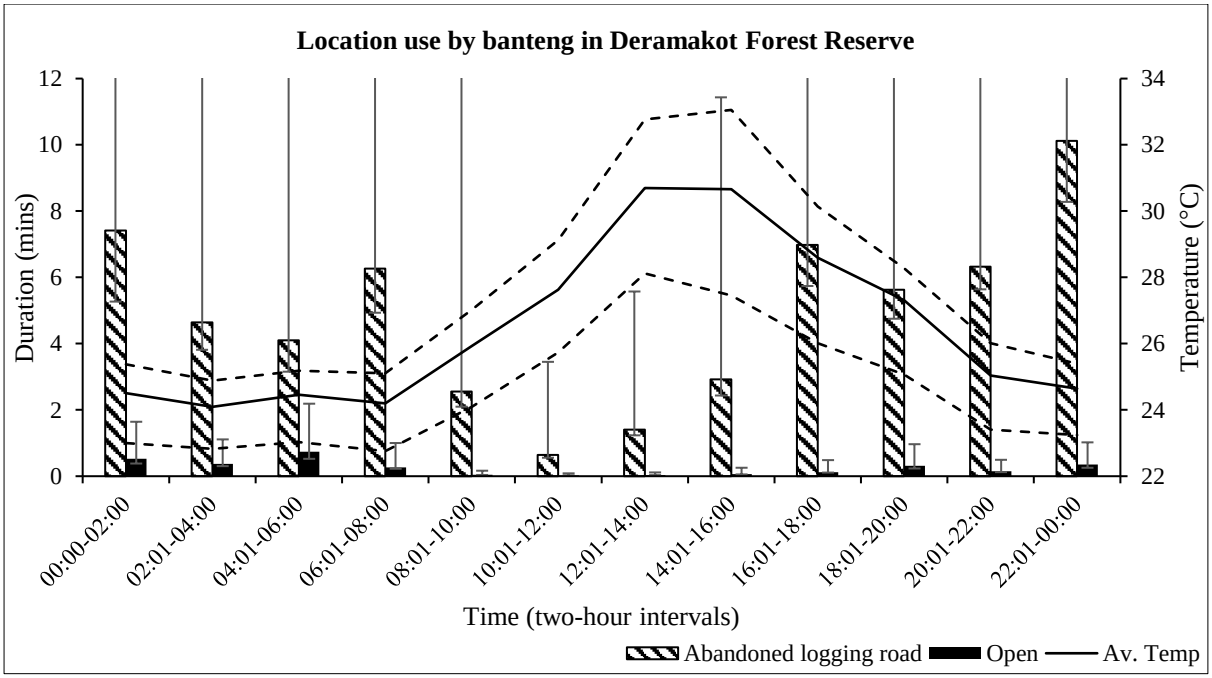

Figure 7: Diel habitat use of bantengs in Deramakot Forest Reserve (DFR) and ambient temperature plotted according to three locations and two-hour intervals across the 24-hour period using non-parametric bootstrapping to estimate 95% confidence intervals. Note, no captures of banteng were obtained along forest trails and no active access roads were not monitored.

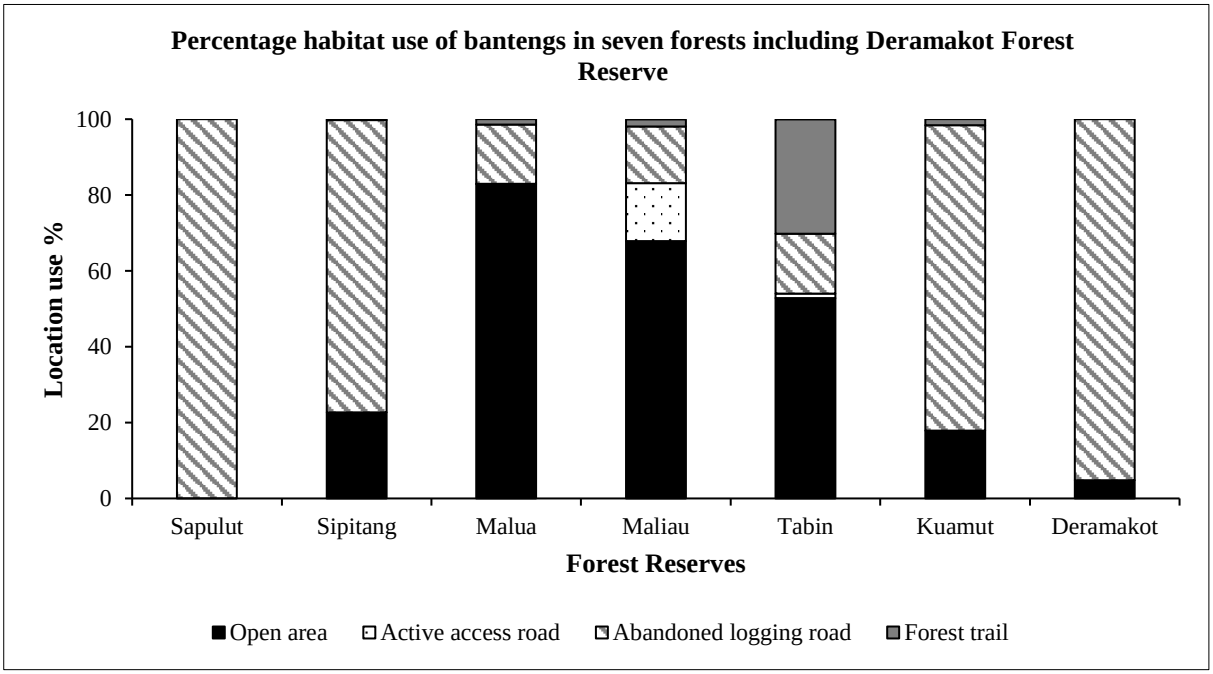

Figure 8: The habitat use budgets of bantengs expressed as percentage frequencies in seven different forests including Deramakot Forest Reserve. The four locations were Open area, Active access road, Abandoned logging road and Forest trail. Note: Active access roads were not monitored in Deramakot, Kuamut or Sapulut Forest Reserve.

Diet and foraging ecology

There is no information pertaining to the diet and foraging ecology of bantengs within Deramakot. A study by Ridge (2014) on the foraging ecology of bantengs is available for other forests however, including Malua Forest Reserve.

Population status

Distribution

Bantengs were captured at 14 (47%) of the 30 camera trap stations deployed by the Bornean Banteng Programme across Deramakot during the year 2015 (Figure 9). Their distribution was recorded across the reserve (Figure 10) at elevations ranging from 59-288 metres above sea level.

Bantengs in Deramakot were observed in herds of up to 8 individuals, comprising mature cows, heifers and calves, whereas mature bulls occurred in pairs or as solitary individuals. Based on preliminary 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 Deramakot was 15km by a mature bull. Identification of cows and calves was more problematic due to an absence of markings, therefore travel distances are not provided in this instance.

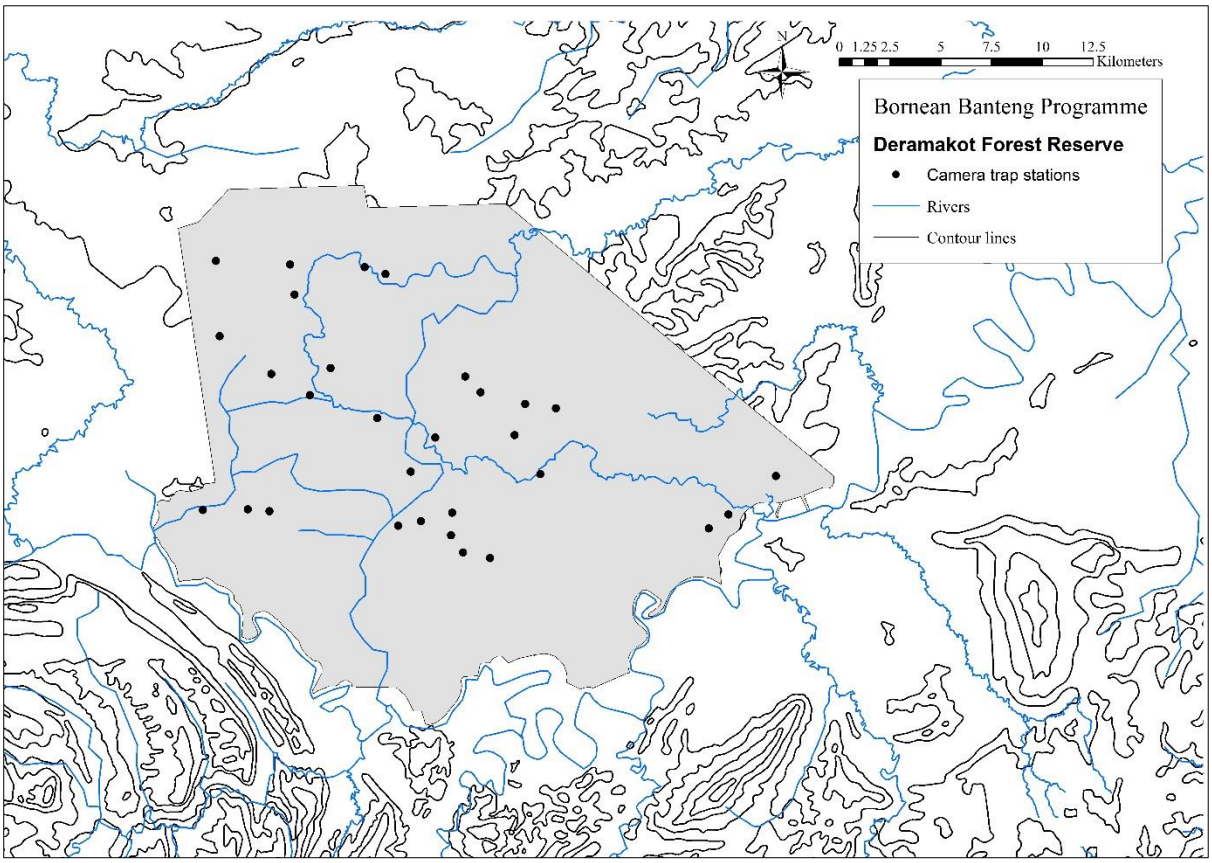

Figure 9: Camera traps deployed by the Bornean Banteng Programme in Deramakot Forest Reserve during year 2015 to collect data on bantengs behaviour and to identify individuals. The population size estimate of bantengs represents these survey points only.

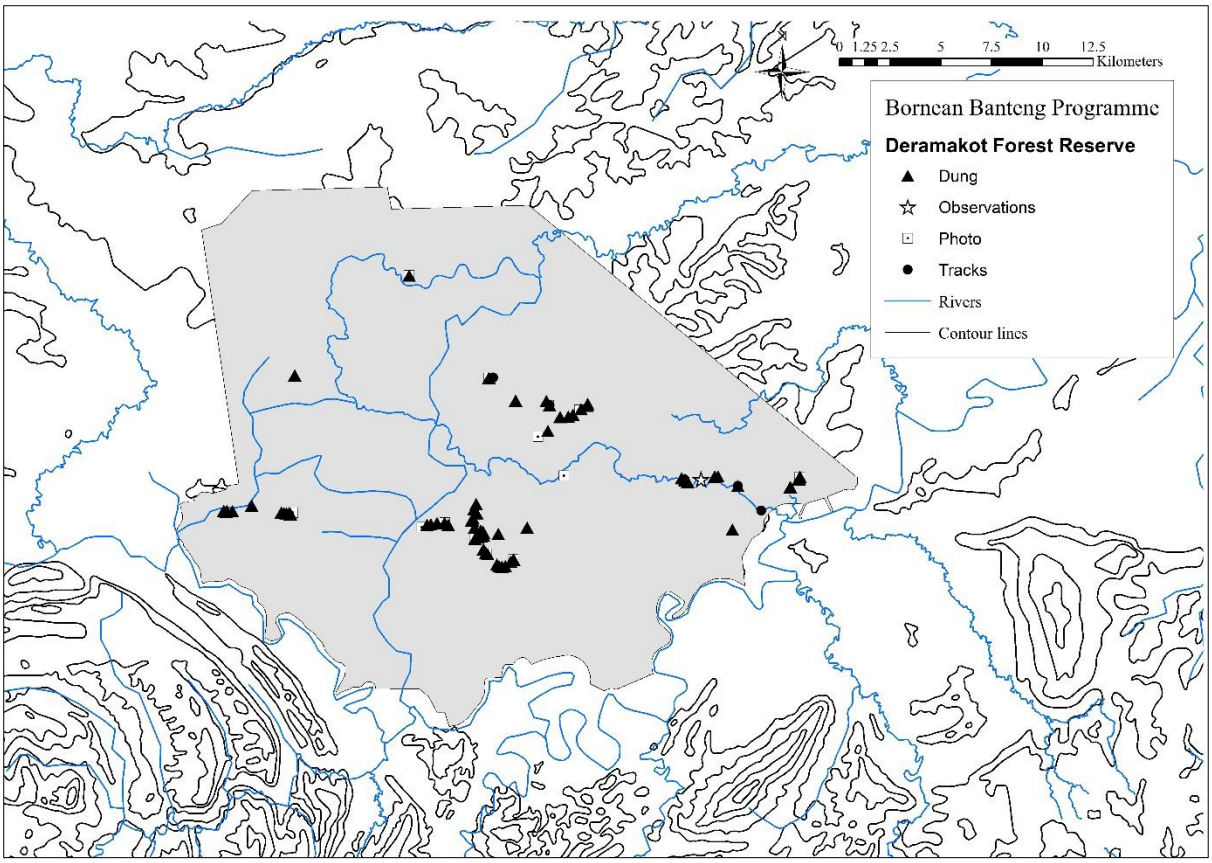

Figure 10: The distribution of banteng signs across Deramakot Forest Reserve using camera traps and encounters of tracks and faecal deposits during surveys conducted by the Bornean Banteng Programme during year 2015. Note, signs are only representative of the survey area and routes covered by the team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

Population size

Based on recaptures of identified individuals from camera trap data within the Bornean Banteng Programme study areas, a total of 22 individuals may inhabit Deramakot (Figure 11): 6 bulls and bullocks, 12 cows and 4 calves. One mature bull, with a prominent leg injury and multiple scars, was recaptured at nine different stations throughout the survey. Deramakot bantengs formed small herds relative to other forests, comprising of 8 individuals or less. Due to poor photographic visibility and a lack of scars or insufficient coverage of multiple features and angles, identification of cows in particular carried uncertainty. Therefore, this population size is a crude estimate and it is likely that the actual population size may be smaller. This estimate does not represent the genetic diversity.

Figure 11: A large mature bull recognisable by an injured right fore leg, large white scars on the body and tears in the ears. This individual was recaptured on multiple occasions and at nine different camera trap stations and travelled a straight-line distance of ~15km between the furthest two stations.

Figure 12: A young calf captured on camera trap on 28th August 2015 in Deramakot Forest Reserve, and was thought to be around ~2 months in age.

Breeding activity

Photographic captures during the survey indicated the presence of up to four young calves, which may have been born during or before the survey commenced. One was most likely to have been around ~2 months in age, born in June or July 2015 and photographed at the end of August 2015, based on the partial development of the white stockings and on the small horn buds (Figure 12). The second young calf may have been a recapture of the first, however without further verification it was difficult to confirm this. Two slightly older calves were also observed together

in the same herd, and were probably born around the same month - possibly in April or May 2015, based on the darker pelage colour and presence of white stockings.

Population genetic structure

A total of 25 faecal samples were collected for molecular analysis, primarily spanning from the west, central and east of the reserve, with no samples collected from the north. Samples and analyses using mtDNA on this subpopulation are currently in progress at the Lok Kawi Laboratory in Kota Kinabalu, following the same laboratory procedures as those outlined in the PhD thesis of P. Gardner (2015). The distribution of faecal samples collected from Deramakot can be found in Figure 13.

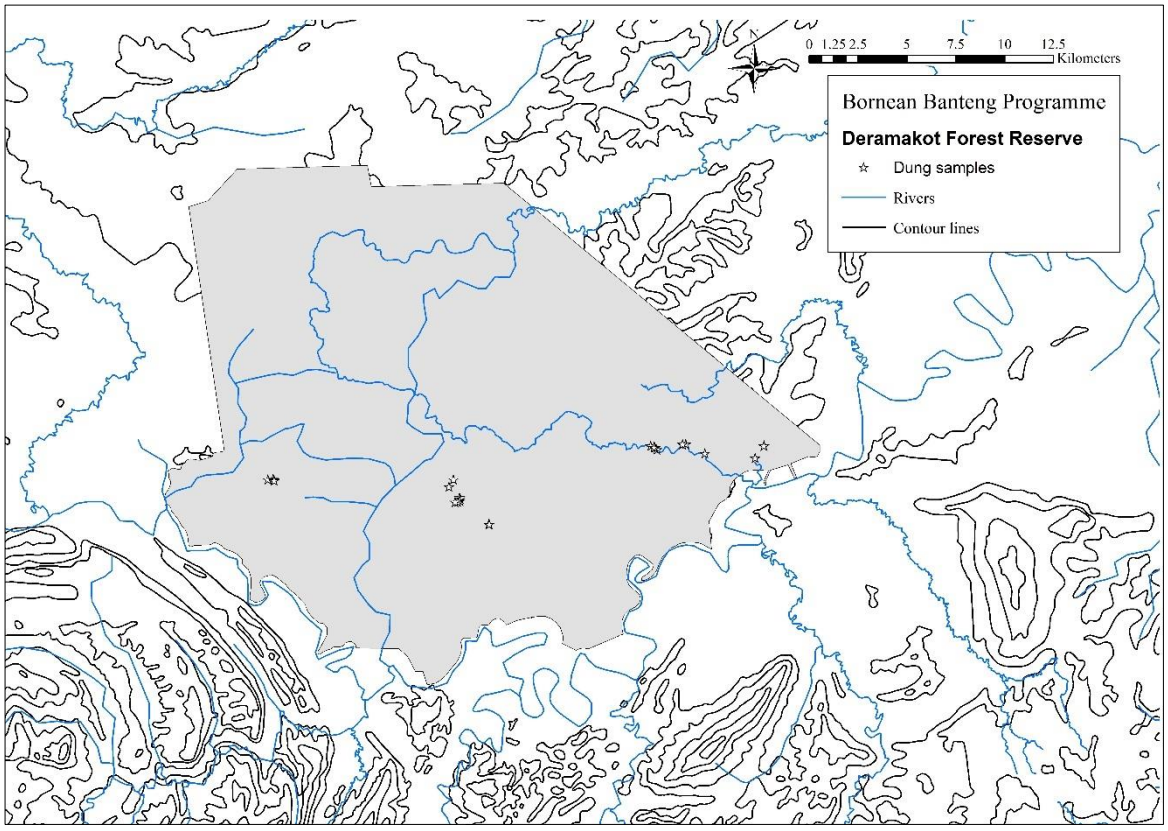

Figure 13: The distribution of dung samples collected for molecular analyses in Deramakot Forest Reserve during field work in 2015. The samples have been extracted and are currently being sequenced at Lok Kowi lab in Kota Kinabalu.

Major threats

Illegal activity recorded in Deramakot

The number of illegal activity events recorded using camera traps and direct observations was minimal compared to other forests, and comprised only 1 event which was of a lone dog in the forest. See Figure 14 for the location of this capture and Figure 15 for the image.

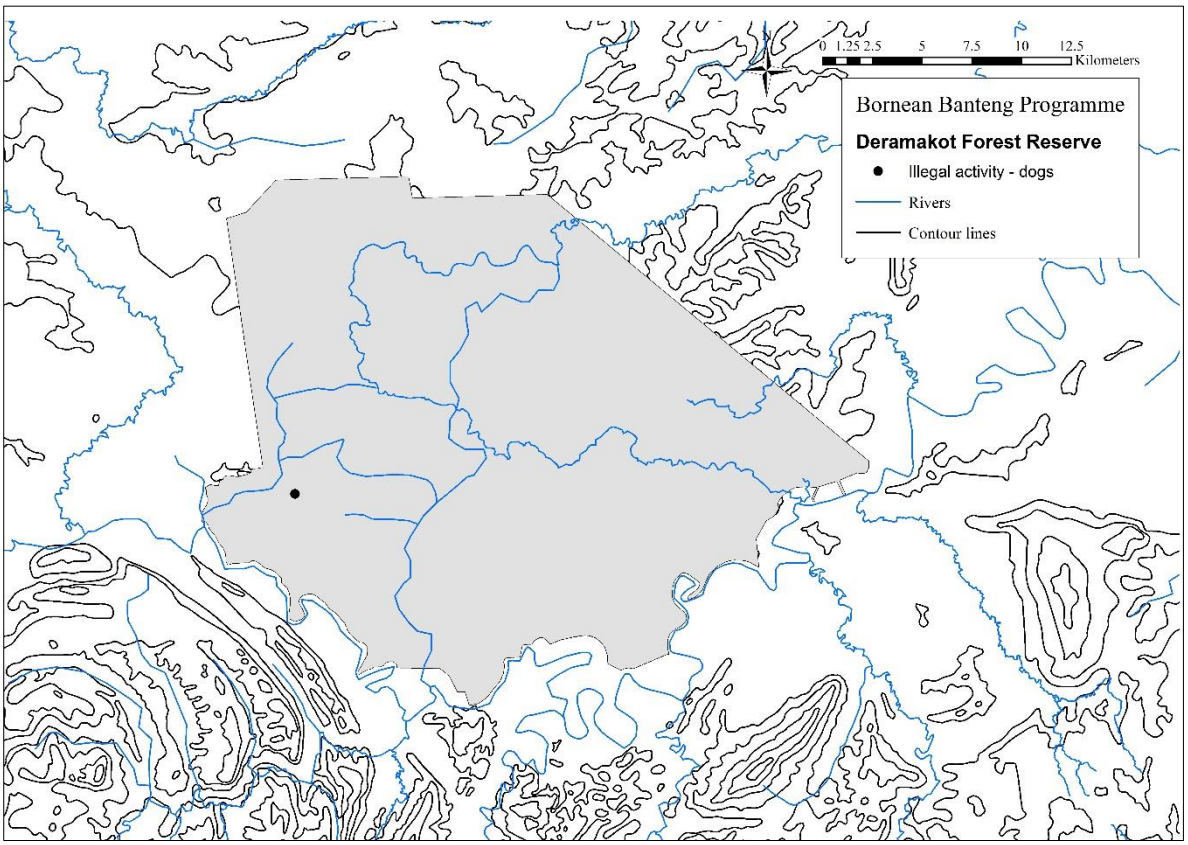

Figure 14: The distribution of illegal activity in Deramakot Forest Reserve. Only one observation was recorded, of a dog within the forest in the late morning caught on camera trap.

Figure 15: A dog caught on camera trap along an old logging road in the east of Deramakot Forest Reserve.

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 Deramakot in respect to security of banteng are detailed in Table 1.

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

Security weaknesses of Deramakot	Security strengths of Deramakot
Encroachment may occur from neighbouring forest reserves, Tangkulap and Kuamut, or from rivers bordering Deramakot Forest Reserve.	A high presence of staff inside the reserve to prevent unwanted encroachment.
	Sabah Forestry Department have the capacity to ensure communications are maintained with researchers actively working in the field who may encounter encroachment, which may facilitate effective conservation work in a commercial forest. Due to the larger number of staff within Deramakot, it may be a good starting point for trialling a monitoring tool like SMART to strengthen and motivate wildlife patrols.

Other species records

Species diversity

Including banteng, a total of 24 mammals, 1 reptile and 3 bird species were recorded in Deramakot by camera traps and by direct observations (Table 2). Refer to Figures 16 for images of banteng and Figure 17 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.

Table 2: List of species recorded in Deramakot Forest Reserve using camera traps and direct observations (*) by the Bornean Banteng Programme in 2015.

Common name	Latin name
Mammals	
Banded civet	*Hemigalus derbyanus*
Bearded pig	*Sus bartbatus*
Binturong	*Arctictis binturong*
Bornean bay cat	*Catopuma badia*
Bornean clouded leopard	*Neofelis diardi bornensis*
Bornean pygmy elephant	*Elephas maximus borneensis*
Bornean sun bear	*Helarctos malayanus*
Borneo banteng	*Bos javanicus lowi*
Island palm civet/Common palm civet	*Paradoxurus philippinensis*
Leopard cat	*Prionailurus bengalensis*
Long-tailed macaque	*Macaca fascicularis*
Malay civet	*Viverra tangalunga*
Marbled cat	*Pardofelis marmorata*
Mongoose	*Urva spps*
Moonrat	*Echinosorex gymnurus*
Mousedeer	*Tragulus spps*
Muntjac	*Muntiacus spps*
Orangutan	*Pongo pygmaeus*
Pig-tailed macaque	*Macaca nemestrina*
Porcupine	*Hystricidae spps*
Red langur/maroon langur	*Presbytis rubicunda*
Sambar deer	*Cervus unicolor*
Sunda pangolin*	*Manis javanica*
Tree shrew	*Tupaiidae spps*
Unknown bird	NA
Unknown rodent	NA
Unknown squirrel	NA
Reptiles	
Monitor lizard	*Varanus salvator*
Unknown snake	*NA*
Birds	
Great argus pheasant	*Argusianus argus*
Bornean ground cuckoo	*Carpococcyx radiatus*
Bornean crested fireback	*Lophura ignita*

Figure 16: Bornean banteng in Deramakot Forest Reserve captured on camera trap in 2015 by the Bornean Banteng Programme.

Figure 17: Wildlife caught on camera in Deramakot Forest Reserve in 2015: From top, left-right – Clouded leopard, pangolin, sun bear, bearcat/binturong, mongoose, water monitor lizard, orangutan and marbled cat.

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