ITTO PROJECT PD 16/99 Rev. 2 (F)

DEVELOPMENT OF LANJAK ENTIMAU WILDLIFE SANCTUARY AS A TOTALLY PROTECTED AREA • PHASE III

A STUDY OF HABITAT CONDITIONS, POPULATIONS, AND DISTRIBUTION OF ORANGUTAN IN LANJAK ENTIMAU WILDLIFE SANCTUARY AND BATANG AI NATIONAL PARK, SARAWAK, MALAYSIA

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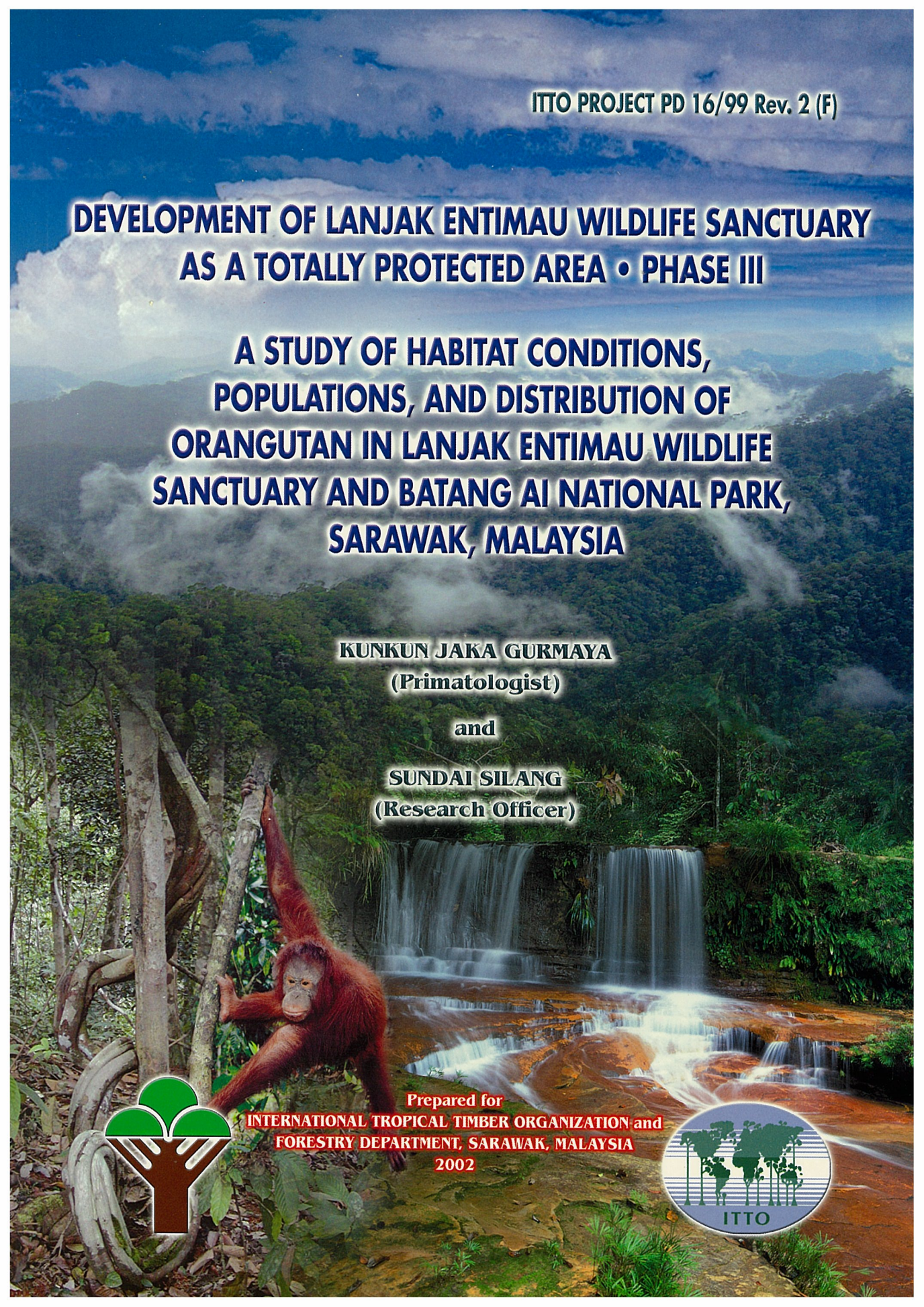

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ITTO

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GLOSSARY

BANP	Batang Ai National Park
Batang	main river
BKNP	Betung Kerihun National Park
BTP	Borneo Trans-frontier Park
Bukit, Bt.	Hill
cm	centimetre
Danau	lake
dbh	diameter at breast height
DNA	deoxyribonucleic acid
DSWR	Danau Sentarum Wildlife Reserve
E, N	East, North
GPS	Global Positioning System
ha	hectare
IPB	Institute Pertanian Bogor
ITTO	International Tropical Timber Organization
km	kilometre
LEWS	Lanjak Entimau Wildlife Sanctuary
LTS	Line Transect Sampling
m	metre
m a.s.l.	metres above sea level
NG, Ng.	river mouth or confluence
SOP	Standard Operation Procedures
Sg.	river
Temuda	secondary forest
TL	transect line
TPA	Totally Protected Area
Ulu	up river, interior

INTRODUCTION

Orangutan has been classified as endangered and vulnerable wildlife species with a high risk of extinction by IUCN (Tilson *et al.* 1993). Since more than 90% of the largest orangutan forest habitat in Kutai National Park was burnt during the 1997/1998 forest fires in Indonesia, the Trans-boundary Biodiversity Conservation Area (TBCA) of Lanjak Entimau Wildlife Sanctuary (LEWS) and Batang Ai National Park (BANP) in Sarawak, Malaysia, and Betung Kerihun National Park (BKNP) in West Kalimantan Province, Indonesia, is believed to be the largest remaining orangutan habitat in the tropical rain forest. One of the main objectives for the establishment and development of LEWS as Totally Protected Area (TPA) is to protect the orangutan population of Sarawak. The International Tropical Timber Organization (ITTO) in cooperation with the Forest Department of Sarawak, supported the development of LEWS on the current project PD 16/99 Rev.2(F): Development of Lanjak Entimau Wildlife Sanctuary as a Totally Protected Area – Phase III.

This study is under the Project PD 16/99 Rev.2(F) and the terms of reference are (1) to determine the abundance and distribution of the orangutan populations in LEWS and Batang Ai National Park (BANP) and Betung Kerihun National Park in West Kalimantan Province, Indonesia; (2) to collaborate with BKNP sister project in carrying out the above study; (3) to develop guidelines for collaborative management with BKNP to ensure the survival of orangutan in Borneo.

A BRIEF REVIEW OF THE SOCIO-ECOLOGY AND BEHAVIOUR OF ORANGUTAN

Orangutan is an endemic and one of the protected species of Northern Sumatra and Borneo. Taxonomically two species are recognized, the Bornean (*Pongo pygmaeus*) and the Sumatran (*Pongo abelii*). During the Pleistocene, they were distributed throughout South-east Asia from Java to the Tropic of Cancer in Southern China (von Koenigswald, 1982). The IUCN has classified orangutan as an endangered and vulnerable species with a high risk of extinction, with its populations of less than 16,000 in Borneo and 12,500 in Sumatra (Rijksen *et al.*, 1999). A characteristic socioecology and behaviour of the animal and other great apes (gorilla, chimpanzee and bonobo) is nest building. Orangutan builds nests everyday for sleeping during night time and resting at daytime. Leaning trees, remnants of food such as dry rattan plants are other signs of existence of the species in the habitat besides the nests.

Orangutan is the largest amongst the arboreal primates. In the wild, an average adult male weighs about 86.3 kg and an adult female 38.5 kg, (less than half of the weight of adult males). Besides their size, other secondary sexual characteristics of male orangutan are the long call and cheek pads. The animals move by quadrumanual clambering (using all four hands and feet to grasp and pull themselves along) and occasional brachiating particularly by smaller individuals. They use their body weight effectively to bend and sway small trees using the stored momentum in the tree as a spring to propel themselves across a gap until they can grab an adjacent branch.

Social interaction of orangutan has been difficult to characterize because the animal often ranges over extensive areas and its residence in a given study area may vary widely across time (Knott 1998). However, Rijksen *et al.* (1999), based on ranging activities, showed that the species can be classified into three categories: (1) inhabitant, spending more time in a certain area during several years; (2) semi-nomadic, for several weeks or several months in a year living regularly as nomads; (3) nomadic, never or rarely or only once back to the former site within at least three years. The inhabitant has a high social level and good quality of habitat, the female inhabitant living in a small home range, about 0.6 to 1 km^2, while the male inhabitant has a wider home range for social reproduction, but in high quality habitats the home range is normally less than 10 km^2.

Semi-nomadic orangutan inhabits a wider home range covering more than one good quality habitat (main habitat) and the distance among the main habitats are very far, sometimes reaching 5 km especially for those separated by bad quality of forest, or other individual home ranges. For example, the percentages of success for inhabitant, semi-nomadic and nomadic orangutans in Ketambe forest (Aceh, Indonesia) are about 30%, 60% and 10% respectively (Rijksen *et al.*, 1999). The developmental pattern of young individual often follows a sequence of dependence inhabitant (infant phase), semi-nomad (social, juvenile and sub-adult phases) and inhabitant (semi-solitary) during adult phase (Rijksen *et al.*, 1999).

These animals are solitary species and only live in pairs during mating and nursing period where mother and infant are together up to the weaning period. Daily ranging of an orangutan is about 500 to 1,000 ha and this is very much dependent on the availability of food sources and daily activities. For example, a nursing female will not move very far within the home range. In some cases two or more individuals have overlapping home-ranges where they usually communicate with each other. The use of home range area is different during drier and wetter seasons and this is related to the availability of food.

3. Forest Habitats

The two study areas mainly consist of primary and old secondary mixed dipterocarp forests except in some places where areas of young secondary forest (*temuda*) are found, representing ex-shifting cultivation sites. The forest canopy is formed by tall and big trees of dipterocarp species such as *Shorea* spp., *Dipterocarpus* spp., etc. with some trees having a diameter of more than 150 cm dbh. In the old secondary forest, saplings are more abundant but big trees are fewer compared to the primary forest.

As a habitat of orangutan, the forest of LEWS and BANP is still in very good condition. However, there are some forms of disturbance on the habitats especially in some areas near the Lubang Baya Rangers Station. These only involve small areas and most of the land belong to the local communities who have been given the right to do farming on their respective land, inside the park boundary. Such areas are small and involve only a few families.

Generally, the forest can be divided into 4 vertical layers namely, emergent level, main canopy (the second level), middle canopy and understorey (the ground level). Contiguous forest canopy, which covers most part of the study areas supports the daily movement of orangutan, even across the rivers especially in remote areas where tree canopies on both sides of the rivers form a bridge for orangutan movement. The abundance of small trees (diameter of 10 cm or less) supports their movement from one tree to another. However, the heavy weight of the animal affects the vertical growth of saplings that later become leaning trees. This is a clear evidence of their existence within his/her home range and territory. Although the physical condition of the forest habitat is good, it seems that the daily activity and behaviour of the species and other wildlife species in some areas have been much disturbed possibly due to frequent visits by humans (hunters).

METHODOLOGY

1. The Study Sites

The field study was conducted in the south-eastern part of LEWS and north-eastern part of BANP during the drier season (July and August). These areas are close to each other and the most convenient access to the study sites is from Lubang Baya Rangers Station. Access to the study areas: from Kuching (ITTO Office) 275 km by road to Batang Ai Dam, from here to Nanga Delok Park HQ (outside the BANP) by speedboat, and to Lubang Baya Rangers Station, the entrance into BANP, by long boat. From Ng. Delok to Lubang Baya Rangers Station it took almost one hour by boat ride.

Two study sites were established in LEWS: at Ng. Giling and Ng. Masum. Access to these sites is via Sg. Lubang Baya. In LEWS the group camped at two different campsites: Ng. Giling and Ng. Masum. From Lubang Baya Rangers Station to Ng. Giling campsite, using Sg. Lubang Baya, it was at least 2-3 days journey (depending on water level). Meanwhile, from Ng. Giling to Ng. Masum campsite it was a one-day journey traversing the rugged terrain of LEWS.

For BANP, three study sites were established. These were at Ng. Telangun (Sg. Lubang Baya site) and another two sites at Sg. Batang Ai (Ng. Mujan and Ng. Tiga). The group camped at 3 different campsites: Ng. Telangun (Sg. Lubang Baya) and another two campsites at Ng. Tiga and Ng. Mujan (Sg. Batang Ai). It took almost two days to reach Ng. Telangun and Ng. Tiga campsites during drier season. Due to very shallow water, going upstream was very tough and to reach the field camps all team members had to push the boats almost 90% of the journey.

The numbers of team members were 13 using three longboats in LEWS, and 10 in two longboats in BANP study areas. Further details about the study areas can be found in the previous studies e.g. Blouch (2000); Meredith (1993).

2. Nest Count Using Line Transect Method

There are many factors that determine which methods are suitable for estimating animal abundance in the wild especially in the tropical forest. These factors include size and habits of the animals, habitats in which they live, and the time frame of the research (Marsh and Wilson, 1981).

Line transect sampling (LTS) method has been used to estimate animal abundance in the tropics; (e.g. Dahaban, 1996; Johns, 1983; Lambert, 1992; Zakaria, 1994). The versatility of this method lies in the variety of ways in which a transect line can be traversed. This survey method generally involves the counting of animals (in this case orangutan nest) seen while walking along a measured transect or trail. The advantage of this method is that it allows relatively large areas to be covered in a short period of time (Marsh and Wilson, 1981). This is probably because when using transect survey, more habitats or elevations can be covered during the survey (Jones, 1998).

LTS also provides a convenient method of estimating the number of objects in a study area (Buckland, 1985; Buckland *et al.*,1993). In addition, LTS has served various purposes, for example, to estimate population densities for a variety of vertebrates such as primates (e.g. Marsh and Wilson, 1981; Southwick and Cadigan, 1972; Whitesides *et al.*, 1988). This sampling method has been used in estimating animal populations in a different geographic area (e.g. Emmons, 1984; Freese *et al.*, 1982; Southwick and Cadigan, 1972). Other than that, LTS also can be used in detailed studies within a limited geographic area. For example, the comparison of habitats or conditions within the same geographic area (e.g. Marsh and Wilson, 1981; Wilson and Wilson, 1975), and also estimation of a population in a limited area where other methods are not feasible. This is probably due to the distant data taken which allows direct comparison between species and between the same species in different habitats (Bibby *et al.*, 1998).

In this study, collection of data could not rely on direct observation because the animal is very mobile and has a very large home range; therefore individuals are very difficult to detect. In addition, in this area, the orangutan is wary of human probably due to hunting activities. Due to these constraints the nest counting method was the best way to detect the existence of the animal, as the nests are available for a long period of time. Besides nest counting, the existence of orangutan was also detected from visible signs such as leaning trees, broken branches or twigs, food remains such as rattan and palm shoots, etc. However, this sign method is only suitable for a researcher who already has vast experience on the species or other primates. Without this experience among the team members and time constraint, surveying the animal using nest count was the most effective method to estimate their population and also to determine their distribution and habitat types.

In principle, surveying orangutan nests is one of the established methods for estimating its population, distribution (e.g. van Schaik *et al.*, 1995) and habitat types. In this study the nest count followed the transect line method of Brockelman and Ali (1984) which was developed by van Schaik *et al.* (1995) and implemented by Russon *et al.* (2000) in

Danau Sentarum Wildlife Sanctuary (DSWR), West Kalimantan, Indonesia. All transects followed available ridges. Due to very steep slopes, the riparian forest was excluded from this study. Each transect line was 3 kilometres in length and no fixed-width was applied due to ridges condition. The 3-km transect line was a reliable sample size (van Schaik *et al.*, 1995).

3. Field Data Collection

Data collection (nest counting) was carried out from early morning (0700 hrs) to late afternoon (1500 hrs) with at least two observers. Each day the group consisting of 9-10 persons would survey one transect line only. The group was divided into two teams: the surveyors and the observers. The surveyors would lead the group and cut and marked the trail (using ribbon or flagging tape) that basically followed the ridge. The observer group would follow from behind (approximately 30 minutes behind) to do the counting with the help of the locals. The 30-minute intervals between the two groups were to allow the animals to settle down after being scared by the first group in the team. This was purposely done to determine the occurrence of animals and the data recorded based on direct sighting was excluded from the analysis.

Therefore, the study emphasized on nest-finding with the help of 8 people in a team. The observation followed the ridges, which were part of the previous study sites of Meredith (1983) in BANP and Blouch (1994) in LEWS. Sixteen 3-km transect lines were surveyed, 8 in LEWS (GI-IV at Ng. Giling sites and MI-IV at Ng. Masum site) and 8 in BANP (TI-TIII at Telangun site, NTI-III at Ng. Tiga site and NMI-II at Ng. Mujan site. GPS records of the transect lines or areas nearest to the lines are shown in Table 1. In some sites the GPS failed to record any reading due to no satellite communication, thick forest canopy, thick clouds etc. The topography of the transect lines on the ridges, left and right slopes of the ridges was generally very steep.

Apart from direct sighting and nest observation, the occurrence of orangutan was also determined through the signs of their activities in the forest habitats, such as leaning trees (saplings or small trees which never grow vertically straight after frequently used by the species), broken tops of the trees, bending branches, remains of fruits or shoots (rattan, palm, etc.) eaten by the animal, faeces, smell of urine and vocalization.

Table 1. GPS readings taken along the transect lines and other important locations

No.	LOCATION	NORTH	EAST
LEWS			
1	Ng. Masum	01° 25' 09.6"	112° 09' 24.5"
2	Malaysia-Indonesia Boundary	01 ° 26' 17.0"	112 ° 12' 08.7"
3	Old Helipad near boundary	01 ° 29' 15.8"	112 ° 09' 24.5"
4	Lelap trail	01 ° 26' 19.9"	112 ° 06' 52.1"
5	Ng. Giling	01 ° 24' 41.5"	112 ° 06' 02.9"
BANP			
6	Supa trail 1	01 ° 25' 54.6"	112 ° 06' 03.1"
7	Supa trail 2	01 ° 26' 03.1"	112 ° 06' 01.3"
8	Ng. Mujan	01 ° 21' 48.9"	112 ° 08' 20.3"
9	Ng. Tiga	01 ° 21' 51.9"	112 ° 08' 23.2"
10	Rindeh (Campsite)	01° 22' 32.8"	112° 04' 45.7"

Poor visibility from the riversides made it difficult for the observer to carry out the survey using the stream or the river. Besides that, they were seldom seen building nests in areas that are frequently visited by humans.

The next step was to follow the 3-km transect line to record the perpendicular distance of each sighted nest, and the shortest distance from the nest to the transect line. In this study the nests were classified into three different categories based on their ages:

1. **New nest**: green leaves still abundant and sometimes the smell of urine or faeces was still evident;
2. **Medium-age nest**: older or brown leaves still attached and nest still firm and solid;
3. **Old nest**: almost all leaves are gone and normally the branches or twigs still attached, holes appear in the nest.

Generally, the condition of the nest is based on the presence of fresh or dry leaves on the nest.

Other parameters that were recorded during the survey were:

1. Location of the nest on the tree (estimated): level I (emergent level), level II (main canopy), level III (middle canopy) and level IV (understorey to the ground);
2. Distance of the nest from the main stem;
3. Nesting tree species;

During the data collection, some hair samples were picked up from the nests. However, not all nests detected were examined for hair sample. Hair samples were collected at intervals of 300 m along the transect line with the assumption that a nest found less than 300 m from the first nest would belong to the same individual (Gurmaya pers. comm.). The samples were analysed for their morphology and DNA. Analysed hair samples were used to get individual differentiation, especially for the samples that were collected at the same site. This information is useful in determining the ranging pattern and the absolute numbers of individual at each transect line to ascertain the population density of certain forest area.

4. Field Data Analyses:

a. Altogether 73 hair samples were analysed in Department of Biology, Institut Pertanian Bogor (IPB), Bogor and Primate Research Institute, Kyoto University, Japan to differentiate individuals of orangutan.

b. The densities of nests and population were analysed using the equation (Russon *et al.*, 2000) below:

i. Nest Density Formula:

$$\text{d-nest} = N / (L \text{x} 2w)$$

In this study, d-nest (nest density) was analyzed using Distance Programme (Version 2.2).

ii. Population Density (d) Formula:

$$d = \text{d-nest} / (p \text{ x } r \text{ x } t)$$

d-nest	=	nest density
d	=	population density (individuals/km^2)
N	=	numbers of nests
L	=	length of transect line (km)
w	=	width of transect line (km)
p	=	age-sex class proportion of nest builders
r	=	daily rate of the nest built (n/day/individual)
t	=	estimates of the rate of nest decay (days)

The values of p, r and t in Borneo were published by Russon *et al.*, (2000) based on their study at DSWR. Therefore, this study will follow the standard values derived from Russon *et al.*, (2000) with some considerations:

a. There is no standard values of p, r and t for the study areas;

b. BANP, LEWS and DSWR are at the same region, where DSWR is located within about 100 km to the south-east of the study areas;

c. Due to different environmental condition, the value of p, r and t maybe different between the areas.

However, for this study value of p used is 0.9 which is the same value with Russon's (2000) and Schaik *et al.* (1995), or 90% of age-sex class build nests (infants cannot

build a nest). The value of r is 1.6, (Rijksen (1978), Schaik *el al.* (1995) and Russon *et al.* (2000)) in hilly environment. In the wetland forest of DSWR, Russon *et al.* (2000) used $r = 1.7$ and the value of t is based on standard used by Russon *et al.*(2000) in DSWR which is 145 days. For future studies the value t should be measured for LEWS and BANP. This would need at least 6 months of data collection.

The population and nest densities of orangutan can be generated using two parameters: (1) based on medium-age nests only and (2) based on all nests (new, medium and old). This was done to get a better density estimation. Medium-age nest was used in the first calculation because it still showed the existence of dry leaves with the assumption that only one individual visited the location at one time. If the place were visited more than one time, the former medium-age nest would become an old one.

The second analyses of nest and population densities were using all nests (new, medium and old). Since the numbers of nests are larger, it is expected that the nest density and population density would become higher as compared to using medium-age nests only. Therefore, to avoid over estimation on total population, the estimated population density based on medium-age nests was selected as to the one that was based on all nests. However, the population density generated using all nests was also used to identify the range of population density in the areas. One should take precaution when using all nests as a parameter in generating population density because this usually represents the biggest number of samples collected and there is always a possibility of multiplied value because one individual may visit one location more than once, which in the end can cause over estimation. Even though new nests may provide a better estimation, but no population density estimation could be derived from this parameter due to smaller samples size and also it could lead to under estimation of population density.

The total populations of orangutan in LEWS and BANP were estimated by multiplying the population density (individual numbers per hectare) with the size (in ha) of LEWS and BANP. There were two ways of doing extrapolation. The first one was based on the total size of the BANP or LEWS, and the second was based on total size of BANP or LEWS minus the orangutan's uninhabited forest as multiplication factor. For example, the species rarely inhabits the rivers (known as " edge effect" (Tilson *el al.*, 1993) Between these two extrapolations the second one was preferred to the first one.

RESULTS

1. Orangutan Population

The most reliable estimation of primate species population in natural habitat is by absolute count of the individuals or the groups. In this study, direct sighting was made twice (at NG-II transect line) and orangutan call was only heard once along the 48-km transect lines and 7 km qualitative survey from Ng. Masum camp to Malaysia -Indonesia international boundary.

Table 2. Number of nests based on age classification

Nest Age	LEWS	%	BANP	%	LEWS + BANP	%
Old	178	63.1	115	44.2	293	54.1
Medium	97	34.4	117	45.0	214	39.5
New	7	2.5	28	10.8	35	6.5
Total	**282**		**260**		**542**	

The total numbers of nests recorded were 542 (as shown in Table 2). Most of the nests found were old nests with only 6.5 % new one. This is basically related to the ranging behaviour of the animal, which is mainly influenced by the availability of food sources. The study was conducted during drier season and fruits were rare. Fruiting trees were mainly located at the riparian forests. Based on the numbers of old nests recorded, the last visit of orangutan to the ridges areas were more than 3 months ago, probably before or during the fruiting season. It was assumed that during the drier season, the species visited the ridges less frequently as compared to the riparian areas where food was still available. Rijksen (1974) reported a similar result in Ketambe, Northern Sumatra. However, as mentioned earlier, riparian forest was excluded from this survey.

Table 3 shows the estimated population densities and total populations based on medium-age nests only. Analyses of LEWS and BANP resulted in exactly the same values of population density: d = 0.007 individual/ha. This value is considered as the most nearest estimation of total population of the species in LEWS and BANP. Therefore, in LEWS the estimated population is between 1,000 and 1,200 individuals, meanwhile, in BANP is between 150 and 170 individuals.

The same value of population density d = 0.009 ind./ha was obtained from the analyses of data from Ng. Giling (LEWS), and Telangun and Ng. Tiga sites of BANP. Since the population density was based on a small area, the extrapolation error was considered

high. In Ng. Mujan site (BANP) the population density was not calculated because there were only 2 transect lines (small number of samples). The population density in Ng. Masum (LEWS) was low. Smaller numbers of nests were detected in this remote area and this is probably due to the shortage of fruits.

Table 3. Nest density (d-nest), population density (d) and estimated total population of orangutan based on medium-age nests.

Nos. of TL	Location of TL	d-nest (nests/km^2)	d (ind./ha)	Estimated Total Population (extrapolation)
3	Telangun	191.1	0.009	
3	Ng. Tiga	197.3	0.009	
2	Ng. Mujan	59.2	0.003	
8	**BANP**	**144.8**	**0.007**	**168**
4	Ng. Giling	191.3	0.009	
4	Ng. Masum	111.9	0.005	
8	**LEWS**	**152.6**	**0.007**	**1,181**
Total Population (BANP and LEWS)				**1,349 (168+1,181)**

Note: TL = transect line; size of BANP = 24,040 ha and LEWS 168,758 ha
Source: primary data

In BANP the total population ranged between 72 and 240 (mean=177 individuals). In LEWS the total population ranged from 507 to 1,688 (mean=1,244 individuals). In combining LEWS and BANP, the population ranged between 579 and 1,928, with a mean of 1,421 individuals. As shown in Table 3, the population density in Ng. Mujan TL was too small to compare with other TL analyses and also this value was less viable.

Table 4. Nest density (d-nest), population density (d) and estimated total population of orangutan based on all nest counts (new, medium and old nest)

Nos. of TL	Location of TL	d-nest (nests/km^2)	d (ind./ha)	Estimated Total Population (extrapolation)
3	Telangun	301.2	0.012	
3	Ng. Tiga	378.7	0.018	
2	Ng. Mujan	133.4	0.006	
8	**BANP**	240.1	**0.012**	**288**
4	Ng. Giling	309.6	0.015	
4	Ng. Masum	193.5	0.009	
8	**LEWS**	244.2	**0.012**	**2,025**
Total Population (BANP and LEWS)				**2,313 (288+2,025)**

Note: TL = transect line
Source: primary data

Estimated total population based on calculation of all age nests criteria (new, medium and old) is shown in Table 4. The result is similar to that shown in Table 3; the only difference is the bigger population in Table 4.

A more accurate estimation of total population is the extrapolation of the population density based on the total size of LEWS and BANP minus the areas not occupied by the animal. Rivers are never used as a home range or habitat by the species, but they cross rivers using tree branches or canopy as bridges. They cannot cross over rivers that are more than 10 meters in width, either on the ground or by swimming (Rijksen and Meijaard, 1999). Based on measurement of length on the map and width estimation in the field, the total areas covered by rivers (which appear in the topography map) in LEWS and BANP are 1,631.85 ha and 269.03 ha respectively. Hence, the total areas of their habitat in LEWS and BANP are 167,126.15 ha and 23,770.97 ha respectively. Table 5 shows the total population in LEWS and BANP and these two areas combined, based on the calculation of total sizes of BANP and LEWS minus river areas. As in the previous description, the calculation is based on medium-age nests and followed by all age nests (medium, old and new nests).

Table 5. Nest density (d-nest), population density (d) and estimated total population of orangutan using IUCN-PHVA Version (Population and Habitat Viability Analyses) (Tilson *et al.* 1993) based on total numbers of medium-age nests.

Nos. of TL	Location of TL	d-nest (nests/km^2)	d (ind./ha)	Estimated Total Population (extrapolation)
3	Telangun	191.1	0.009	
3	Ng. Tiga	197.3	0.009	
2	Ng. Mujan	59.2	0.003	
8	**BANP**	**144.8**	**0.007**	**166**
4	Ng. Giling	191.3	0.009	
4	Ng. Masum	111.9	0.005	
8	**LEWS**	**152.6**	**0.007**	**1,181**
Total Population (BANP and LEWS)				**1,347 (166+1,181)**

Source: primary data
Note: TL = transect line; Total areas of orangutan habitat in LEWS and BANP are 167,126.15 ha and 23,770.97 ha respectively.

Table 6. Nest density (d-nest), population density (d) and estimated total population of orangutan using IUCN-PHVA Version (Population and Habitat Viability Analyses) (Tilson *et al.* 1993) based on total numbers of all age nests

Nos. of TL	Location of TL	d-nest (nests/km^2)	d (ind./ha)	Estimated Total Population (extrapolation)
3	Telangun	301.2	0.012	
3	Ng. Tiga	378.7	0.018	
2	Ng. Mujan	133.4	0.006	
8	**BANP**	240.1	**0.012**	**285**
4	Ng. Giling	309.6	0.015	
4	Ng. Masum	193.5	0.009	
8	**LEWS**	244.2	**0.012**	**2,005**
Total Population (BANP and LEWS)				**2,290 (285+2,005)**

Source: primary data
Note: TL = transect line

Following the equation of Brockelman and Ali (1984), the population densities in LEWS and BANP (based on medium-age nest calculation) are similar, with a density of 0.007 individuals/ha (Table 5). If all nests were taken into the calculation, the population density is higher at 0.012 individuals/ha (Table 6).

To gain a more accurate estimation, the extrapolation followed the PHVA (Population and Habitat Viability Analyses) with the exclusion of rivers as unoccupied habitat (known as 'edge effects'). The results show that the total population in LEWS and BANP are 1,181 and 166 individuals (population density: 0.007 individuals/ha) respectively. Meanwhile the total population of orangutan in the whole area (LEWS and BANP combined) is about 1,347 individuals (Table 7).

Table 7. Summary of population density and total population of orangutan in LEWS and BANP

	LEWS (medium-nest calculation)	BANP (medium-nest calculation)	TOTAL
Pop. Density (ind./ha)	0.007	0.007	
Total population	**1,181**	**166**	**1,347**

The best estimate of population density, besides direct observation, involves the analysing of hair samples in a sampling protocol. The samples were collected at several locations (3-5 places) along the 3-km transects line. Analyses of the hair samples can be used to determine how many individuals occur in one transect line (important to estimate population density) and also to identify whether the same individuals were found in other transect lines (to assess distribution pattern). Unfortunately, due to technical difficulty, the laboratory analyses were not able to identify individual animal from the hair samples. The results of the analysis were still under discussion among the genetic scientists of IPB-Indonesia and Primate Research Institute, Kyoto University, Japan.

2. Distribution of Orangutan

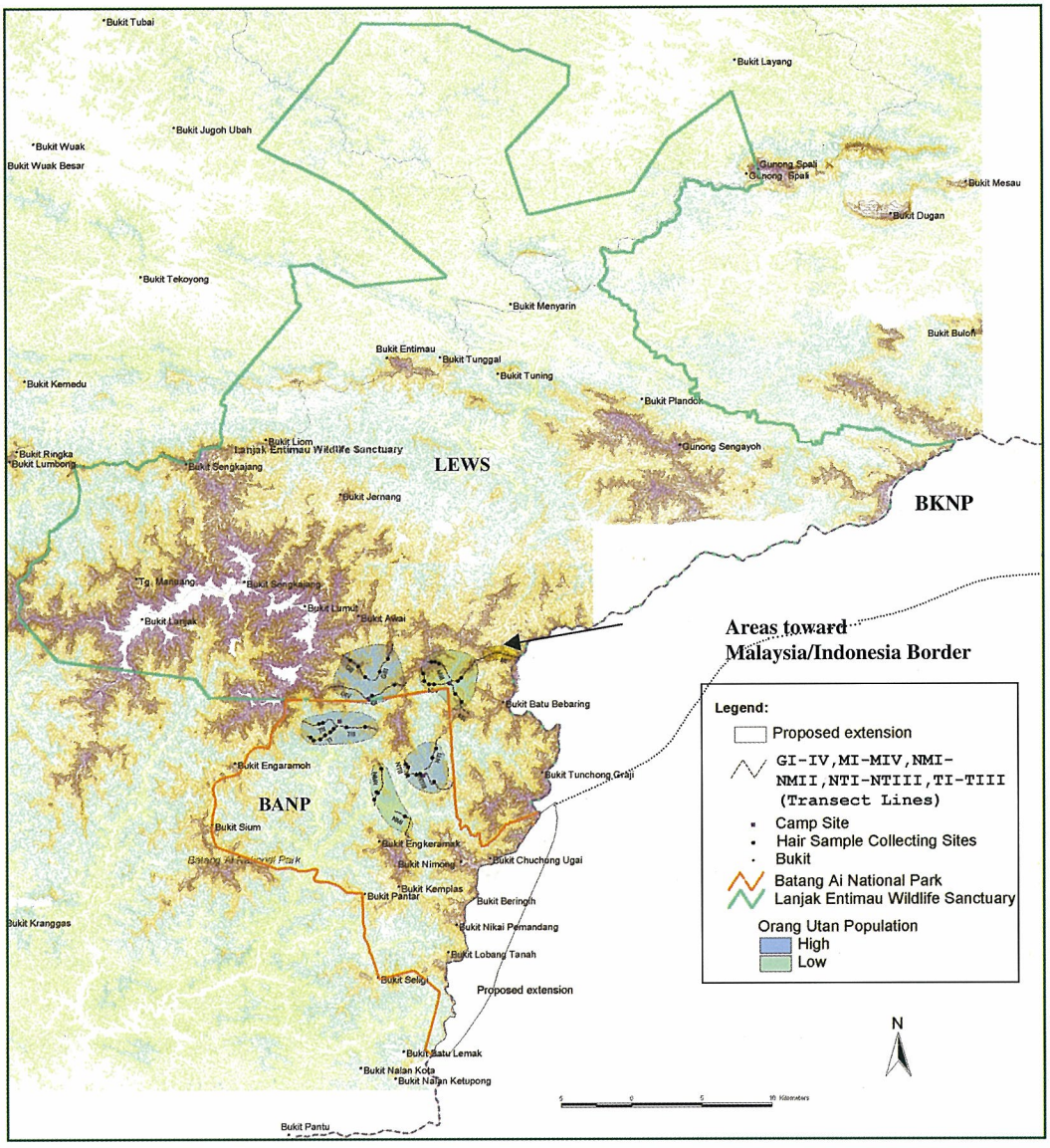
The study covered only a small part of LEWS and BANP, i.e. mainly along the ridges, and the field methodology was based on nest observation and not direct sighting. The distribution of orangutan in the study areas were mainly based on nest distribution and other visible evidence of home-range such as leaning tree, dry leaves etc. Generally, the home ranges covered almost all the study areas. Although the survey was mostly carried out along the ridges, inferred from the movement tracks clearly showed that daily ranges of orangutan also covered slopes and riparian forests. But the animal seemed to avoid the areas frequently visited by humans such as along the fringes of Batang Ai and Lubang Baya rivers, the main transportation routes used by the local people, even though the forest habitat here is similar to the one on the ridge. For example, only two nests were recorded at Sg. Manamong, a tributary of Sg. Batang Ai, but not a single nest was found along Sg. Lubang Baya.

Although in general the population distribution is scattered all over the study areas, the difference is the population density of each study sites. In LEWS, the animal is abundant in Ng. Giling area with a population density of 0.009 ind./ha and fewer numbers in Ng. Masum (0.005 ind./ha) (Map 2). In BANP, Ng. Telangun and Ng. Tiga (Map 2) have higher density (0.009 ind./ha) than in Ng. Mujan. It can be concluded that the population in south-western part of LEWS is more abundant than that in the south-eastern part. Meanwhile, in BANP the population is more abundant in the northern areas than the central part of the Park.

At the area between Indonesia-Malaysia boarder or around LEWS – BKNP boundary line (Map 2), the nests are frequently seen along the boundary line. This indicates that daily ranging of the animal does cover both BKNP and LEWS. The home-range of nomadic individual for example, covers an area of almost 1,000 ha (Rijksen & Meijaard, 1999). Contiguous distribution also occurs across the boundaries of BANP and LEWS and between BANP (Malaysia) and Indonesia area (east of BANP) that falls under the

unprotected land. For global conservation of the primate and other wildlife species, the status of contiguous forest of Indonesia, east of BANP should be included into the conservation area. The area of BKNP should be extended (Map 2) into the southern up to Bt. Batu Lemak or Bt. Perayung at the Indonesia-Malaysia boarder.

Map 2. Distribution of orangutan in LEWS and BANP



3. Forest Habitats of Orangutan

As has been mentioned above, orangutan population is randomly distributed over the study areas. This indicates that the forest habitats of the study areas are suitable for the primate. Orangutan needs good forest habitats for daily activity especially for feeding, resting, sleeping and breeding, and also for shelter from potential predators (defensive

character). Each individual has its own home-range within the habitat.

Use of home-range or forest habitats usually differs between drier and wetter seasons and this is probably related to the availability of food sources. However, in this study the survey only done during the drier period. It was observed that during the drier season, orangutan used riparian forest and surrounding areas rather than on the ridges or hilltops probably because the fruits are still available in these areas. It was assumed that there should be more nests built on the slope (near to the river) than on the ridge. But no survey was conducted along the slope due to difficulty to traverse the areas.

In this study at least three different habitats were surveyed namely, primary forest, old secondary forest and *temuda* or young secondary forest. Even though young secondary forest or *temuda* have been badly disturbed, this study found at least three nests at the edge of the *temuda* and another two nests were recorded within the *temuda* area in BANP. It seems that the animal also uses young secondary forest of ex-shifting cultivation site. In most of the study sites, sightings of the nests were hampered by the abundance of saplings. This was probably because in old secondary forest, saplings are more abundant than big trees as compared to the primary forest. However, saplings are useful for their movement from one tree to another tree. Generally, orangutan prefers habitat with abundant fig trees (Gurmaya pers. comm.), but, fig trees are not common in the study areas.

Ecologically, the forest in LEWS and BANP can be divided into 4 vertical layers: emergent, main canopy, middle canopy and understorey (mostly saplings and small trees). Tables 8 and 9 show the use of forest levels for nesting sites in LEWS and BANP. It was found that the animal seemed to avoid high canopy for resting or sleeping. They built their nests at lower levels (understorey), main canopy and middle canopy levels. Only a small amount of nests in LEWS and BANP were located at the emergent canopy comprising 8.9 % and 4.6 % respectively.

Table 8. The forest level of nesting sites in LEWS (8 transect lines; 282 nests)

Vertical layers:	Study Sites		Total	%
	Ng. Giling	Masum		
Emergent	18	7	25	8.9
Main Canopy	66	14	80	28.4
Middle Canopy	91	36	127	**45.0**
Understorey	21	29	50	17.7
Total	**196**	**86**	**282**	

Table 9. The forest level of nesting sites in BANP (8 transect lines; 260 nests)

Vertical layer	Study sites			Total	(%)
	Telangun	Ng.Tiga	Ng. Mujan		
Emergent	9	3	0	12	4.6
Main Canopy	71	82	17	170	**65.4**
Middle Canopy	27	29	17	73	28.1
Understorey	5	nil	nil	5	1.9
Total	**112**	**114**	**34**	**260**	

Most of the nests are located in the main canopy and middle canopy levels in LEWS (45.0 %), and at the second level in BANP (65.4%). This could be due to different levels of disturbance in both conservation areas. Based on general observation made during the survey, LEWS study sites seemed to be rarely visited by humans as compared to BANP, although the physical conditions of both forests are generally similar. The results of the understorey levels of LEWS and BANP could support the above argument. In LEWS and BANP 17.7 % and 1.9 % of the nests respectively are built at the lowest level of the forest. It can be suggested that in the forest with less human visitors, more nests are built at the lower level.

As habitats of orangutan, the forest is in a very good condition with little physical disturbance by man. Contiguous forest canopy supports the quadrumanual daily movement of the species. In the under storey, saplings (10 cm diameter or less) supports the movement from one tree to another tree. The body weight causes the vertical saplings to become bent and assume a leaning position. Although the physical condition of the forest habitat is good, it seems that the daily activity and behaviour of orangutan and other wildlife species have been much disturbed possibly due to frequent visits of humans mainly in the forest along Batang Ai River up to Mepal tributary and also Lubang Baya River up to Telangun tributary or less remote area. Remote areas are less visited by the local inhabitants.

Although no ecological study on the vegetation was carried out, the nesting tree species were recorded. In LEWS and BANP, altogether 84 nesting tree species from 34 botanical families were recorded (Appendix 2) (53 species in LEWS and 71 species in BANP). *Lithocarpus* sp. (*empili*) is the most frequently used as nesting site (Fr. 13.6 %) in LEWS and *Vatica* sp. (*resak*) in BANP (Fr. 7.8 %). This probably because these trees have many horizontal branches that are ideal for nest building. The nesting branches must be safe from any disturbances such as predators and humans. Besides, it must also provide a good place to detect other individuals, mainly neighbouring orangutans.

Another typical character of the habitat utilization is most of the nests are located very close to the main trunks of nesting trees. In LEWS and BANP respectively 79.9 % and 73.5 % of the nests are located close to the main trunks on the horizontal branches up to 1m away from the trunks (Table 10). Some of these nests are built on the treetop with the upper part being broken to provide a clearer view. This is related to the protective behaviour of the species, as they need a wide view in the dense tropical forest environment. Being closer to the main trunk, the branches are stronger and are able to support the heavy body weight. This is a very common behaviour among the primate species (Rijksen, 1974; Kappeler, 1974).

Table 10. Distance of the nest from the tree trunk in LEWS and BANP

Distance from tree trunk (m)	LEWS (%)	BANP (%)
0-1	**75.9**	**73.5**
>1 – 2	13.1	17.3
>2 – 3	5.3	1.5
>3 – 4	2.5	3.1
>4 – 5	1.4	1.9
>5 – 6	0.7	1.5
>6 – 7	1.1	1.2

4. Other Primate and Wildlife Species

Other primates and wildlife species in the study areas were recorded qualitatively, mainly to determine the occurrence of the animals in the study areas. Detection was conducted by direct sighting and indirect recognition based on habitat signs such as tracks of movement, footprints, faeces, hairs etc. In less remote areas hunting tracks (mainly of wild boar) were seen in many sites and most of the animals seemed to be avoided these sites.

Besides orangutan, five other primate species occur in LEWS and BANP: Long-tailed macaque (*Macaca fascicularis*), Pig-tailed macaque (*Macaca nemestrina*), Maroon Langur (*Presbytis rubicunda*), Fronted Langur (*Presbytis frontata*) and Mueller gibbon (*Hylobates muelleri*). Generally, almost the entire terrestrial habitats of the study area is occupied by primate species, each having preferential habitats of its own. Mueller gibbon was recorded mainly along the ridge; the population was considered high based on the signs and morning calls made by the species. Gibbons depend very much on habitat

with contiguous canopies of trees for their brachiating movement. It was noted that in some locations, many movement tracks of the gibbon were seen where there was an absence of orangutan nest. It seems that gibbon and orangutan do not live together sympatrically at the same location at the same time, although they possibly share overlapping home-ranges. The reason is they possess the same behavioural characters: brachiating movement, arboreal, frugivorous, and possibly having a similar niche. More detailed study is needed to support this view.

Based on general observation, gibbon normally had their early morning calls after dawn and another call at about 09:00 a.m. (if the weather is good). But in the forest areas those frequently visited by human, less or no regular morning calls were heard although many signs of gibbon were identified. However, a few gibbon-alarm calls were heard probably as a result of inter-group interactions and reaction towards human appearance. In less visited areas by humans (along the trail towards the Malaysia-Indonesia International Border), mainly in LEWS (upper Latong), the Batang Ai watershed area (upper Mepal river, a tributary of Batang Ai river) and Lubang Baya watershed area further up Ng. Telangun (Giling toward Ng. Supa), regular morning calls were heard almost daily. This could be due to less hunting activities in these areas.

The langurs (Fronted langur-*Presbytis frontata* and Maroon langur- *P. rubicunda*) were also found on the ridge and riparian forest habitats during the survey. It was difficult to detect the Maroon langur in less remote areas, while in the remote areas regular morning calls were heard many times. The Fronted langur was recorded many times along the ridges as well as in riparian forest.

Based on their signs, the Long-tailed and Pig-tailed macaques were normally found in riparian forest habitats. However, there were also signs of their presence on the ridges about 300 m from the river in LEWS (close to Malaysia-Indonesia international boundary line).

The most abundant species among the animals found in LEWS and BANP is the wild pig (*Sus barbatus*). Besides direct observation, this species can be easily identified through footprints, wallowing pools and soil marks on the tree trunks, which occur almost everywhere in the study sites. Small caves or burrows and small tunnels underneath the ferns or bushes were also found in the study areas. Their abundance is probably an indicative of the high fecundity.

Indirect detection of Malayan sun-bear (*Helarctos malayanus*) was recorded at least 7 times. The bear is recognized by its claw marks on the tree trunks after climbing the trees, and also from holes made in the trunk in search of honey, insects (termites) etc.

DISCUSSION

There are different ways to calculate the population densities. These include separate calculations based on medium-age nests and all age nests giving rise to different population density values: 0.007 ind./ha or 0.7 ind./km^2 and 0.012 ind./ha or 1.2 ind./ km^2 respectively. These calculations have much influence on the estimate of the total individuals in LEWS and BANP. Based on medium-age nests, the estimated population in LEWS and BANP are 1,181 and 166 individuals respectively. However, if using all nests, the estimate of population size tends to increase e.g. in LEWS 2,005 individuals while in BANP 285 individuals.

The first calculation using medium-age nests is considered to be relatively more accurate estimation as compared to the calculation based on all nests probably because it could reduce the chances of making over estimate on the population. However, both results were used as a range of estimated population size in the study areas. Therefore, the range of total population in LEWS is between 1,181 and 2,005 individuals and in BANP is between 166 to 285 individuals. Meanwhile, the population density is from 0.007 ind./ha to 0.012 ind./ha, or 0.7 ind./km^2 to 1.2 ind./km^2.

Blouch (1994) estimated that the population densities in LEWS were 1.73 ind/ km^2 in the south, 0.31 ind /km^2 in the central region and 0.21 ind/km^2 in the north of the area, with the total population of 1,024 individuals. These results of Blouch were similar to the estimates derived from this study except for the estimates based on all nest calculation (2,005 individuals). Therefore, it supports the previous argument of this report that medium-age nest calculation is probably a more accurate estimation of orangutan population density and total population. The location of this study (16 of 3-km transect lines with a total of 68 km surveyed transects) is part of Blouch's 8 months field study (20 of 4-km transect lines at 10 sites with a total of 1,568.6 km survey transects).

In BANP, Meredith (1993) estimated a population density of 1.5 ind./km^2 with a total of 360 individuals. This density is much higher than the result of the present study, probably because even though both studies used the same methods of survey and data analyses, Meredith's estimates of the total population could probably based on the entire TPA which might include the river systems. Besides that it is also possible that the population of orangutan may have decreased since the last survey.

Compared to other studies (based on nest count method) at similar habitats in Borneo, the population densities recorded here is within the range of those for other areas (Table 11).

Table 11. Comparison of population density (ind./km^2) between this study and other studies in Borneo

Studies	Study Area	Pop. Density (ind./km^2)
This study (2002)	LEWS & BANP	0.7
Blouch 1994	LEWS (Southern part)	1.73
	LEWS (Central part)	0.31
	LEWS (Northern part)	0.21
Galdikas 1978	Tanjung Puting	3.0
Johns 1992	Danum Valley	0.3
MacKinnon 1971	Ulu Segama	0.8
Meredith 1993	BANP	1.5
Page *et al.* 1995	Sebangau	2.2
Payne 1988	Kawaq	0.3
	Tabin	1.1
	Crocker	0.1
	Meliau	0.8
	Kulamba	3.0
Russon *et al.* 2000	Danau Sentarum	3.5

Nest-count method actually needs a standard value of *r* (daily rate of the nest built: n/day/individual) and *t* (estimate of the rate of the nest decay: days) to fulfill the formula. Until now there are no standard values for LEWS, BANP and BKNP areas. For this study the values follow the Russon's *et al.* (2000) study in DSWR, which may not be suitable because of its flat wetland forest area. A long-term study on the ecology (population, distribution and habitat) and sociology of orangutan in the hill dipterocarp forest of LEWS, BANP and BKNP is the best way to obtain the standard values.

The animals show a random distribution in the study area, even up to the Malaysia-Indonesia (LEWS-BKNP) boundary lines. Therefore, the distribution covers the contiguous dipterocarp forest of LEWS, BANP and BKNP. There is a great possibility of trans-boundary migration in LEWS, BANP and BKNP, especially when some nests have been recorded along the international boundaries. Actually the word "migration" means daily movement of the individual within his/her home range that coincidentally covers the forest along the international boundaries of both countries. The trans-boundary movement occurs within a remote area with almost no human interference. However, the ecology and conservation in BKNP-Indonesia is not exactly known. For conservation management at the landscape level, it is recommended to carry out similar studies in

BKNP. A joint Malaysia-Indonesia management for orangutan conservation is essential. In relation to the study at landscape level, the population density, total populations and socio-ecology of the species in the western part of BKNP must be studied.

According to Meredith (1993), the population was concentrated in the southern part of BANP, especially in the eastern part of Malaysia-Indonesia international boundaries. Similar trans-boundary migration has also been observed between BANP and adjacent forest areas in Kalimantan. Concerning global conservation and for the management purpose of the biggest orangutan habitat in the world (combined LEWS-BANP-BKNP), it is strongly recommended to propose the enlargement of BKNP in Indonesia to the south up to Bukit Perayung area (Map 2). Integration of trans-frontier Malaysia-Indonesia conservation areas may be a long process but it will further guarantee the survival of the species.

As observed in this study they are well distributed all over the study areas. However, there seems to be some concentrated populations in certain locations. This is probably due to several factors:

1. **The socio-ecological life of orangutan**. There are 3 types of social organization of orangutan: inhabitant, semi-nomadic and nomadic (Rijksen & Meijaard, 1999). The inhabitant possibly lives within a concentrated population, while the nomadic and semi-nomadic ones seem to be scattered over a wider area.
2. **The quality of habitats in relation to the availability and quality of food sources**. Although the diet in the study areas has never been studied, the animal usually prefers fruits with a fleshy pulp (van Schaik *et al.*, 1995), e.g. the fruits of *Ficus* trees are the most preferred food sources in Sumatra (Rijksen *et al.* 1999). Very few *Ficus* trees were found in the study areas.
3. **Behavioural disturbances**. Hunting or poaching activities in some areas can affect the daily life and social behaviour of the animal although according to the local hunters this particular primate is not hunted.

The habitats in LEWS and BANP are still intact. Although nearly 90% of geographical distributions of orangutan are in Indonesia, the habitat conditions there are not good. Habitat disturbance occurs everywhere because of illegal logging, forest fires, forest conversion etc. Ever since 1998, illegal logging has spread to the conservation areas such as national parks, wildlife sanctuaries etc. including orangutan habitats. It was only after January 2003 that the government of Indonesia began to stop illegal logging and emphasized on conservation forest management. The current status and their habitats in BKNP is not exactly known. It is strongly recommended to carry out ecological and

7. There are clear signs of orangutan occuring along the boundary lines of LEWS, BANP and BKNP especially along the boundaries of both countries.

8. Altogether 542 nests with 282 nests in LEWS and 260 nests in BANP were recorded. From the total numbers of nests recorded, 6.5% were new nests and another 39.5% were medium-age nests. The highest numbers of nests found were old nests with 54.0%. The study also recorded 84 species of trees used by the orangutans to build their nests. Characteristics of the nesting sites are:

    a. Out of the four forest canopy levels, most nests were located at the third level in LEWS and second level in BANP, indicating that in less disturbed areas the nests are built nearer to the ground.

    b. Most of the nests are located close to the tree trunks of the nesting trees.

9. The primate and other wildlife species exhibit a normal behaviour in remote areas such as in upper Lubang Baya River (after Sg. Telangun tributary) and area upper Mepal tributary of Batang Ai watershed. In less remote areas frequently visited by man, the behaviour of wildlife species is very much disturbed.

10. The physical conditions of the forest habitats in LEWS and BANP are good, with almost no forest disturbance been recorded especially in remote areas. This reflects good conservation management effort.

RECOMMENDATIONS FOR CONSERVATION MANAGEMENT

The conservation management of the TBCA as the largest orangutan habitat in the world should involve Malaysia, Indonesia and ITTO. Some thoughts and suggestions are presented below for the realisation of a collaborative management plan for implementation to ensure the survival of the animal and other wildlife species in their original natural habitats.

I. GUIDELINES ON LEWS-BANP-BKNP COLLABORATIVE MANAGEMENT TO ENSURE THE SURVIVAL OF ORANGUTAN IN BORNEO

1.0. Management Objectives

a. To develop a regional conservation management of endangered species as a part of global nature conservation efforts;
b. To protect and conserve the remaining tropical forest as the original habitat of orangutan and other wildlife species;
c. To develop a programme for collaborative management.

2.0. Collaborative Management

Collaborative management of BANP-LEWS-BKNP is emphasised. A co-management body should be established. If possible, the TPAs of LEWS-BANP-BKNP should be integrated into a " Borneo Trans-frontier Park" (BTP). Regular discussions should be held by both countries to plan, integrate and implement the management plan, conservation laws and regulations. The management plan of the BTP should be based on the available management plans of the respective TPAs.

3.0. Law Enforcement

a. A mechanism for law enforcement should be developed and implemented jointly and effectively;
b. Standard operation procedures (SOP) of law enforcement on nature conservation of both countries should be discussed, understood and integrated;
c. Boundary marking of each zone to indicate the restricted zones is very important for law enforcement. A good topography map showing the ridges and rivers will be useful for preparing patrolling routes;
d. No wildlife hunting and harvesting of forest produce is allowed in the BTP. However, the co-management committee should set aside areas for controlled fishing, hunting and forest produce harvesting by the local communities.

4.0. Eco-tourism

There are many good sites for eco-tourism in the conservation areas. The eco-tourism

activities in BTP should be developed for limited visitors. At least two main entrance gates (Batang Ai Dam (BANP) and the Embaloh River (BKNP) can be promoted to facilitate the eco-tourism activities in BTP. Tourism facilities such as accommodation etc. should be placed in the buffer zones outside the BTP.

5.0. Zonation

Zonation management systems are proposed for TPAs. Based on natural conditions, socio-economic and culture of the local communities near the conservation areas, the BTP should be divided into various zones such as:

a. Strict protection zone
b. Eco-tourism zone (for BANP and BKNP only)
c. Buffer zone
d. Intensive use zone
e. Traditional use zone.

It is very important to propose an enlargement of BKNP to the south up to Bukit Perayung as a buffer zone to protect the orangutan habitat in BANP.

II. Research

Some suggestions for research in LEWS, BANP and BKNP are as follows:

a. To continue this study in BKNP to gather preliminary ecological data for the entire TBCA. This scientific data will form the basis for a more detailed study, for law enforcement and wildlife conservation in general.
b. Permanent transect lines should be established for observation and monitoring purposes. These areas should include the study sites of Meredith (1993) in BANP, Blouch (2000) in LEWS and of the present study in LEWS and BANP. Similar transects are recommended for BKNP-Indonesia. Currently in LEWS and BANP, there are at least 60 transect lines each of 3-km in length that can be maintained. Additional transect lines in the slopes and riparian forest are suggested to cover a wider habitat range of orangutan and other wildlife species;
c. A study based on block system (referring to watershed areas) should be done. Absolute counting and nest count methods are suitable for the collection of ecological field data for orangutan;
d. Encourage Malaysian and Indonesian scientists and students to carry out studies on a long-term basis to understand its ecology, sociology and behaviour and at the same time to establish a database on orangutan in the TBCA.
e. A permanent research station in Lubang Baya Rangers Station and other sites as proposed by previous researchers, Meredith (1993) and Blouch (2000), including the research stations in Embaloh watershed (western part) should be established.
f. To establish an association of Malaysian-Indonesian Orangutan specialists group including scientists, forest managers and students of local universities, etc.

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Appendix A

Perpendicular distance of orangutan nest from the transect line (BANP) Transect Lines

TI	TI *cont.*	TII	TII	NTI	NTII	NTII	NMI	NMII
0	15	4	5	0	0	0	0	20
10	0	15	10	1	0	0	0	0
10	3	15	2	2	0	0	5	10
5	3	8	1	2	0	0	10	15
12	15	15	20	2	0	1	20	20
12	7	10	5	2	1	2	0	15
20	5	20	40	3	1	3	35	4
0		10	3	3	2	3	40	5
18		5	5	5	2	3	8	2
5		30	10	5	2	3		20
5		30	5	6	2	3		0
20		7	15	7	2	3		40
8		35	25	8	3	5		25
1		8	2	10	3	10		10
1		3	10	10	4	10		10
8		8	2	10	4	10		20
10		3	1	10	5	15		1
5		1	1	10	5	15		10
8		10	20	10	5	20		8
0		3	25	10	5	20		20
0		3	25	10	7	25		4
25		10		12	8	25		30
25		10		15	8	25		8
40		15		15	8	25		10
20		15		15	8	25		25
20		5		15	10	30		
10		6		20	10	30		
10		20		30	10	35		
10		15		30	10	35		
10		30			12	35		
15		3			15	40		
8		8			15	40		
20					15	40		
20					15	40		
2					15	40		
20					15	42		
5					20	42		
2					20	42		
15					20	42		
10					20	42		
10					20	50		
20					20			
5					22			
15					30			
5								
25								
40								
15								

Appendix A *cont.*

Perpendicular distance of orangutan nest from the transect line (BANP) Transect Lines

NGI	NGII	NGII *cont.*	NGIII	NGIV	MI	MII	MIII	MIV
10	1	10	10	4	2	15	15	15
30	3	35	10	4	6	10	1	20
30	5	15	15	4	6	10	25	10
12	5	1	10	3.5	2	10	20	5
18	20	10	1	20	2	10	10	4
10	15	50	12	17	4	5	12	12
15	20	40	1	4	2	0.5	7	8
30	25	6	5	6	4	10	15	7
40	30	40	30	4	4	3	10	5
3	25	40	1	15	15	20	20	3
25	2	40	15	15	10	12	3	4
30	5	42	2	5	15	35	10	15
25	2	42	2	4	1	15	12	20
20	5	3	15	7	30	2	6	7
15	20	7	0	2	20	3	6	
15	18	25	35	8	30	20	6	
0	20	10	15	15		1		
1	10	6	15	1		10		
12	2	5	10	6		10		
20	1	2	2	15		10		
25	20	25	30	15		20		
30	20	40	5	1		30		
20	15	15	20	10		15		
10	15	8	0	15		3		
1	15	1	3	15		4		
15	8	3	20	4		6		
35	35	15	15	10		1		
10	37	9	0	16		3		
2	40	9	1	10		10		
5	25		15	12		15		
12	40		5	20		25		
2	10		8	13		25		
4	0		4	20		25		
1	35		2			15		
10	25		10			20		
5	25		20			30		
8	0		30			35		
5	40		30			15		
	2		30			5		
	3		6			3		
	3		3					
	3		3					
	3		30					
	3		2					
	25		20					
	25		1					
	25		2					
	25							
	2							

Appendix B

Nesting tree species used by the orangutan in BANP and LEWS

Family	Species	Local name	% (LEWS)	% (BANP)
Alangiaceae	*Alangium circulare*	Midong	1.41	1.54
Alangiaceae	*Alangium* sp.	Midong daun besar		0.38
Anacardiaceae	*Mangifera* sp.	Raba		0.77
Anacardiaceae	*Melanochyla elmeri*	Rengas	0.71	
Annonaceae	*Polyathia* sp. (1)	Selaut	0.35	
Annonaceae	*Polyathia* sp (2)	Pendok	0.35	
Annonaceae	*Anaxagorea* sp.	Penduk		0.38
Annonaceae	*Mezzettia parviflora*	Kepayang babi	0.35	0.77
Burseraceae	*Canarium caudatum*	Merambang	2.48	2.69
Burseraceae	*Canarium* sp. (1)	Seladah		1.92
Burseraceae	*Canarium* sp. (2)	Seladah daun halus		0.38
Burseraceae	*Canarium* sp. (3)	Unggit	3.55	0.77
Burseraceae	*Dacryodes* sp.	Kemayau	5.32	1.92
Chrysobalanaceae	*Atuna nannodes*	Mara batu	0.35	0.38
Crypteroniaceae	*Crypteronia* sp.C42	Ubah semut		0.38
Dilleniaceae	*Dillenia reticulata*	Pru		0.38
Dipterocarpaceae	*Hopea* sp. (1)	Luis	3.9	1.15
Dipterocarpaceae	*Hopea* sp. (2)	Melitan	1.06	0.77
Dipterocarpaceae	*Shorea laevis*	Selangan batu		0.38
Dipterocarpaceae	*Shorea parvifolia*	Meranti sarang punai		1.15
Dipterocarpaceae	*Shorea scabrida*	Meranti lop		0.77
Dipterocarpaceae	*Shorea* sp. (1)	Meranti	4.61	3.46
Dipterocarpaceae	*Shorea* sp. (2)	Meranti daun halus		0.38
Dipterocarpaceae	*Shorea* sp. (3)	Perawan		0.38
Dipterocarpaceae	*Shorea* sp. (4)	Melapi		0.38
Dipterocarpaceae	*Shorea* sp. (5)	Selangan batu	2.48	0.77
Dipterocarpaceae	*Shorea* sp. (6)	Engkabang		0.38
Dipterocarpaceae	*Shorea* sp. (7)	Kedangan	4.96	1.15
Dipterocarpaceae	*Shorea* sp. (8)	Mikai	2.48	0.38
Dipterocarpaceae	*Shorea* sp. (9)	Meranti melantai	0.35	1.15
Dipterocarpaceae	*Vatica* sp. (1)	Resak	7.45	*7.85
Dipterocarpaceae	*Vatica* sp. (2)	Resak daun besar	0.35	0.77
Ebenaceae	*Diospyros* sp.	Kayu malam	0.35	0.38
Euphorbiaceae	*Aporusa* sp.	Kayu masam	2.84	0.38
Euphorbiaceae	*Baccaurea* sp.	Tampoi	0.71	0.38
Euphorbiaceae	*Mallotus eucaustus*	Ensarai		0.77
Euphorbiaceae	*Pimeleodendron* sp.	Kelampai		0.77
Euphorbiaceae	*Trigonopleura malayana*	Sedi	2.13	5.77
Flacourtiaceae	*Homalium* sp.	Senumpul	1.77	10
Fagaceae	*Lithocarpus* sp.	Empili	*13.62	5.77
Fagaceae	*Lithocarpus* sp.	Berangan padi	1.06	0.77
Guttiferae	*Callophylum* sp.	Bintangor daun halus	0.35	1.54
Guttiferae	*Garcinia* sp.	Kandis	0.35	2.69
Guttiferae	*Kayea elmeri*	Mergasing	0.35	1.92
Hyperiaceae	*Cratoxylum* sp.	Gerungggang		0.38
Lauraceae	*Endiandra coriacea*	Medang bejubai	0.35	0.38
Lauraceae	*Eusideroxylon* sp.	Tebelian		0.38
Lauraceae	*Litsea* sp.	Medang	2.48	1.54
Lecythidaceae	*Barringtonia lanceolata*	Karut	0.35	0.38

Appendix B *cont.*

Nesting tree species used by the orangutan in BANP and LEWS

Leguminosae	*Dialium* spp.	Keranji	0.35	
Leguminosae	*Koompassia malaccensis*	Menggeris/ Kempas	0.35	
Melastomataceae	*Kibessia* sp.	Pulu		0.38
Meliaceae	*Aglaia* sp.	Segerak	0.71	0.38
Moraceae	*Ficus benjamina*	Beringin		0.38
Moraceae	*Ficus* sp.	Kara		0.38
Moraceae	*Strebus glabber*	Empatak		0.77
Myristicaceae	*Endocomia* sp.	Kumpang	9.22	6.54
Myrtaceae	*Eugenia corymbifera*	Ubah jambu		0.38
Myrtaceae	*Eugenia leucoxylon*	Ubah padang merah		0.38
Myrtaceae	*Eugenia lunduensis*	Ubah daun besar		0.38
Myrtaceae	*Eugenia* sp. (1)	Ubah	9.92	10
Myrtaceae	*Eugenia* sp. (2)	Ubah ribu	0.71	1.54
Myrtaceae	*Eugenia tenuicaudata*	Ubah putih	0.35	0.77
Myrtaceae	*Eugenia* spp.	Ubah kurap	0.35	
Olacaceae	*Ochanostachys amentacea*	Sentikal	1.06	0.77
Olacaceae	*Strombosia ceylanica*	Belian landak	0.71	1.54
Oleaceae	*Olea rubrovenia*	Mok		0.77
Polygalaceae	*Xanthophyllum stipitatum*	Mangok	1.06	
Polygalaceae	*Xanthophylum* sp.	Nyalin	0.35	0.77
Rosaceae	*Prunus beccarii*	Enteli		1.54
Rubiaceae	*Porterandia* sp.	Mengkudu hutan		0.38
Sapindaceae	*Nephelium ramboutan-ake*	Pudun/ Rambutan	1.06	0.77
Sapindaceae	*Nephelium* sp.	Melanjan / Engkeranji		0.38
Sapindaceae	*Xerospermum noronhianum*	Ilat	1.06	0.38
Sapindaceae	*Nephelium lappaceum*	Kedabang	0.35	
Sterculiaceae	*Sterculia* spp.	Biris	0.35	
Theaceae	*Adinandra* sp.	Legai		0.38
Tiliaceae	*Microcos* sp.	Bunsi	0.35	0.38
Verbenaceae	*Teijsmaniodendron* sp.	Entabuluh	0.71	1.15
Verbenaceae	*Vitex* sp.	Kepapa laut		0.38

Appendix C

ORANGUTAN NEST COUNT

Date: _____

Study Site: _____

Transect Line: _____ **Observer:** _____

No	Station/ Dis- tance On	Right Angle Dis	Nest Height	Height Of Nesting Tree	Dis- tance From Tree	Nest Size	**Nesting Tree	**Nest Age	Nesting Tree	Remarks

** Nesting tree location: Ridge or Slope.

Nest Age: C1 - New Nest (leaves are still green, smell of urine or faeces is still intact)
C2 - Older Nest (leaves may still be attached, original shape is conserved, leaves are mixed green and brown)
C3 - Old Nest (all leaves are brown, and holes are visible in structure)
C4 - Many leaves are gone and holes visible in structure
C5 - Twigs and branches still present but no longer in original shape of nest

Photograph 1: Route to international border (End of Tinting Awai)

Photograph 2A: Old secondary forest, Telangun.

Photograph 2B: Old secondary forest, Ng. Tiga. Saplings are abundant

Photograph 3: Ridges in the study area

Photograph 4: The small leaning tree (see arrow) is caused by orangutan.

Photograph 5: New orangutan nest found at the Malaysian – Indonesian border

Photograph 6: Picking up an orangutan hair sample from the nest using forceps to avoid direct touch with hand

Photograph 7: Survey team campsite at Telangun

Photograph 8: During dry season the journey involved a lot of boat pushing along shallow water

Photograph 9: Pushing boat over rocks at Mepal Waterfall of Batang Ai River

Photograph 10: Medium-age nest of orangutan on the treetop

*Photograph 11: Damaged **Eugeissona** (Pantu) palm after orangutan picked up the shoot*

*Photograph 12: A hole on the tree trunk made by the Malayan sun-bear **(Helarctos malayanus)***


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