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Behavioral ecology of reintroduced Orangutans in the Bukit Batikap, Central Kalimantan, Indonesia

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Abstract. *Nayasilana IN, Hadisusanto S, Wijayanto H, Atmoko SSU, Prasetyo D, Sihite J, Van Schaik CP. 2017. Behavioral ecology of reintroduced Orangutans in the Bukit Batikap, Central Kalimantan, Indonesia. Biodiversitas 18: 875-886.* Conversion habitat is the major threats to orangutan survival. More than 600 orangutans in rehabilitation center Nyaru Menteng BOSF, Central Kalimantan, waiting to be released to their nature habitat. The success of reintroduction is strongly dependent on the ecological component of the new habitat's quality. Orangutans' spatial behavior strongly related to fruit availability fluctuation, which will effects adaptation success. The goal of the study is to differentiate adaptation patterns of reintroduced orangutans (*semi-wild* and rehabilitant) base on habitat suitability. This study focused on 16 reintroduced orangutans (8 *semi-wild* and 8 rehabilitant) with a distribution of vegetation analysis overlaid with ranging for ecology effect. Day journey length and ranging of orangutans were collected for 18 months (2012-2014) by means of focal animal sampling. Ranging data was analyzed using ArcMap GIS 9.3 Kernels program, the correlation between ranging and vegetation by Canonical Correspondence Analysis (CCA), diversity and biodiversity vegetation analysis which was then compared to wild orangutans (Sebangau and Tuanan Research Station). We found, 98% of Sorensen's similarity in vegetation and similar diversity for Simpson's, Shannon-Wiener and biodiversity indexes. Significantly high proportions of food patches consumed were fruit ($p < 0.81$) and rattan ($p < 0.58$). Our data also show the range of reintroduced orangutan vertical movements were between 0 m to >20 m, minimum home range for males was 619 ha and females 544 ha, with overlapping areas between orangutans 0.09%-77.85%. Based on the correlation between ranging and food distribution, reintroduced orangutan distribution was found to be concentrated on food resources, with other factors indicating that they still felt comfortable around humans, and ranging was found to be similar compared to wild orangutans. In conclusion, an adaptation of reintroduced orangutans, both *semi-wild* and rehabilitated, in their new habitat was found to be similar.

Keywords: Food patch, orangutan, ranging, vegetation, vertical-use

INTRODUCTION

The Bornean orangutan is a critically endangered species (Ancrenaz et al. 2016). Habitat loss and hunting have led to a large number of wild-born orphaned orangutans being cared for within rehabilitation centers, where the main goal is to successfully reintroduce them to their natural habitat. The reintroduction process requires intensive preparation, both of the individual orangutan and the habitat into which they will be reintroduced. Reintroduction success is strongly dependent on the quality and security of the habitat. These newly released animals lack the experience and knowledge to navigate this new setting, and must quickly learn how to find food and develop social relationships. Food availability affects orangutan distribution and their behavior when adapting with ecological changes (van Schaik and Pfannes 2005). Food is also a factor in temporal variability of availability (Cannon et al. 2007). Animals will respond to food availability, especially fruit, based on changes in habitat use. Changes in food availability have different consequences on energy use as an adaptation factor. Orangutans will also increase their range to defend any resources available as an adaptation to habitat change.

Orangutan range covers different habitat types, from high-quality areas with year-long fruit availability, to low-quality areas with seasonal fruit availability, which is only used by a small number of individuals (Meijaard et al. 2001). Habitat quality influences range behavior (Singleton et al. 2009), and because reintroduced orangutans are new to their environment, they need time to establish their home ranges (Russon 2010). Home range overlap may also occur within reintroduced orangutan populations, especially when they are still investigating their new habitat, as well as competition between individuals while establishing dominance relationships (Atmoko 2000; Singleton 2000).

Orangutans are generally solitary and wide-ranging, they are difficult to find therefore no precise figure for success are available. Data from Kalimantan imply that reintroduction is successful in 20% to 50% of the release apes (Rijksen and Meijaard 1999; Smits et al. 1995). Important factors for success are thought to include: if orangutan has passed infancy and had spent its early years in the wild before capture; if it has been neither too badly nor too well treated in captivity, so that full physical and mental health can be regained; if dependent on the above, independence from human care is encouraged by a gradual but determined process; if the center set-up encourages the animal to remain arboreal and away from the buildings; if a young animal can form a close relationship with another individual, and learn by imitation from more independent animals; if after quarantine and/or infancy, minimal contact is maintained with the center person (who should themselves have regular medical checks), and contact with visitors is always prevented; if the center and environments are isolated by natural barriers from human population and agricultural areas.

Data generated for the survival rate of released orangutans can be used as an indicator for the success of the reintroduction program between 20-80% (Russon 2009). The common causes of death include inadequate foraging, skill-related injuries (e.g. fall from the tree due to inadequate training), assaults by predators and conspecifics, and poor health caused by high orangutan densities or excessive human contact (Russon 2009). Another cause may contribute to the poor survival rate of these animals is that many of them have arrived in physically and physiologically impaired conditions due to accident inadequate rehabilitate care or abuse, and different kind of diseases.

The context of the range includes horizontal and vertical spatial use. Orangutans horizontal or vertical movements depend on fruit availability fluctuation, which affects adaptation success. More than 131 formerly rehabilitate individuals from Borneo Orangutan Survival Foundation’s (BOSF) orangutan rehabilitation center at Nyaru Menteng have been reintroduced to Bukit Batikap since February 2012. Those reintroduced orangutans must be able to survive with fluctuating food sources. The reproductive and vegetative process of fruiting plants also affects ranging patterns. Productivity was measured through phenology data and food patch usage by each orangutan. Forests of high quality provide food sources to orangutans (Marshall et al. 2009). Abundant food sources may limit the ranging area for each individual and may allow interactions between individuals, and vice versa. This assumption is that ecological factors affect orangutan adaptation. The goal of this study was to differentiate adaptation patterns of reintroduced orangutans (*semi-wild* and rehabilitant) based on habitat suitability. We present data in order to describe the food patch data on vegetation analysis and ranging. We specifically ask whether (i) vegetation effects are apparent on *semi-wild* and rehabilitant orangutans, (ii) food patch effect are apparent on vegetation, (iii) different pattern of food patch are *semi-wild* and rehabilitant (iv) ranging effected orangutan food resources, (v) food resource correlated are ranging overlap. Finally, we discuss the extent to which these results can be generalized to another site where Bornean orangutans occur, and provide a recommendation for orangutan reintroduction in a new habitat.

MATERIALS AND METHODS

Study area

The study was carried out at the Borneo Orangutan Survival Foundation (BOSF) orangutan release area in Bukit Batikap Protection Forest (Conservation Forest), Central Kalimantan, Indonesia, with a geographical postion of 0º24’S - 0º40’N; 113º12’-114º13’ E. Once ready for reintroduction, rescued and confiscated orangutans from the Nyaru Menteng orangutan reintroduction center are transported to the release site at Bukit Batikap Protection Forest (Figure 1). Bukit Batikap comprises 35,267 ha and the research area covers 8,000 ha of peat swamp high quality, lowland rainforest with extensive plateaus, and heath forest. Most of the research area is covered at elevations 200-500 m asl.

Habitat

To measure the forest structure, we identified plant species and quantified their height (m), diameter at breast height (DBH) at 1.40m above ground in cm and canopy cover chosen forest plots (600 x10 m; 950 x 10 m; 900 x 10 m; 450 x 10 m) and an additional plot around the river (1000 x 10 m), within each of the 6 plots, trees were measured if DBH was $\geq$ 10 cm and figs and lianas if $\geq$ 3 cm. All species were identified by the scientific name. To assess the habitat of the orangutan reintroduction area, we developed a list of criteria which were; the number of food plant species in each particular area, the mean proportion of time feeding on the focal plant species (trees, figs, lianas, and pith), and DBH of the focal plant. The six plots then were separately calculated for trees, ficus, and liana (Mueller-Dombois and Ellenberg 1974). The map of the study area was selected with a random number compare with release point and camp. The selected were used to establish to plots. All plots were established and investigated in July 2014. all species (trees, liana, and fig) were identified a scientific name and local name. We determinate canopy cover as “the proportion of the forest floor covered by the vertical projection of the tree crowns”. DBH is used as a proxy for crop size of a particular tree because it has been shown to be a consistently accurate and reliable index of the potential crop size in the tropics compared to other methods such as crown volume estimation (Chapman et al. 1992; Felton et al. 2003).

Vegetation analysis as a basis to understand the ecology of the orangutan in a new habitat. The order to assess the vegetation analysis, we developed a measure, absolute food patch value, considering that food resources are the basis of a species survival. This measure relates the food patch choice of orangutans to the number of food patch species present in a particular area and their respective potential crop size. Mean proportion of food patch choice was calculated for plant species base on behavioral data collection from February 2012 until November 2014 (see below of all individual orangutans that we followed). The per plot was calculated separately for trees, figs, and liana.

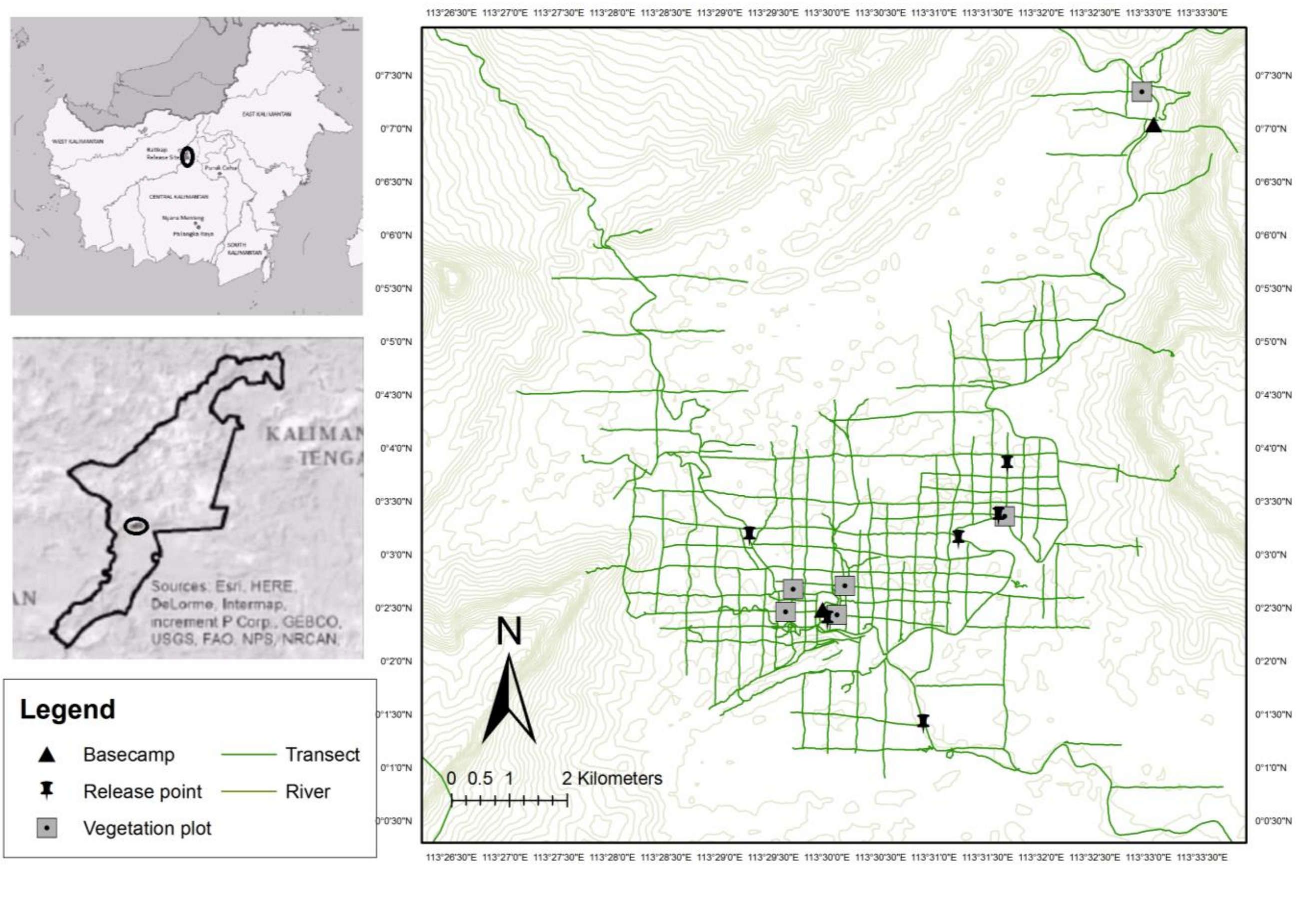


Figure 1. Location of Bukit Batikap, Murung Raya, Central Kalimantan, Indonesia (0ºº24'S - 0º40'N; 113º12'-114º13' E)

Object of study

Sixteen individual orangutans (*Pongo pygmaeus wurmbii*) were observed: 8 *semi-wild* individuals (4 males and 4 females) and 8 rehabilitant individuals (2 males and 6 females), between the ages of 8 and 25 years (Table 1). Different to *semi-wild* and rehabilitant, *semi-wild* orangutans are those who at the time of rescue, have previously encountered humans yet have retained sufficient natural behaviors and vital skills to survive alone in the wild. Rehabilitant orangutans are those individuals rescued at a young age and/or confiscated from people who have kept them in captivity. These orangutans did not have or had lost most of the necessary skill to survive independently in the forest and thus mush go through and intensive rehabilitation process (forest school and the final pre-release stage on and island/halfway house), which can take up to 7 years on average.

Before being released, the orangutans had stayed at the rehabilitation center for a variable amount of time. Term ecological rehabilitation to describe the process by which the animal becomes able to survive on its own in the forest and social integration to describe its acceptance into the wild population and the development of normal social responses. Every rehabilitation center has different steps, some have forest school or merely a quarantine. But in general rehabilitation orangutans from rescue and confiscated will be brought to the rehabilitation center. Orangutan is given full medical check upon arrival, then letter on will go the rehabilitate process one of them is having a forest school, after forest school, before they release, for *semi-wild* they when back to cages, but not rehabilitate they go to the island (pre-release). In the cages, *semi-wild* get a food 3-7 years, well get rehabilitate a get supporting food 6-8 years. They live free really in release island (pre-release). All individuals were cared for at Nyaru Menteng Orangutan Reintroduction Center, close to Palangkaraya, Central Kalimantan, where for rehabilitate they had completed a lengthy process of rehabilitation. All individuals completed quarantine, rehabilitation process and comprehensive health screening prior to release.

Base on the IUCN Best Practice Guideline for the reintroduction of Great Apes (Baker 2002; Beck et al. 2007), rehabilitate mean held in a rehabilitation center, such as enclosures, private homes, or *semi-wild* environments, for a prolonged period after being rescued and put into a rehabilitation center. The orangutans are fully released into their new habitat and they are no longer provisioned by humans. Released orangutans are monitored and followed to assess their food patch, climbing skill and spatial used compared with vegetation, thus their chance to survive in the wild.

Table 1. Orangutan reintroduction in Bukit Batikap Protection Forest, Murung Raya, Central Kalimantan, Indonesia

Name of individuals	Sex	Released date	Age (yr)		History	Length in rehabilitation center (yr)		Day Follow (N-N)	Time Observation (hours)
			Intake	Released		Cage	Island		
Semi-wild								**328 (107)**	**2176.9**
Astrid	F	28 Feb 2012	9	14	R	5	-	50 (24)	313.7
Monic	F	28 Feb 2012	4.5-5	8	R	3	-	57 (25)	430.4
Ika	F	31 Mar 2012	4-4.5	10	R	6	-	43 (10)	281
Ebol	F	09 Aug 2012	2	8	R	6	-	59 (15)	418.1
Tarzan	M	28 Feb 2012	18	25	R	7	-	55 (18)	339.9
Heldy	M	31 Mar 2012	4-4.5	9	R	5	-	33 (9)	222.7
Jojo	M	31 Mar 2012	4-4.5	8	R	4	-	10 (3)	46.2
Edwan	M	14 Feb 2013	4-4.5	9	R	6	-	21 (3)	124.9
Rehabilitation								**200 (26)**	**1182.4**
Emen	F	03 Nov 2012	4-4.5	17	C	4	8	42 (3)	252.5
Gadis	F	03 Nov 2012	2.5-3	15	C	4	8	31 (4)	186.7
Leonora	F	03 Nov 2012	3-3.5	16	C	4	8	36 (5)	224.9
Manggo	F	14 Feb 2013	0	7	C	-	7	22 (3)	119.5
Markisa	F	14 Feb 2013	4-4.5	17	C	6	8	27 (3)	161.1
Mita	F	17 Aug 2013	3.5-4	17	C	4	10	11 (2)	45.9
Danur	M	16 Feb 2013	4-4.5	17	C	4	14	25 (4)	128
Mogok	M	15 Feb 2013	2-2.5	13	C	4	6	14 (2)	63.8

Prior to reintroduction, each individual orangutan was implanted with a radio transmitter that emits a unique individual radio signal which can be detected through a handheld radio tracking device. Instead of using radio tagging this study used chips which were implanted under the skin in their neck and could be checked by a radio transmitter, active period of transmitter 3-5 years. This tool helps to 70-100% actually found the individual with greater ease, with the distance between radio transmitter with an individual less than 400m. Once an individual was located, he or she would be followed for the entire day. Data were recorded using a standardized set of orangutan data-collection protocol methods with instantaneous focal animal sampling (once every 5 minutes) to record general behavior (Altman 1974). The data collected were based on February 2012 until November 2014, during nest to nest follows or until the focal individual was lost, and followed pre-established standards published online (Morrogh-Bernard et al. 2002; van Schaik and van Noordwijk 2003), which activities included food patch choice (trees, liana, and figs) and vertical orangutan movement (on the ground, 1-5m, 6-10m, 11-15m, 16-20m and >20m.

For mapping, individuals were followed all day until the built their evening nest. The following day, start the follow after day wakes up and leave they're (morning nest). The active day length differed considerably (7-13 hours). Every 15 minutes. We recorded the geographic position of the focal subject by GPS (Garmin 60Csx) for activity day length (horizontal spatial use) and the position of each food patch. We divided food patches into three major substrates: tree, liana, fig or *pith* (rattan). The orangutan's day range can provide information on overall range, food availability or social alliances. Day range is the total distance traveled by an individual from the time they leave their night nest right through to the time they build their new night nest. It is associated with food abundance, and in general, time spent traveling correlates positively with day range and home range size (Strier 2000). Determining an orangutan's range can be calculated using *Minimum Convex Polygon* (MCP) and *Grid cell* (Singleton and van Schaik 2001), but MCP may often produce a bigger area than the real range, counting unused areas into the range estimation (Wartmann 2010). The Kernels method for estimating range area produces a more accurate result than MCP (Wartmann 2010; Seaman and Powell 1996; Pettersson 2007).

Data analysis

The component analysis was used for the 6 forest plot variable and Canonical Correspondent Analysis (CCA) was used for the vertical and horizontal space, conducted using the program Canoco 4.5 (Leps and Smilauer 2003). For statistical analysis, were conducted using the program IBM SPSS 20. All tests were two-tailed, some data did not meet the assumptions for parametric testing (i.e. normal distribution and homogeneous variances between groups), and thus were analyzed with non-parametric test (group-comparison and two independent samples: Mann-Whitney-U; K independent samples: Kruskal-Wallis, two related samples: Wilcoxon; K related samples: Friedman, Shapiro-Wilk tests were carried out). For all plot variable and the for the variable absolute food patch value. For food choice and space used, CCA was performed to select variables. CCA was used to determine and analyze the relationship between species composition and underlying environmental factors and constructed the whole structure of species distribution pattern. CCA is simpler and more efficient than orthodox statistical analyses, requiring much less linear data and giving precise species-environmental correlation (Leps and Smilauer 2003). CCA is the method the extracts the best synthetic gradients from field data on biological communities and environmental features. It forms a linear combination of environmental variables that maximally separates the niches of the species (Klami et al. 2013).

Vegetation analysis used Sorensen's, Simpson's, Biodiversity and Shannon-Wiener. Calculating community similarities (what the communities have in common in terms of species), we will Sorensen's coefficient give a value between 0 and 1, the closer value is to 1, the more communities have in common (i.e. complete community overlap is equal to 1 and complete community dissimilarity is equal to 0), Sorensen's coefficient 2c/s1+s2 (where c is number of species two communities have in common, s1 and s2 is the total number of species found in community 1 and 2). The Simpson's is dominant because it gives more weight to common or dominant species. In this case, a few rare species with only a few representative will not affect the diversity. The Simpson's N (N-1)/ni (ni-1) (individuals of one particular species found (n) divided by the total number of individual found (N)). Biodiversity index is the assumption that the diversity found within the quadrat is representative of study site as a whole, 1-Σ (ni (ni-1)/N (N-1)).The Shannon-Wiener index is an information statistic index, which means is assumes all species are represented in a sample and that they are randomly sampled. The Shannon-Wiener index Σ*pi ln pi* (*p* is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individual found (N), *ln* is the natural *log*, Σ is the sum of the calculation, and s is the number of species).

All follow data from GPS to ArcMap GIS 9.3 software are routes (line) to be measured to estimate range sizes Kernels. Plotting all points at which an individual was every seen, given a sample of a point known to be within range. The points were then liked using ABODE v.5 Kernels program for home range method. Food patch coordinates that we recorded in the field, were also transferred and store in ArcMap GIS software as a point. I categorized them into the wood plant, figs, and liana layers. After that, day journey length from the moment the individual leaves the nest in the morning or point where research found the individual to end evening nest when the individual lies down. Food patch was measured as a total number of each tree or figs or liana seen eaten by rehabilitant orangutans divided average of day journey length.

The Kernels density estimator uses non-parametric methods for estimating probability density, and because it is non-parametric it has the potential to accurately estimate densities of any shape, provided that the level of smoothness is selected appropriately. The kernels method consists of placing a kernel (probability density) over each observation point in the sample. A rectangular grid is superimposed on the data, and an estimate of density is obtained at each grid intersection, using information from the entire sample. The density at any location is an estimate of the amount of time spent there so that the density will be higher in areas with many observations, and lower in areas with few observations, thus this method is appropriate for analyzing habitat use.

RESULTS AND DISCUSSION

During their daily activities period, all individuals were recorded as present. Some newly released orangutans use the space in their habitat to a search of food, making difficult to find individuals or to locate them after they were lost during focal follows. This means it is difficult to distinguish between an individual being present but going unrecorded and individual not present in the study area. This is unfortunate because presence can also be used to estimate survival (Table 1). Of the sixteen individual, 8 *semi-wild* (4 males and 4 females) and 8 rehabilitant (2 males and 6 females), one year after *semi-wild* and rehabilitant males explored the area more thoroughly and females were seen again around release point. All of them the choice to tree, figs, and liana for food patch and spatial use. Spatial use in this study was divided into vertical (dependent on tree height) space and horizontal (dependent on the range) space. Vegetation structure in the habitat correlates with spatial use.

Vegetation analysis and food patch

In a total of 6 vegetation plot, we found standard deviation for relative dominance, relative density, and importance value in each was similar. The top 15 INP species utilized by orangutans as food resources were: *Hydnocarpus* sp. (6.550), *Syzygium* sp. (6.306), *Diospyros* sp. (5.458), *Aglaia* sp. (4.900), *Drypetes polyneura* Airy Shaw (4.560), *Canarium littorale* Blume (4.276), *Santiria* sp. (4.265), *Spatholobus* sp. (4.108), *Artocarpus anisophyllus* Miq. (4.093), *Oncosperma horridum* (4.082), *Baccaurea pyriformis* Gage (4.021), *Dacryodes rugosa* (Blume) H.J. Lam (3.932), *Artocarpus* sp. (3.854), *Canarium* sp. (3.438), *Baccaurea macrocarpa* (Mig.) Mull. Arg. (3.255). These species are dominant food tree and nest trees, this good condition for food patch was supported, the individual. Sorensen's similarity index on 6 vegetation plot is 98%. While Simpson's diversity (DS), Shannon-Wiener's diversity index (H') and Biodiversity (D), were as Table 2.

Table 2. Vegetation analysis for six plots

Vegetation plot		ST Dev			Simpson	Biodiversity	Shannon-Wiener
Coordinate	m asl.	DR	KR	INP	(DS)%	(D)	(H')
N0°02’26.2"; E113°30’02.0"	188	0.04	0.72	1.21	30.76	0.97	3.52
N0°02’27.9"; E113°29’48.7"	195	0.05	0.84	1.61	18.28	0.95	3.22
N0°02’19.9"; E113°30’10.4"	148	0.03	0.66	1.15	16.89	0.94	3.17
N0°07’21.1"; E113°32’59.0"	196	0.03	0.83	1.36	16.48	0.94	3.11
N0°03’21.8"; E113°31’39.1"	188	0.13	1.40	2.21	11.98	0.92	3.04
N0°02’31.3"; E113°30’01.7"	147	0.04	0.82	1.49	16.33	0.94	3.17

Simpson’s diversity is a calculation of variety which takes into records both richness and evenness. Simpson’s diversity is a correlation with biodiversity index, it has been a useful tool to understand the profile of biodiversity across the study area. As Simpson’s diversity has swift convergence to limited diversity value for minor sample size, therefore is principally suitable for rapidly evaluating regions for conservation. Shannon-Wiener diversity index value was estimated to be 3.04-3.52. The Shannon-Wiener diversity index, which specifies the comparative occurrence of many species was used associate species abundance and relative richness amongst species. As value Shannon-Winer diversity index of 6 plot, which predicts that the number of individuals of all species was evenly distributed in the study area.

Vegetation analysis describes the composition and number of species that forms a forest. Our research informs us that fruit trees in Bukit Batikap illustrate a good forest condition, through continuously regenerating parenting trees. The presence of fruit trees is a supporting parameter for the successful adaptation of reintroduced orangutan in Bukit Batikap. The standard deviation for relative dominance between 0.03-0.13, relative denseness between 0.66-1.40 and importance value between 1.15-2.21, show a species similarity of vegetation in plots. Sorensen's similarity index on 6 vegetation plots describes the presence of the composing species in an equal distribution, while the diversity index describes abundance and the various inter-species vegetation distribution in Bukit Batikap.

The complexity of trees in a community on Simpson's index shows that the plot number 1 was the most complex, followed by 2, while 3 other plots (3, 4 and 6) had a similar complexity in the community. These differed from plot number 5 which had lower complexity compared to other plots. Shannon-Wiener diversity index on 6 plots also indicated that plot number 1 had a higher diversity, productivity, and species stability compared to the other plots, even if diversity in the other plots were quite similar (3.04-3.22). Biodiversity index also had a similar value of around 0.92-0.97.

Variation of proportional food patch usage of *semi-wild* and rehabilitant orangutans at Bukit Batikap are presented in Figures 2a and 2b. There was similarity of food patch utilization for *semi-wild* and rehabilitants (t= -0.076, p=0.47, α=0.05). The biggest food patches were trees, followed by rattan, figs, and lianas.

The high percentage of tree food patches recorded is important information on food patch usage variety. Trees are used for movement and nesting areas, as well as feeding (Sugardjito and van Hoof 1986; Prasetyo et al. 2009). Besides trees, the highest food patch usage was rattan. This is likely due to the high abundance of rattan, which is not affected by season making it an important alternative food source for reintroduced orangutans when fruit availability is low. Figs also had a higher proportion compared to lianas. Base on research, during 2012-2014 figs is all season to food supply and rattan also always there the needs. Fig is similar to rattan as it is not affected by different seasons when research time, especially during the scarceness of fruits, during In Sumatra, Fig is an important food source for primates during food scarceness (Rijksen 1978; Sugardjito and van Hoof 1986; Utami at al. 1997), with a relatively stable fruit production (Rijksen 1978). Reintroduced orangutans did utilize fig and rattan when fruit is scarce. This is developed appropriate foraging strategies, orangutans ability for survival and the success of reintroduction (Rijken 1978). The other individual, such as monkey, she did not eat fig for three years however she eats fig leaf after 3-year release. This approach indeed gives measure how animals handle their environment (wich et al. 2002).

The vertical and horizontal spatial use

Vertical orangutan movement ranged from on the ground (0 m) to >20 meters. The most frequent vertical use by *semi-wild* orangutans occurred at >20m (31%) and for rehabilitant orangutans at 16-20 (23%). The least utilized space was similar for both groups, which was 0-5 m height for *semi-wild* (4%) and rehabilitant (6%). They sometimes come down from trees (0-5 m), drink from the river. Reintroduced orangutans mostly utilized space at 16-20 m height (26% average), followed by >20 m height (23%) and 11-15 m height (22%) (Figure 3), while vegetation analysis of the 6 plots show an average tree height of 14.13 m (SD = 4.24) with an average diameter of 72.65 cm (SD = 55.64). This use of space at heights of 16-20 m was supported by high fruit availability and high nutrition within that space. Trees of sources a high value were are mostly in middle and upper of forest (Rijksen 1978). Furthermore, when orangutans consumed browse, they occupied the space above 20 m, and when consuming pith remained below 10 m. Reintroduce orangutan did utilize high level to found fruit on trees and low level to finding pith or insect in terrestrial. Although pith can be found on the trees, in general, the pith is found on terrestrial. Vertical space use is also related to the arboreal nature of the orangutans to avoid threats on the forest floor. The space between 11-15 meters was mostly used for resting or moving, as this space had an ideal density for moving around.

Horizontal space use by reintroduced orangutans in Bukit Batikap was supported with food source spread. Overall, *semi-wild* to able to use successfully in acquiring food, the even encountered *semi-wild* ranges are larger than those of rehabilitated, especially for a female. But different for male range (Singleton et al. 2009). rehabilitated Average daily ranging area for *semi-wild* orangutans was 762 m and rehabilitants 716 m (SD = 279.53) (Figure 4a).

The home range of reintroduced orangutans in Bukit Batikap during the study are presented in Figure 4. Orangutans will explore for food and other daily activities, which is why home range varies with food patch abundance. The biggest home range recorded for the reintroduced males was for Danur, a flanged orangutan (619 ha), followed by Edwan, a *semi-wild* unflanged orangutan (465 ha) and Tarzan, a *semi-wild* flanged orangutan (243 ha), Home range for males were between 19-619 ha (SD = 227 ha), while for females in descending order; Ebol, a *semi-wild* orangutan (544 ha), Ika orangutan *semi-wild* (399 ha) and Monic *semi-wild* (373 ha). Female home ranges were between 150-544 ha (SD = 112 ha). A significantly smaller home range than other individuals was found for Mogok (unflanged male rehabilitated), with only 19 ha. Mogok (unflanged male) was reticent to explore, demonstrated significant resting periods and ranged only around the point of his release. The range of *semi-wilds* was 329 ha compared to rehab orangutans' 279 ha, both of which are similar to wild female orangutan range (300-330 ha) and more than for wild male orangutans in Tuanan and Sebangau (Singleton et al. 2009). There was no correlation found with point count amount with home range. When the number of points its little, but range are bigger, then the home range is the biggest and vice versa. The Pearson correlation of home range between *semi-wild* and the rehab (0.217), males (0.499) and females (0.149).

A same spatial use among individuals was often found to be overlapping as shown in Table 4. Base on our analysis, the home range of individuals overlapping, range 0-77.85% (0-279.68 ha). This may be caused by the abundance and spread of food trees. The largest range overlap was recorded between mango and markisa (77.85%) which was philopatric (female with offspring), followed by Astrid and Tarzan (38.90%), Monic and Tarzan (33.90%) and finally Astrid and Monic (30.13%). In general, female range overlaps those of other females and sub-adult male ranges overlap those of other sub-adult males (Galdikas 1979). There was no clear pattern of the home range (overlap) use yet because the most individuals spend the time to search food and still learning or did not know where individuals would need to go to find resources.

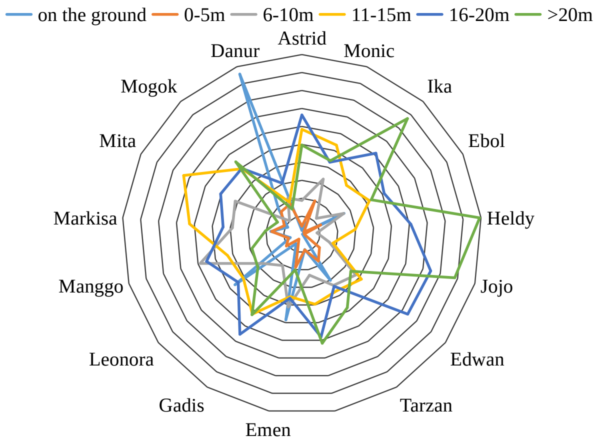


Figure 3. Vertical use by reintroduced orangutans in Bukit Batikap Protection Forest, Murung Raya, Central Kalimantan, Indonesia

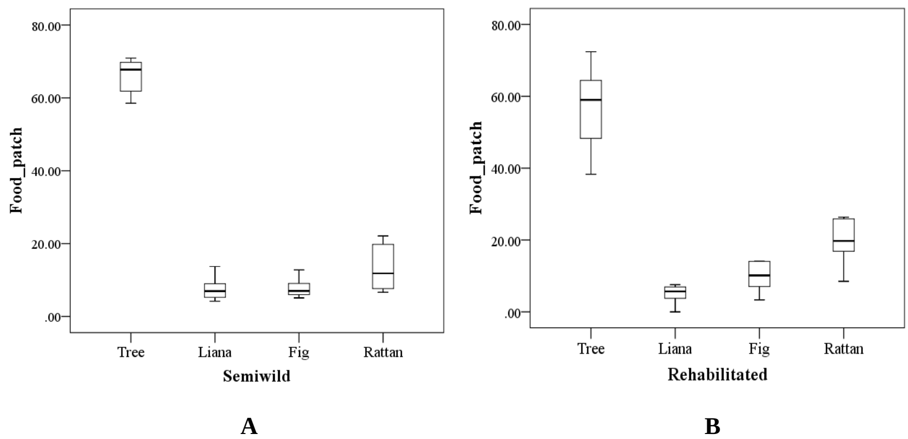


Figure 2. Food patch utilization frequency of orangutans. A. *Semi-wild*, B. Rehabilitated

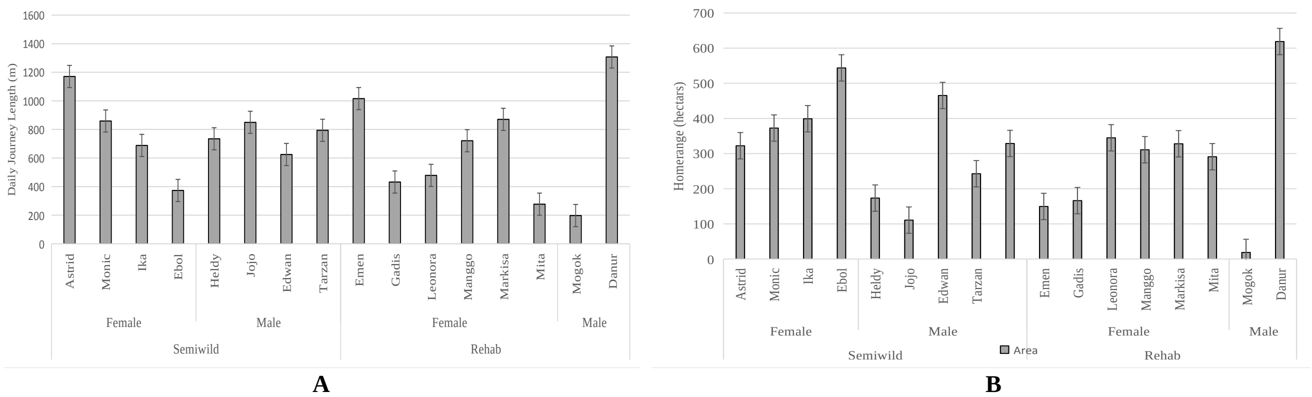


Figure 4. The daily range and home range of reintroduced orangutans in Bukit Batikap Protection Forest, Murung Raya, Central Kalimantan, Indonesia. A. The daily range, B. Home range

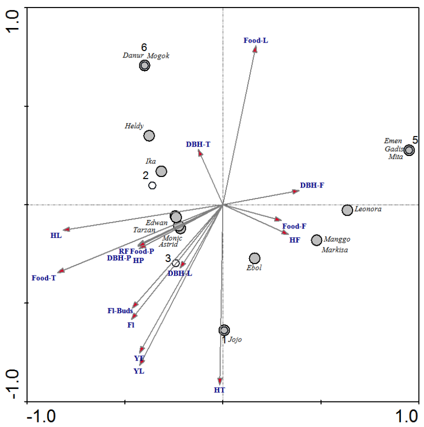


Figure 5. CCA between vegetation analysis and orangutan presence in Bukit Batikap Protection Forest, Murung Raya, Central Kalimantan, Indonesia based on food patch spread and food items (HT-high trees, HL-high liana, HF-high ficus, HP-high pith, DBH-Trees, DBH-Liana, DBH-Ficus, DBH-Pith, Food-Trees, Food-Liana, Food-Ficus, Food-Pith, Flower, Flower-Buds, Young Fruit, Ripe Fruit, Young Leaves)

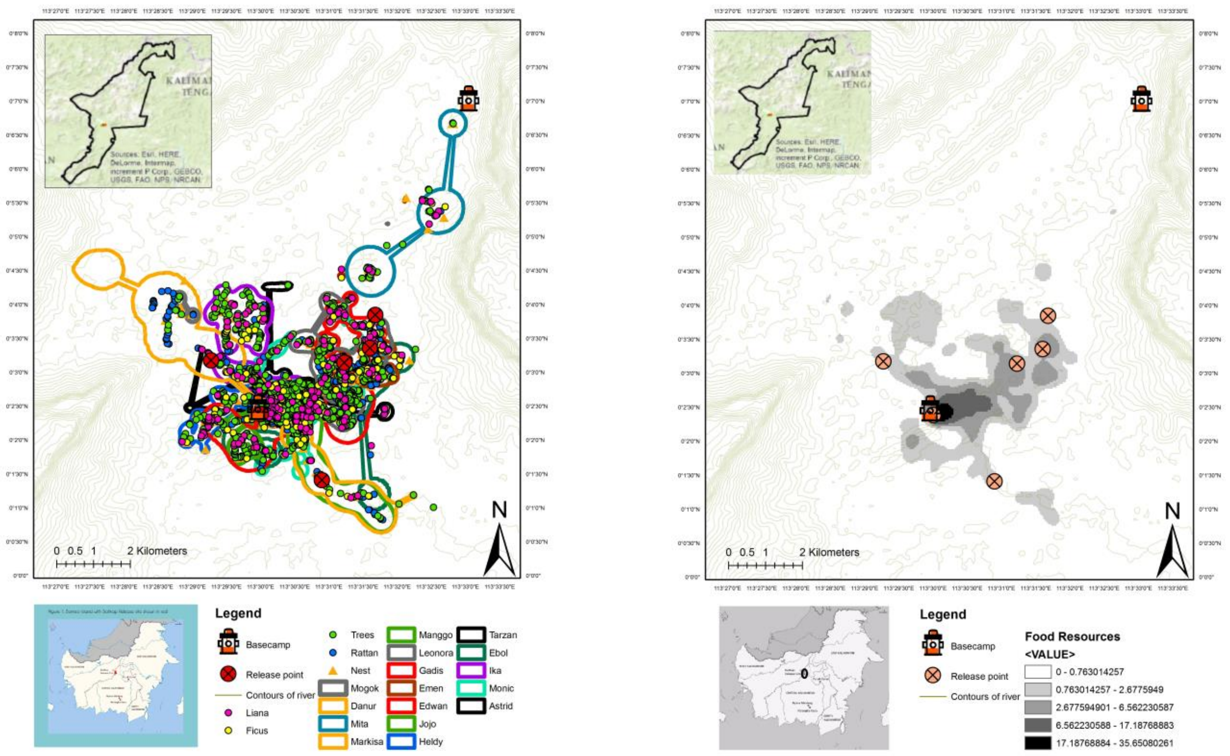
Canonical Correspondent Analysis (CCA) result showed a total inertia of 1.242. The first axis alone explained 60.1% of the total unexplained variance. Taken together, the first and second axis of the data set explained 80.5% of total inertia, indicating a high species-environment correlation. Orangutan presence and the six vegetation plot analysis based on food patches and food items showed, linear sum of gradient length of canonical (Figure 5). The TT, TL, TF, TP, HT, HL, HF, HP, DBH-T, DBH-L, DBH-F, DBH-P, Food-T, Food-L, Food-F, Food-P from settlement all showed strong positive correlation with te first CCA axis, whereas individuals in the plots of intensity showed strong correlation along the second CCA axis. Although all environmental variables showed great strength, the most influential limiting factor food patch (Food-T, Food-L, Food-F and Food-P). The six plots vegetation are clustered to the point of the CCA, although Sorensen's test showing the similarity its community.

The CCA also shows orangutans were focused in vegetation plot 3, followed by 1, 2, 5 and 6, while 4 is located in a distant place and rarely visited by orangutans, even though the vegetation comprised a similar food abundance. Food patch trees, figs, and pith are favored by orangutans. While moving and resting, orangutans favored the height of trees and lianas compared to figs and pith. However, there were also some individuals that showed no preference for either food sources or movement.

Kernels analysis showed that reintroduced orangutans' ranging patterns for the study were affected by food source abundance (Figure 6a). The ranging area will follow their foraging, less food availability for a species might consequently make smaller foraging area than habitats with high food availability. But assessing food availability is difficult, in this study using food patch size. Individuals were depended on the seasonal fruit availability and habitat quality (van Noordwijk and van Schaik 2005). The ranging pattern also visibly overlapped between each individual, especially between males and females. Reintroduced orangutans seem to influence their abilities to readapt to forest life. The sources abundance comparison with orangutan density by interpolation model, this indicated as the response for habituation individual in this area. The space utilization of those individuals by some spatial and temporal factor, it's concentrated in the central area of dark color (Figure 6b). The dark color within food resources by kernels tools of 17.188-35.651 is high utilize. Orangutans utilize central area maximally when supported by food patches availability. While the presence of camps also shows that reintroduced orangutans still preferred to be around humans while carrying out their activities.

The ranging difference between *semi-wild* and rehabilitant orangutans was tested with Mann-Whitney non-parametric test (P-*value*=0.401). *Semi-wild* and rehab females showed a ranging similarity (P-*value*=0.033) and *semi-wild* and rehabilitant males showed a ranging difference (P-*value*=1.00). There was no significant difference found between *semi-wild* and rehabilitant orangutans, including between *semi-wild* and rehabilitant males and both had a similar home range area. Each individual attempted to find and decide their own range based on their chance of finding abundant food patches.

In general, reintroduced orangutan home range in Bukit Batikap was quite similar to wild orangutan home range in comparable habitat: Sebangau and Tuanan Research Station (Table 5). Data collected in this research describes the average home range area of observed reintroduced orangutans.



A B

Figure 6. A. Overlay between *semi-wild* and rehabilitated ranging with food resources and nests; B. Orangutan distribution was found to be concentrated on food resources in middle position

Table 4. Overlapping range between individuals of orangutans in Bukit Batikap Protection Forest, Murung Raya, Central Kalimantan, Indonesia

% \ Ha	Astrid	Monic	Ika	Ebol	Heldy	Edwan	Tarzan	Jojo	Emen	Gadis	Leonora	Manggo	Markisa	Mita	Mogok	Danur
Astrid		160.9	26.67	109.2	-	115.996	158.247	11.91	12.19	-	83.16	9.70	3.86	-	-	6.62
Monic	30.13		72.46	138.5	11.93	105.306	155.788	12.05	1.29	3.91	43.39	41.18	41.79	-	-	8.99
Ika	3.84	10.36		9.933	27.89	3.58	47.09	1.08	-	-	-	-	-	-	-	64.55
Ebol	14.44	17.81	1.06		0.64	237.98	94.33	79.19	104.42	14.71	110.75	38.55	51.30	-	-	8.99
Heldy	-	2.23	5.12	0.09		40.75	11.95	3.30	-	-	-	-	-	-	-	4.82
Edwan	17.27	14.37	1.06	30.86	6.81		77.45	99.33	1.1269	-	76.55	1.49	8.88	-	-	5.98
Tarzan	38.90	33.90	7.92	13.63	2.96	12.28		10.59	-	-	9.22	26.11	26.29	-	-	9.39
Jojo	2.83	2.56	0.21	13.76	1.17	20.83	3.09		-	-	-	-	-	-	-	1.56
Emen	2.65	0.25	-	17.73	-	0.18	-	-		24.29	89.53	-	-	-	-	-
Gadis	-	0.73	-	2.11	-	-	-	-	8.33		67.10	-	-	-	-	-
Leonora	14.23	6.44	-	14.23	-	10.43	1.59	-	22.11	15.11		-	-	-	-	-
Manggo	1.56	6.41	-	4.72	-	0.19	4.95	-	-	-	-		279.68	-	-	-
Markisa	0.60	6.34	-	6.25	-	1.13	4.83	-	-	-	-	77.85		-	-	-
Mita	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Mogok	-	-	-	-	-	-	-	-	-	-	-	-	-	-		18.81
Danur	0.71	0.91	6.77	0.78	0.61	0.55	1.10	0.21	-	-	-	-	-	-	3.04	

Table 5. Comparison of home range in Bukit Batikap Protection Forest, Murung Raya, Central Kalimantan, Indonesia with two locations (Sebangau and Tuanan Research Station) (Singleton et al. 2009)

Study site	Island Subspecies	Habitat mosaic	Study area size (ha)	Study duration (months)	Average home range (ha)	Adult female overlap	Daily path lengths - sexually active females
Bukit Batikap	B-*w*	Homogeneous	8000	18	304	At least 5	689
Sebangau	B-*w*	Homogeneous	900	24	250-330	4	769
Tuanan	B-*w*	Homogeneous	1100	24	250-300	4	1025

Note: *B-w Borneo, *P.p. wurmbii*. average home range in Bukit Batikap Protection Forest: *semi-wild* and rehabilitant

Vegetation analysis shows us a forest stratification image that orangutans may utilize. Food patches spread in the research area correlate positively with orangutan presence in vegetation plots. CCA show that existing vegetation structure results in an explained all variance of the correlation of 92.4% and en eigenvalue of 1.242, thus indicating that our hypothesis is correct, vegetation effects are apparent on reintroduced orangutans. In generally the standardized test scores and aptitude test a positive value on orangutan activity while using the space, vertically or horizontally to cover food sources. Although, not all reintroduced orangutans used vertical space to a tree's maximum height, horizontal occupancy is also important.

During the study, newly reintroduced orangutans preferred to occupy heights between 0-5 m, compared to wild orangutans. Orangutans spent time on the ground 1-48% of the time and rarely spent time at the maximum tree height. This is different compared to those that have been reintroduced for a long time, who spent their time at 16-20 m (15-37%). Orangutans reportedly spend time at those heights for comfort and to reduce fear (Rijksen 1978). Tree height choice for orangutans at 16-20 m is affected by food source presence, and the ability of orangutans use space at this height could be vital to their successful adaptation. The successful parameters for reintroduced orangutans are their ability to climb in the middle section of the canopy and spend time on the ground, and moving arboreally (Rodman and Mitani 1987; Ashbury et al. 2015). However, the use of space at heights of 16-20 m does not apply to male orangutans who spend more time on the ground because of their larger body size (Sinervo 1997). Such was the case for males Tarzan and Danur, who searched for rattan pith or insects (ants, termites) on the ground. Learning and understanding vertical space can be easily found in newly reintroduced orangutans, even though adult males (flanged males) or adult females will sometimes return to moving on the ground as a result of their flanged male. Wild adult male often travel long distance on the ground, ground use by rehabilitants occurred most frequently in the context of feeding and seems to result from human contact (Snaith 1999)

In addition to vertical space, the use of horizontal space is important to understand the movements of reintroduced orangutans in their new habitat. Day length range forms a home range, that is the influence of horizontal space. Horizontal space determined inseparable from the existence of a fruit abundance. Range areas also have an impact on social behavior, such as flanged male when long call as a determinant of territories as part of horizontal space utilize. Snaith (1999) reporting on daily ranging behavior also was effect by fruit availability was low, the subject was exploiting permanent resources, for which there is little competition and orangutans can more often to travel and feed together under these conditions. Knott et al. in Singleton et al. (2009) explain, population density may play an additional role in explaining variation density and patchy resources should increase of scramble competition for food, to which orangutans respond. Orangutans will also defend a certain habitat, for reasons such as potential food abundance reproduction, which is part of horizontal space utilize.

Observation shows that a number of waypoints of GPS and monitoring days do not correlate to the range area and reintroduced orangutan presence, as all reintroduced orangutans, *semi-wild* or rehabilitant were still trying to find their comfortable ranging area. Research also show that males are more difficult to find, and estimates of male orangutan range are not clear (Singleton et al. 2009; Atmoko et al. 2009). Male orangutans often leave research areas for an uncertain amount of time and go missing before returning, such as Tarzan and Danur (flanged males) who both went missing and returned. The reverse occurred with Heldy and Jojo who initially explored around the release point, but widened their range and went missing during monitoring. Heldy and Jojo (*semi-wild* subadult male) showed typical explorer orangutan behavior. Compared to Mogok (rehab-subadult male) who was a typical explorer, but stopped during his first-year post-reintroduction because of illness. Upon reintroduction, he limited his activities to around the release point. He subsequently went missing for two months before he returned to his original release point in an unhealthy condition and these factors explain his small home range.

We recorded on reintroduced orangutans in Bukit Batikap are minimum raging since they had not established a definite area at that point, especially males. Singleton et al. (2009) mention males have a bigger home range area compared to females. Furthermore, the factor that determines of food sources trees availability pattern also knowledge by raging of reintroduced orangutans. Ecological factors such as food tree presence and other spatial sources also effect home range, especially within females (Cowlishaw and Dunbar 2000). Overlapping home range may be caused by several factors such as habitat quality, food sources and female presence (Singleton and van Schaik 2001; Knott 1998). Competition may also happen when individuals were at the same time and location in overlapping areas in habitat. Each individual will find food source locations, recognizing food species and determining food as part of survival behavior in a forest (Grundmann et al. 2007). Survival behavior of reintroduced orangutans will be demonstrated independently depending on personal ability, even though inter-individual competition happens.

Comparison of horizontal spatial use on reintroduced orangutans have similarities with other research locations (Sebangau and Tuanan Research Station), with an average home range of 304 ha, overlapping females in one location found on at least five individuals with an adult female daily range of 689 m. The philopatric tendencies of female orangutans, at Tuanan a mother was seen to interfere when her maturing daughter was attacked by another adult female. This condition, females do not also need to increase their mean daily path length to switch between habitat patches. These switches can generally be made with journeys that do not exceed the normal day range. Usually, that females preferential association (controlling for home range overlap) and reproductive synchrony and were thought to consist of close relatives (Singleton et al. 2009).

The reintroduced orangutans in Bukit Batikap still learn to survive, even though they had some obstacles. There is learning builds on experience, and that increases with duration of forest life, that is supported by an ecological factor. Russon (2010) explain progress in adjusting to forest life can then indicate how quickly and how well rehabilitants adapt, how well they were rehabilitant, what competencies are difficult to acquire, and who copes best or suffers most. Orangutan ex-captives who readapt well to forest life may not abandon human ways; simply they become adept at both (Russon and Galdikas 1995; Snaith 1999). Consistent with learning, greater change has been found in the first year post release than the second in other reintroduced primates (Stoinski and Beck 2004).

In conclusion, vegetation effects are apparent on reintroduced orangutans with food patch utilize and space use. There are similarities for food patch and space use pattern. Vertical spaces used by earlier reintroduced orangutans were at the 16-20m height. Horizontal spatial use shows a positive value for orangutans to explore food source presence. Reintroduced orangutans did learning processes to save energy, as they did space use. Ranging area and the home range is a factor on how reintroduced orangutans survive in their habitat. Orangutan presence was concentrated around the camp during the study, indicating that they still felt comfortable around humans. In general, reintroduced orangutans (*semi-wild* and rehabilitants) showed similarities in adapting to their new habitat.

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