MEASURING AND PREDICTING SUCCESS OF ORANGUTAN REINTRODUCTION

FITRIAH BASALAMAH

GRADUATE SCHOOL
BOGOR AGRICULTURAL UNIVERSITY
BOGOR
2016
STATEMENT LETTER

I hereby declare that dissertation entitled *Measuring and Predicting Success of Orangutan Reintroduction* is original result of my own research supervised under advisory committee and has never submitted in any form at any institution before. All information from other authors cited here are mentioned in the text and listed in the reference at the end part of the dissertation.

Jakarta, July 2016

*Fitriah Basalamah*
Student ID G362100041
SUMMARY

FITRIAH BASALAMAH. Measuring and Predicting Success of Reintroduction Orangutans. Supervise by DYAH PERWITASARI, SRI SUCI UTAMI ATMOKO, IBNUL QAYIM, AND CAREL PVAN SCHAIK.

The genus *Pongo*, the orangutan, is the only Asian great apes. At present, two species are recognized; *Pongo abelii*, which are confined to the northern most parts of Sumatra, and *Pongo pygmaeus* on Borneo (Groves, 2001). Orangutans are under threat throughout their range from habitat destruction through logging, conversion of forest for plantation and mining land-uses, and from hunting either for meat or for the illegal pet-trade. Animals confiscated to enforce the law against the trade of orangutans, have to be reintroduced to suitable and protected areas following international guidelines (*Guidelines for Nonhuman Primate Re-Introduction of the IUCN/SSC Reintroduction Specialist Group*; Baker 2002). Successful reintroduction is the ultimate aim of rehabilitation process but in the past reintroduction practices have sometimes been sub-optimal. Therefore, even though it is a critical component of the law enforcement, relatively little is known about the success rate of past orangutan re-introduction (Russon 2009). Because ex-captive orangutans must adapt to forest life (Russon 2002), post-release-monitoring becomes an important tool to evaluate the reintroduction process. The Indonesian Orangutan Action Plan, which was launched by the president of Indonesia in December 2007, stated that The Orangutan Reintroduction Program will be closed in 2015 and all viable healthy ex-captive orangutans will be released due to course.

The studies making up this dissertation were conducted in Kehje Sewen Forest - East Kalimantan during one year beginning April 2012 and in Jantho Sumatran Orangutan Reintroduction Station, Aceh Province from April 2011 until December 2012. This monitoring allowed us to observe every step of their adjustment to the new environment and to evaluate the adequacy of the procedures of such re-introduction programs. I observed the forest skills (daily activities, diet pattern, height, nesting behavior, association, home range and food patch) of 16 ex-rehabilitant orangutans, estimated to be 4 – 13 years old. The observation showed that all individuals in both location survived their first year.

This dissertation is divided into six chapters: (1) background information on orangutan life history, ecology, threats and conservation related with this study (2) a literature review of reintroduction process on readjustment of forest skills (3) monitoring orangutan reintroduction : results of activity budget, diet composition, vertical use, nesting behavior and associations during the first year post-release in Kehje Sewen, East Kalimantan (4) preliminary result on ranging behavior orangutans reintroduced into Jantho Sumatran Orangutan Reintroduction Station – Aceh Province (5) general discussion; and (6) conclusions.
Based on observation in Kehje Sewen, ex-rehabilitant orangutans spent most of their time feeding and had a largely frugivorous diet, similar to comparable wild orangutans. They were able to build a nest, and often reused or rebuilt old nests. They also spent more time on the ground of their total activity time than their wild counterparts. Associations between male-female and female-female were almost similar on a distance of <50 meter over the entire period, and they spent only limited in close association (<10m).

The home ranges of ex-rehabilitant orangutans in Jantho ranged from 0.61 – 78 ha, with an average day journey length of 428-1280 meters. Individual home ranges overlapped, especially around the acclimatization cage (release point). The presence of the acclimatization cage, food provisioning and human oriented might have affected ex-rehabilitant orangutans ranging behavior. The influence of possible ecological resources on ex-rehabilitant orangutan ranging behavior was examined by assessing the number of woody tree (1.7 - 10.7 patch/km), Ficus (0 - 4.2 patch/km) and lianas (0.5 – 12.3 patch/km) that were consumed.

In general, this study aims to analyze and evaluate the release of orangutans by SOCP-YEL in Jantho Nature Reserve (Aceh Province) which is without forest school stage and by PT. RHOI in Kehje Sewen ecosystem restoration concessions forest (East Borneo), which does have such a forest school stage. In addition, the results contribute to optimizing the selection and release procedures, and almost certainly to optimize the preparation of animals for release. The animals’ adjustment to the new environment could be influenced by several factors, such as age, duration of stay in quarantine or acclimation cages as well as local ecology (i.e. phenology and overall productivity). One of the most important indicators for a successful reintroduction of an orangutan into a new habitat is their ability to build its own sleeping nest.

Key words: ex-rehabilitant orangutans, reintroduction, adjustment, daily activity, food patch, and home range.
RINGKASAN

FITRIAH BASALAMAH. Mengukur dan Memprediksikan Kesuksesan Reintroduksi Orangutan. Dibimbing oleh DYAH PERWITASARI-FARAJALLAH, SRI SUCI UTAMI ATMOKO, IBNUL QAYIM, AND CAREL PVAN SCHAIK.


Disertasi ini terdiri dari enam bab, yaitu: (1) latar belakang histori kehidupan orangutan, ekologi, ancaman, dan konservasi yang berkaitan dengan studi ini (2) sebuah kajian literatur dari proses reintroduksi dalam penyesuaian pada kehidupan liar (3) pengamatan aktivitas harian, diet, pemanfaatan ketinggian, bersarang dan asosiasi pada 6 eks-rehabilitan orangutan selama satu tahun dilepasliarakan di Kehje Sewen, Kalimantan Timur (4) hasil awal study pada penjelajahan 10 orangutan eks-rehabilitan di Stasiun Reintroduksi Orangutan Jantho Sumatera, Provinsi Aceh.
Berdasarkan pengamatan di Kehje Sewen, eks-rehabilitan orangutan menghabiskan banyak waktu harianya untuk aktivitas makan dan proporsi terbesarnya mengkonsumsi buah, serupa dengan proporsi orangutan liar. Eks-rehabilitan mampu membuat sarang baru, dan sering menggunakan sarang lama atau memperbaiki sarang yang lama sebelum digunakan kembali. Orangutan eks-rehabilitan juga banyak menghabiskan waktunya untuk beraktifitas di tanah disbanding dengan orangutan liar yang seusianya. Asosiasi antara jantan-betina dan betina-betina terlihat sering terjalin dan hampir sama pada jarak <50m disetiap periodnya, namun sedikit persentasenya pada jarak yang dekat (<10m).

*Home range* (daerah jelajah) dari orangutan eks-rehabilitan di Jantho berkisar antara 0.61 – 78 Ha, dengan rata-rata panjang jelajah harian 428-1280 meter. Daerah jelajah orangutan eks-rehabilitan tersebut terlihat saling tumpang tindih, terutama pada sekitar kandang aklimitasi (titik pelepasliaran). Keberadaan kandang aklimitasi dan pemberian pakan serta *human oriented* mungkin memengaruhi dalam perilaku penjelajahan individu-individu tersebut. Pengaruh sumber pakan pada daerah jelajah eks-rehabilitan orangutan terlihat dalam penggunaan pohon (1.7-10.7 patch/km), *Ficus* (0-4.2 patch/km) dan liana (0.5-12.3 patch/km) yang dikonsumsi sebagai pohon pakan.

Secara umum, penelitian ini bertujuan untuk menganalisa dan mengukur kesuksesan orangutan eks-rehabilitan yang dilepasliarkan di Jantho tanpa adanya tahapan sekolah hutan sebelum dilepasliarkan, dan di Kehje Sewen yang menggunakan tahapan sekolah hutan. Penelitian ini berkontribusi dalam prosedur seleksi yang optimal dan proses pelepasliaran orangutan eks-rehabilitan kembali ke habitatnya. Penyesuaian pada orangutan terhadap lingkungan yang baru dapat dipengaruhi beberapa factor, seperti umur, durasi keberadaan di karantina atau kandang aklimitasi juga ekologi lokalnya (phenology and produksi keseluruhan). Salah satu indicator penting untuk suksesnya reintroduksi ke habitat baru adalah kemampuan orangutan untuk membuat sarang tidurnya sendiri.

Kata kunci : orangutan eks-rehabilitan, reintroduksi, penyesuaian, aktivitas harian, *food patch* dan penjelajahan
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MEASURING AND PREDICTING SUCCESS OF ORANGUTAN REINTRODUCTION

FITRIAH BASALAMAH

Dissertation
Submitted in partial fulfillment of the requirements for
Doctoral Degree
in
Animal Bioscience Study Program of Graduate School of Bogor Agricultural University

GRADUATE SCHOOL
BOGOR AGRICULTURAL UNIVERSITY
BOGOR
2016
Examiners in the Close examination:

1. Dr. Entang Iskandar (Researcher, Primate Research Center, Bogor Agricultural University)
2. J. Sugardjito Ph.D (Director of Centre for Sustainable Energy and Resources Management (CSERM) - Universitas Nasional)

Examiners in the Open Doctorate Promotion:

1. Dr. Ir. Agus Priyono Kartono, MSi. (Staff of Ecology and Wildlife Management – Faculty of Forestry - Bogor Agricultural University)
2. J. Sugardjito Ph.D (Director of Centre for Sustainable Energy and Resources Management (CSERM) - Universitas Nasional)
ENDORSEMENT PAGE

Title: Measuring and Predicting Success of Orangutan Reintroduction
Name: Fitriah Basalamah
Student ID: G362100041
Major: Animal Biosciences

Endorsed by,
Supervisory Committee
Dr. Ir. R. R. Dyah Perwitasari, MSc.
Chair
Prof. Carel P van Schaik
Member
Dr. Sri Suci Utami Atmoko
Member
Dr. Ibnul Qayim
Member

Acknowledged by,
Chair of Study Program of Animal Biosciences
Dean of Graduate School,
Dr. Ir. R. R. Dyah Perwitasari, MSc.
Dr. Dahrul Syah, M.Sc.Agr.

Examination date: 18 July 2016
Graduation date: 18 Aug 2016
Open Doctorate Promotion date: 18 Aug 2016
ACKNOWLEDGEMENTS

I would like to thank full to dear lord Allah SWT for blessing and gift me to accomplish my field research in Jantho Sumatran Orangutan Re-introduction Station in Aceh Province and Kehje Sewen Forest - East Borneo and dissertation in IPB.

A great appreciation goes to the Rector of Bogor Agricultural University, IPB; the Dean Faculty of Mathematical and Natural Sciences and The Head of Departement of Biology (Dr. Iman Rusmana) for their permit.

This dissertation would not have been possible without the support of countless people and organizations. First, I would like to thank my supervisors: Dr. Ir. R. R. Dyah Perwitasari, Prof. Dr. Carel P. van Schaik, Dr. Sri Suci Utami Atmoko and Dr. Ibnul Qayim, for their guidance throughout this project. I especially thank to Prof. Dr. Carel P. van Schaik and Dr. Sri Suci Utami Atmoko for their advice and patience, and for pushing me in focusing and finishing the study and having supported me during my research in orangutan project.

I gratefully acknowledge Biology Faculty of Universitas Nasional, especially Dr. Tatang Mitrasetia MSi., Imran SL Tobing MSi., for opportunity given to me to execute this scholarship to continue my study and Anthropological Institute (AIM) of The University of Zurich, especially Prof. Dr. Carel P. van Schaik for his advice and numerous constructively critical comments on manuscript, I appreciative the guidance I have received from Dr. Maria A. van Noordwijk, who helped me to use the database, Dr. Tony Weingrill, Dr. Erik Willems, Dr. Michael Krützen, and Claudia Zebib who have supported and helped managed the administrations, analysis the data during stayed in Zurich and friendship over these many years. I thank to Swiss National Foundation for the grant supporting this study.

This study was conducted within the framework of memorandum of Understanding between UNAS, IPB and Anthropological Institute (AIM) of the Zurich of University. I thank the Sumatran Orangutan Conservation Programme (SOCP) – YEL and Borneo Orangutan Survival (BOS) Foundation and Restoration Habitat Orangutan Indonesia for permission to work in the Jantho Re-introduction Station, BKSDA in Banda Aceh and Kehje Sewen Release site.

I am most grateful to the director of SOCP, Dr. Ian Singleton, and the CEO of BOSF, Dr. Jamartin Sihite for giving me permission to do this project in their release site. I thank Dr. Muhammad Agil, who has helped me with the administration in IPB. I thank the SOCP teams, Dr. Matt Nowak, Mistar SSi, Asril MSi, Asriadi SHut, Mukhlisin SHut, Sugesti, drh. Yenny Saraswati, Ines Novitasari Saragih MSc, Nova, Nuzuar SHut, Ariesta SSi, Ayudi Yudai, Rio Ardie SHut, Udin, Mina, Ajir, Fikar, Samidan, Safrijal, Damson for all of their hard work at Jantho. Also RHOI-BOSF teams, Dr. Aldrianto Priadjati, Widodo, Maria Ulfa, drh. Gonda Nisam, Eko Prasetyo SSi, Sidahin Bangun SSi, Aschta Boestani-Tajudin MSc, drh. Agus Irwanto, Masino, Agus Sugianto, Imam Ghazali, Firman Abadi, Sugianto, Robi Sampel, Ahmad Supriadi, Rupiadi, Sudirman, Bambang, Sem Edri, Putri, Aliya, Izur, Syawal, Dycky, Hanafi, Deni, Awal, Agus for their good work and their help and support at Samboja Lestari Rehabilitation Center and Kehje Sewen Release Site. I thank my friends in FABION-UNAS, Arif Rifqy SSi, Didik Prasetyo MSi, Ike Nayasilana MSi, Rika
Safira SSi, Afifi Rahmadetiaassani SSi, Muhammad Khoir SSi, Diaz Puspitasari SSi, Cristian MSc, who helped in my project. I thank all those local people who helped me with surveying orangutan in Jantho. I thank my project collaborators at the IPB, drh. Taufiq Nugraha MSi. and Dr. Puji Rianti Hilbert MSi, for help and nice friendship during stay in Zurich.

I acknowledge valuable direction and advice to finalize this dissertation from the external examiners: Dr. Entang Iskandar; J. Sugardjito Ph.D and Dr. Ir. Agus Priyono Kartono, MSi.

I thank to my friends in Zurich University; Dr. Ellen Meulman, Lynda Dunkel, Laura Damerius, Dr. Esther Carlitz, Brigitte Spillmann, Dr. Maria Jedensjo, Dr. Caroline Schuppli, Michelle Schubiger for their warm friendship during my stay there. I also gratefully thank to my Indonesia families in Zurich, especially Nana Dafron family and Syarifa Hanoum, who let me stay in their nice house and a beautiful family, Agung Bondan family, and Bondaniah big family for kindness, help and wonderful togetherness and religious moments for almost during my stay in Zurich.

I am very grateful and own special thanks to my family, my mom Laties Hidayati, my father Zein Basalamah, my brother Abdul Rachman and family, my sister Zulhijjah and my husband Hendra Irawan, who have supported my studying. Without your understandable and support, my work would not have been accomplished. Also my little angle, Abrizhan Hafizh Alfarizhi who inspired me to finish my study.

Jakarta, July 2016

Fitriah Basalamah

Student ID G362100041
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1 GENERAL INTRODUCTION

Distribution and conservation status

Orangutans (*Pongo pygmaeus*) are members of the great apes (Family Pongidae) which includes gorillas (*Gorilla gorilla*), chimpanzees (*Pan troglodytes*), and bonobos (*Pan paniscus*) (Groves 2001). All great apes have larger bodies and larger brains than other primates, and are to some extent sexually dimorphic (Rowe 1996). Orangutans are usually solitary, but sometimes aggregate around large food sources (Rijksen, 1978) or during periods of high fruits abundance (Sugardjito et al. 1987; van Schaik 1999). Orangutans occur in two geographically isolated subpopulations on the islands of Borneo (*Pongo pygmaeus* spp.) and Sumatra (*Pongo abelii*) in Indonesia and Malaysia (e.g. Rijksen and Meijaard, 1999). There are 3 separate Bornean orangutans subspecies, *P.p.wurmbii* (Central Borneo), *P.p.pygmaeus* (West Borneo) and *P.p.morio* (East Borneo) (Figure 1). Sumatran orangutans have a more lightly colored face as well as longer, thicker, and also more lightly colored body hair than Borneo Orangutans (Courtenay et al. 1988). Adult male orangutan’s exhibit an extreme bimaturism, where two sexually mature and fertile morphs can be distinguished (Utami 2002).

![Figure 1 Map of release sites and distribution of wild orangutans (orange color) (Picture by Perry van Duijhooven)](image)

Orangutans are currently found on the islands of Sumatra and Borneo (Delgado & van Schaik 2000), and 90% of its habitats are part of the Republic of Indonesia (Rijksen & Meijaard 1999). But on Sumatra, now a day their range is restricted to the northern part of island. The remaining populations of orangutans are estimated around...
35000 individuals on Borneo (IUCN 2016) and around 14613 individuals on Sumatra (Wich et al. 2016). The Sumatran orangutan population has decreased by 85% over the past 100 years (van Schaik et al. 2001). Both the Sumatran and Bornean orangutan are now classified as critically endangered (Wich et al. 2016; https://news.mongabay.com/2016/07/bornean-orangutan-declared-critically-endangered-as-forest-shrink; http://www.iucnredlist.org/details/17975/0), although the Bornean orangutan, with a greater remaining habitat range, was previously thought to be less at risk of immediate extinction and was classified as endangered (IUCN 2006).

The natural habitat of orangutan, the tropical forests of Sumatra and Borneo, are declining as a result of human activities. The population decline is caused by poaching, habitat loss (forest conversion to plantations), habitat degradation (illegal logging) and habitat fragmentation (road building and transmigration projects) (Rijksen & Meijaard 1999; Delgado & van Schaik 2000; van Schaik et al. 2001). Each immature individual in illegal custody stands for at least one dead mother (Rijksen & Meijaard 1999). As an umbrella species for rainforest conservation, orangutans need to be well protected.

**Demography of orangutan**

Orangutans live in lowland dipterocarp forest, heath forest, peat swamp forest, alluvial plains, and mountain slopes (Delgado & van Schaik 2000), and have the greatest concentrations in altitudes between 200 and 400 meters (Rijksen and Meijaard 1999). Home range sizes vary from 65 ha to >850 ha for females and 500 ha to 4000 ha for males (Delgado & van Schaik 2000; Singleton & van Schaik 2001; Singleton et al. 2009). The males have larger range than females, and individual of both sexes have overlapping ranges (MacKinnon 1974; Delgado & van Schaik 2000; Singleton & van Schaik 2001; Singleton et al. 2009). Females tend to stay near the range they were born. They therefore inhabit ranges near or overlapping with those of their mothers (MacKinnon 1974; Rijksen 1978 and Singleton 2000; van Noordwijk et al. 2013).

Sumatran orangutans seem to use a higher altitudinal range, feed more on fruits (with a special preference for fruits with soft pulp, Djocosudharma & van Schaik 1992) and insects, while Bornean orangutans spend more time consuming low-quality foods like the cambium bark layer during low fruit availability. These periods of food scarcity have more serious impact on females than males (Knoot 1998; Delgado & van Schaik 2000; Fox et al. 2004). Orangutans also have high tolerance for bitter, toxic and unripe fruits (MacKinnon 1974).

It is implied that orangutan have solitary lives, as a result of competition for food resources, and also the costs of group living are too high for orangutans to live permanently even in small groups (MacKinnon 1974; Sugardjito et al. 1987; van Schaik & van Hooff 1996). Nevertheless, orangutans do occur occasionally in groups and may even form a travel band which will stay together for several days (MacKinnon 1974). Grouping in wild orangutan in Sumatra were associated particularly with giant strangling fig and were formed throughout the year (Sugardjito 1986). Female Sumatran orangutans are more gregarious than the mostly solitary Bornean orangutans, fitting the socio-ecological prediction that when food resources are more abundant or distributed in larger patches orangutans should become social (Delgado & van Schaik 2000). During short grouping time, adult females are usually accompanied by one or two
dependent offspring, independent sub adults, and adolescents (Rodman 1988). There is a marked level of aggression between fully adult males, with adult males exhibiting a level of tolerance for unflanged (sexually mature but not fully developed) males (Utami et al. 1997). Sumatran orangutans are considered to be more social than their relative on Borneo, as the proportions of time that Sumatran orangutans spend in parties is higher and the party size is larger (MacKinnon 1974; Delgado and van Schaik 2000).

Females reach sexual maturity at approximately 11 to 15 years in the wild but first birth often occurs several years later (van Noordwijk et al. 2009; Knoot et al. 2009). Wich et al. (2004) reports a mean inter-birth interval of 9.3 years at Ketambe-Sumatra, 8.2 years at Suaq Balimbing- Sumatra (Singleton & van Schaik 2002), 7.7 years at Borneo (Galdikas and Wood 1990), and 6.1 years at Kutai (Suzuki et al. 2009). Male orangutans are commonly fully sexually mature at the age of 14 (te Boekhorst et al. 1990), whether bimaturism represents an alternative reproductive strategy (Utami 2002).

**Threats**

The timber industry and palm oil plantation development are the main driving forces behind the destruction of the forest. Although orangutans exhibit high behavior and dietary flexibility that allows them to persist in secondary logged forest (Lackman-Ancrenaz et al. 2001), densities do decline following logging, particularly in the long term (Rijksen and Meijaard 1999; Meijaard et al. 2005). Deforestation and the illegal pet trade have produced many orphaned orangutans, which frequently end up in captivity or rehabilitation centers or translocated to new habitat. This provides an ecological and social environment drastically different from the original situation. Orangutans may be more seriously affected by removal of their mother than other primates because in the wild, immature orangutans interact almost exclusively with their mother. They improve their ecological skill by learning from their mother during the immature stage, and begin to travel and forage on their own during the juvenile stage (Jaeggi et al. 2010; van Noordwijk et al. 2013). Understanding how orangutan populations of the two species react and adapt to logging is becoming one of the major priorities for conserving the species at the landscape scale (Ancrenaz et al. 2010).

There are many variables to evaluate the success of individuals release to make them readjust their forest skills, in example it will increase forage effort, change in their diet, ranging pattern, party size (see chapter 1) (Chapman 1988; Brugiere et al. 2002). Great apes foraging situations suggest implications for the acquisition of their foraging skills. Technique for obtaining the most demanding foods may not be fully acquired until near adulthood (Schuppuli 2016). Russon (2006) explained that major development like altered nutrition needs, parenting and competition are likely to generate new learning needs, abilities and opportunities for foraging through to adulthood. Some of great apes foraging problems are extremely difficult, such as anti-predator defenses and food acquisition techniques, like food embedded matrices, predator ants, spines, toxins, or distasteful exudates. Techniques for obtaining difficult foods constitute organized and flexible sets of basic skills (Russon 1998). Generally, infants focus on the easiest foods or scrounge foods semi-prepared by their mothers;
young juveniles focus on weaning foods and adolescents may focus on food found beyond their natal range (Russon 2003).

Before being released, the subjects have stayed at the rehabilitation center for a variable amount of time. Rijksen has coined the term ecological rehabilitation to describe the process by which the animal because 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.

**Rehabilitation and reintroduction of orangutans**

According to the “IUCN Best Practice Guidline for the Reintroduction of Great Apes”, reintroductions are defined as an attempt to establish a species in an area which was once part of its historic range, but from which it has been extirpated or become extinct. Re-establishment is used to indicate that the reintroduction has been successful. Rehabilitation is defined as the process by which captive great apes are treated for medical and physical disabilities until they regain health, are helped to acquire natural social and ecological skills, and are weaned from human contact and dependence, such that they can survive independently in wild (Beck et al. 2007). Reintroductions are coming into increasing use (Kleiman 1989) as one of the most important conservation measures following fast depletion of natural habitats.

Rehabilitation and reintroduction of orangutans began in the 1960s when it was thought that the orangutan was nearly extinct in the wild (Harrison 1962). Several orangutan rehabilitation sites have been established but there has been little or no evaluation of the success of released animals (because of logistical and financial problems) (Yeager 2002). In 1995, the government issued a new decree regulating the practice of reintroduction, which declared that orangutans must be released into suitable habitat that is geographically isolated from population of wild orangutan, receives long-term protection, and is free of wild populations.

Rehabilitation involves providing former captive individuals the experience or training necessary to survive and reproduce successfully in the wild (Yeager 2002). In rehabilitation, orangutan rehabilitant or captives are being provisioned with food and cared for by humans. Rijksen & Meijaard (1999) mention that rehabilitant orangutan must be independent and should avoid contact with humans. They should acquire skills such as knowing the location and seasonal availability of edible plants, how to avoid the dangers, etc. As a solitary animal, each infant should be raised separately with one caretaker who would carry the infant almost full time for the first several years of life (mother-infant relationship) (Yeager 2002). The length of time spent in captivity, the time of separation from their mothers, the age and the mental state of the individual orangutan all influence this reintroduction process, and the success will be different for each individual. It has been suggested that orangutan between the age of 3 and 8 years with some earlier experience in the wild have a greater chance of survival after reintroduction, whereas infants and animal reaching sub-adulthood have poorer chances (Rijksen & Meijaard 1999). The acquisition of adult foraging strategies involves the development of processing techniques and social learning (Jaeggi et al. 2008, 2012). Because in the wild juvenile orangutans usually still accompany their mothers (Noordwijk et al. 2009), the quick development of adult-like foraging strategies of
reintroduced juveniles can be crucial for their survival, particularly in times of severe food scarcity.

Before being released, the subjects had stayed at the rehabilitation center for a variable amount of time. Rijksen has coined the 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 rehabilitations center has different steps (see Figure 5 for Tanjung Putting); some have a forest school or merely quarantine. Different rehabilitation sites will have different protocols for rehabilitating and reintroducing orangutans, but in general, the rehabilitation and reintroduction program can be divided into three parts:

1. Rehabilitation (confiscation)

   Illegally held orangutans that are confiscated will be brought to the rehabilitation center. Orangutans are given a full medical check upon arrival; they are treated for illnesses and undergo a quarantine before being introduced to other orangutans in group cages. Small transponders are inserted with a surgical procedure between their shoulder blades to track them with telemetry equipment after their release to monitor their progress. When orangutans are considered suitable for release by the managing veterinarian based on their health, behavior and potential to survive in the wild, these orangutans will be transported to the release site.

2. Reintroduction

   Based on the “IUCN Best Practice Guidline for the Reintroduction of Great Apes”, ex-captive mean held in captivity, such as in enclosures, private homes, or semi-wild environments, for a prolonged period after being rescued and put into rehabilitation centre. Captive stock can be wild-born or captive-born. Semi-wild individuals are rescued from the forest but for some reason cannot be released directly and are thus put into a rehabilitation center.

   Reintroduction can follow two distinct strategies, namely:

   a. Soft-release:

      After arrival at the release site, the orangutans will spend some time (1-30 days) in soft-release/habituation/acclimitization cages to habituate them to the location. During this time, they are feed with natural forest foods from the surrounding forest to familiarize them with the local food before they are fully released. The orangutans must be able to show at least some essential natural orangutan behavior including nest building and must be able to forage on forest foods before they are considered for release.

   b. Hard-release:

      The orangutans are fully released into their new habitats and they are no longer provisioned by humans. Released orangutans are monitored and followed to assess their foraging and climbing skills and thus their chance to survive in the wild. In the case of heavy injuries or sickness released individuals will be captured and treated, or even brought back to the rehabilitation center. There they will go again through rehabilitation and reintroduction.

      The soft release strategy should include the socialization and release in groups, the opportunity for orangutans to acquire necessary skills for their survival in the wild prior to release and post-release support (Baker 2002). The forest school stage during
rehabilitation process has positive affect for ex-rehabilitant candidates before released. Confiscated individuals must be tested for contagious diseases, medicated if necessary and collected in quarantine facilities, which are separated from the reintroduction area (stay for 30 days to 6 months before reintroduced) (Baker 2002). Orangutan rehabilitation centers in the past did not test orangutan for infectious disease nor establish their genetic origins. The centers released captive orangutan back into national park that contained viable wild orangutan populations. It was clear that orangutan rehabilitation needed to have standardized practice involving quarantine, disease testing, genetic screening, socialization process, and pre release behavior monitoring to determine release groups into forest that does not contain a wild population, supplementary deeding of released individuals, and post release monitoring (Reintroduction news 2001). At many rehabilitation sites (e.g. Sepilok, Bahorok and Tanjung Puting), individuals are released into appropriate habitat with several other individuals. Daily feedings are provided and young individuals are returned to cages at night to prevent predation (Yeager 2002).

As orangutans are generally solitary and wide-ranging, they are difficult to find; therefore no precise figures for success are available. However, all centres can cite examples of individuals which have readapted well to forest life and have been seen in healthy condition several months after leaving the area, include on fruits session and low. Several adult female rehabilitants have mated with adults male and in some instances produced offspring (Aveling 1982). Data from Kalimantan imply that reintroduction is successful in 20% to 50% of the released apes (Rijksen & Meijaard, 1999; Smits et al. 1995). If the first direct measure of success of reintroduction program is that reintroduced females give birth (IUCN 2006), this criterion is met because one of the orangutans at Kehje Sewen Forest, East Borneo has given birth.

Important factors for success are thought to include:

a. If the orangutan has passed infancy and had spent its early years in the wild before capture
b. If it has been neither too badly nor too well treated in captivity, so that full physical and mental health can be regained
c. If, dependent on the above, independence from human care is encouraged by a gradual but determined process
d. If the centre set-up encourages the animals to remain arboreal and away from the buildings
e. If a young animal can form a close relationship with another individual, and learn by imitation from more independent animals
f. If after quarantine and/or infancy, minimal contact is maintained with the centre person (who should themselves have regular medical checks), and contact with visitors is always prevented
g. If the centre and environments are isolated by natural barriers from human population and agricultural areas.

The survival rate of released orangutans can be used as an indicator for the success of the reintroduction program. Data generated so far showed that survival rates of released orangutans are 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 that 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 accidents, inadequate captive care or abuse, and different kind of diseases.

**Novelty of this study**

Reintroduction attempts in the past were poorly documented and their success rates were probably poor to moderate at best. Several releases have been implemented, but their results have not been adequately monitored, analyzed and evaluated. Previous studies of post-release monitoring focused more on detailed subject (culture, feeding technic etc.), and more short-term, and generally are conducted at only release site, making it impossible to compare the results with other sites. However, it should be noted, that it is very difficult to assess reintroduction success, because sometimes it is impossible to relocate released orangutans, especially since some of them may have moved into remote areas without any access.

It is important to help the conservation management in the form of new research based on post-release monitoring conducted. This is also recommended by the Directorate General of Forest Protection and Nature Conservation, Ministry of Forestry, which revised the Ministerial Decree No. 280 of 1995 on the Guideline of Orangutan Rehabilitation (*Pongo pygmaeus*) to become Ministerial Regulation on Orangutan Translocation, Rehabilitation and Reintroduction.

This research assessed the factors limiting the success of individuals that were reintroduced (ex-captives and one semi-wild individu) and in order to draw up guidelines for future efforts. Previous reintroduction efforts were not documented well enough to estimate success due to poor monitoring records (Kleiman *et al.* 2000; Goossens *et al.* 2002). Although orangutans are known to show high behavioral plasticity, this plasticity has never been examined in such conditions. The new elements of this study are:

a. Provide the result and analysis to allow us to predict the success of orangutan reintroduction
b. Provide the measuring procedure guidelines for evaluating the success of orangutan reintroduction
c. Spell out the implication for conservation management of orangutan

**Study aims**

This study is based on the National Strategy and Action Plan for Orangutan whose goal is the release of all captive by 2015 and the establishment of new population of reintroduced orangutan; and on the IUCN, which lists long term post release monitoring as one of the most important facets of a reintroduction program (Baker 2002). This study was part of a broader ongoing program.

This dissertation aims to study the behavioral ecology and demography of reintroduced orangutans; both rehabilitated ex-captive individuals ‘orangutans, in order to
assess their success rate at finding adequate food and the acquisition of general forest skills (navigation and nest building).

**Study outcome**

Behavioral data monitoring throughout the whole rehabilitation and reintroduction process is important to justify the risk during this process. With this information, the survival rate probability of released individuals can be predicted and recommendations to improve the management and rehabilitation center, which ultimately could improve the survival rate of released orangutans can be made.

In general, the results will support the orangutan conservation program and assist the implementation of the ministry of Forestry’s Regulation No.P53/Menhut-IV/2007 about the Indonesian National Orangutans Conservation Strategy and Action Plan 2007-2017.

**Frame work of study and the outline of dissertation**

This study was divided into six chapters: (1) focus on best time of orangutan life history, ecology, threats and conservation related with this study (2) a literature review of reintroduction process on readjustment of forest skills (3) monitoring orangutan reintroduction: results of activity budget, diet composition, vertical use, nesting behavior and associations during the first year post-release in Kehje Sewen, East Kalimantan (4) preliminary result on ranging behavior orangutans reintroduced into Jantho Sumatran Orangutan reintroduction Station – Aceh Province (5) general discussion (6) conclusion. A brief outline for the three main chapters is provided below on Figure 2.
Figure 2 Frame work of this study

General method

Study sites

According to Guidelines for Nonhuman Primate Reintroduction of the IUCN/SSC Reintroduction Specialist Group (Baker 2002), Sumatran Orangutan Conservation Programme (SOCP) contributes for the conservation of ape in the reintroduction of confiscated orangutans. Based on a survey in 2009, after evaluating several aspects when determining whether an area might be suitable for a potential reintroduction program, SOCP found the Jantho Nature area promising for orangutans’ reintroduction (Wich 2009). In 2011, the SOCP program, they released first group of orangutans (5 individuals) which I monitored. The study site is located in Nanggroe Aceh Darussalam–Sumatra, inside of Jantho Nature Reserve (05°08'15”- 05°16'45” LU dan 95°38'15”-95°44'30” BT) (Figure 1). The nature reserve covers 16.640ha of forest and grasslands (SK Menhut No. 184/Kpts-II/1984) and lies below 750m a.s.l. Outside of the Jantho Nature Reserve boundary, there is at least an additional 4000 ha of protected forest with a different status (protection forest) under 750m a.s.l., on the eastern side and a further 1400ha or more of forest (also protection forest) below 750m on the western side. The forest in the Jantho ranges from 100-1800 meters and consists of relatively flat areas with some steep slopes (48% of the area 15-40%). In the Jantho forest at least 40 species of orangutan food trees are found, for example species from the families Moraceae, Annonaceae, Lauraceae etc. (Wich 2009).

The second site at East Kalimantan managed by PT. RHOL-BOSF. The Borneo Orangutan Survival Foundation (BOSF) is an Indonesian charity whose efforts focus on the conservation, rescue, rehabilitation and reintroduction of Bornean orangutans (Pongo pygmaeus). To achieve their goals, the foundation is responsible for the ongoing management of two orangutan reintroduction programs, one in East Kalimantan, Samboja Lestari and one in Central Kalimantan, Nyaru Menteng. As at the beginning of 2012, these programs cared for approximately captive 850 orangutans focusing on the welfare, rehabilitation and reintroduction of wild-born rehabilitated orangutans to secure natural forest.

The reintroduction area is the ecosystem restoration forest concession (IUPHHK-RE) – Ex-Mugitriman (Kehje Sewen Forest). The study site located in East Borneo (1°6’36” LU - 1°40’48” LU; 116°1’12” BT - 116°28’12” BT) (Figure 1) and roughly 86,450 Ha in size, inside the ex-logging concession (HPH) of PT. Mugitriman Intercontinental located in the District of Muara Wahau, Regency of East Kutai, East Kalimantan, ±500 km from Samarinda City (http://www.theforestforever.com/project/read/rhoi-i-kalimantan-timur).

The Mugitriman forest has been disturbed by logging activity, but a survey in 2008 found there are still 482 tree species, 229 birds, 53 mammals, 24 amphibians and 15 reptiles’ species. There is still a high abundance of orangutan food species (at least 104 trees species, 13 liana species, 22 rattan species (Yayasan Penyelamatan Orangutan Borneo 2008).

Objects of the study
The objects of study are ex-rehabilitant orangutans, which will be reintroduced into Jantho Nature Reserve and Kehje Sewen Forest. There are have difference skema of rehabilitation process as well as the reintroduction method. Before being released, all individuals were implanted with a micro-chip under the skin on the nape of their neck. In Kehje Sewen, followed 6 Bornean orangutans (P. p. morio) between 8 to 13yo, who were released in early 2012 (see chapter 3). In Jantho, I followed 10 Sumatran orangutans (Pongo abelii): 3 juvenile females, 1 adolescent female, 1 sub adult male and 5 juvenile males (see chapter 4).

Behavioral observations

To assess their readjustment to forest life, I followed the animals that could be located using focal animal sampling and compared the results with wild populations (see grey bar on result figure 4 on chapter 3). Individuals were followed for 12 months post-release using focal animal sampling (Altmann 1974). Upon finding an animal, they were followed all day. During the first three months, individuals were followed whenever encountered. After that, they were not followed for more than 6 days per month, to reduce human impact. However, not all individuals could be followed each month. Over 3218 hours of total daily active time were collected from April 2012 to April 2013 (with between 0 - 14 follow days per month).

Data were recorded using a standardized set of method (http://www.aim.uzh.ch/Research/orangutannetwork/FieldGuidelines.html), which includes instantaneous scans every 2 minutes of activity, food item, and height. Activities included feeding, moving, resting, and others (incl. nesting, socializing, playing). Whenever feeding occurred, we recorded the food item consumed: fruit, leafy material (included stem and pith), cambium/bark, invertebrates (ants, termites, and bees), flowers, and others (human/trash food, water, soil). All behavior was registered after having engaged in the activity for at least ten seconds. Height was scored as follows: 0 m (on the ground with at least one foot); <5 meters: between 0 and 5 m high; and >5 meters. Additionally, to a list of monitored data, fruits that were eaten for a minimum of 10 minutes were collected and photographed with local names and identifiable scientific names.

Social behavior and other remarkable events were recorded continuously. Nest building was a special focus. I recorded whether individuals built new nests from scratch, rebuilt existing nests, or simply used existing nests without modifications.

For mapping, individuals were followed for 6-12 months post-release using focal animal sampling and nest-to-nest follows (Altmann 1974). Upon finding an animal, they were followed all day until they built their evening nest. The following day, start the follow after they wake up and leave their (morning) nest. I examined data on movements during focal follows of April 2011 to December 2012. The active day length differed considerably (7-13 hours). Every 15 minutes, I recorded the geographic position of the focal subject by GPS (Garmin 78s) and position of each food patches they were seen eating from, as well as the food item consumed. I distinguished between fruits, figs, leaves and others (epiphytes, soil, insect, flowers etc.). Generally, I divided these into 3 major food types; woody tree, figs or lianas.

Based on problems reintroduction program in the past, Kelle et al. (2013) were the first to intensify post release monitoring effort by radio-tagging (transmitter)
individuals and checking them more regularly after release to assess reproductive status and offspring survival. Instead of using radio tagging this study used chips which were implanted under the skin in their neck and could be checked by radio transmitter.

To conduct and get good data on these studies, I needed more people to follow orangutans during the day. These people were trained, and practiced the data protocol for data collection, so as to standardize data collection and so maximize the comparability of the data.
2 ORANGUTAN REINTRODUCTION: HISTORY AND PROCEDURES

Orangutan’s life

Orangutans are arboreal, spending their time in the middle canopy (Rodman 1977) and they are solitary animal (MacKinnon 1974, Rodman 1979). Adult males occupy large territories which encompass the ranges of several adult females. Female offspring settle nearby, establishing a range which overlaps that of their mother, while males disperse from their natal range into a new large area (Singleton 2000). There are likely to be differences in ranging behavior and home range overlap according to food availability, physiological status, and the presence of dependent young, population density, and floristic composition of the forest, topography and degree of disturbance by factors such as logging, hunting, habitat fragmentation, and fire.

The social and ecological skills necessary for adult life in the wild is provided by the mother (Horr 1977; Yeager 1997). Since birth until 2.5 yo orangutans are completely dependent on their mothers. The infants sucked but show interest in food eaten by their mothers and sometimes reached out to take pieces from them. By the second year infants are becoming increasingly adventurous, exploring further from the mother, finding more of their own food, and begin to travel on their own (MacKinnon 1974). During the juvenile phase they are independent in feeding and travelling but still accompany their mothers and sleep in the same nests.

History of reintroduction

Rehabilitation developed as a consequence of law enforcement initiatives and aimed to return confiscated animals to the forest to boost the declining wild populations. Law enforcement involved confiscation of captive orangutans, most of which were infants. Immature orangutans are normally directly dependent on their mothers for up to six years, and confiscated individuals often develop adverse psychological and behavioural traits associated with captivity. Consequently, housing and group socialization of confiscated individuals at rehabilitation centres for varying periods of time prior to release, as well as prerelease exposure to forest habitat, were considered essential for these individuals to acquire the mental and behavioral skills necessary for survival in their natural habitat.

Reintroduction is an attempt to return species to parts of their historical ranges where they were extirpated, and might involve release of either captive-bred or wild-caught individuals. More recently, translocation for the purpose of re-establishing endangered animals into their native habitat has become an increasingly popular conservation technique (MacKinnon and MacKinnon 1991; Kleiman 1989). The IUCN (International Union for the Conservation of Nature and Natural Resources, also known as the World Conservation Union) (2007) defines translocation as a deliberate and mediated movement of wild individuals or populations from one part of their range to another and a reintroduction an attempt to establish a species in an area which was once a part of its previous historical range. It is important to note that the IUCN definition of a reintroduction makes no mention of the origin (i.e. wild-caught or captive-born) of the
Reintroduction has been seen as a valuable tool for conservation with the potential to save many species from extinction (Kleiman 1989; MacKinnon and MacKinnon 1991; Sarrazin and Barbault 1996). Reviews have found that translocations and reintroductions of endangered species for conservation purposes have average success rates ranging from 11% to 53% (Beck et al. 1993; Fischer and Lindenmayer 2000; Wolf et al. 1996), which suggests that the use of translocations and reintroductions as a conservation tool needs to be further investigated and improved upon in order to ensure that they are viable options.

It was therefore seen as an acceptable solution to rehabilitate and “return” orangutans to these forests. However, it soon became clear that the majority were in fact captured during forest destruction and conversion (e.g. in logging concessions, during conversion for plantations etc) and that releasing confiscated animals into protected areas, where the existing “healthy” populations were struggling to survive, was actually an additional threat to these already threatened and vulnerable populations. Not only did it increase competition for the food resources in the forest, but it also ran the risk of introducing diseases picked up by ex-pet orangutans in captivity, to the wild population (Wich 2009) and animals in captivity often show a loss of natural behaviours. Other considerations include captive-born animals’ lack of immunity to viruses/diseases prevalent in their wild counterparts (Bush 1993; Cunningham 1996; Woodford and Rossiter 1994).

Orangutan reintroduction has had a long history starting in 1963 in Sarawak and since then several sites on Sumatra and Borneo (Russon 2009). Tanjung Puting and Baharok Rehabilitation Centers continued function from 1973 until 1995, when new government legislation forbade the release of rehabilitated orangutans into habitat containing existing wild populations. In 1978, rehabilitation of orangutans at Ketambe was discontinued due to concerns that rehabilitated orangutans had transmitted respiratory diseases, acquired from humans to wild orangutans. But there are no publications regarding releases and outcomes from these rehabilitation centers (Yeager 1997; Rijksen and Meijaard 1999). Several releases and translocations have been implemented in the past, but their results have not been adequately monitored, analyzed and evaluated. As a result, researcher is still facing many issues that complicate orangutan rehabilitation and reintroduction program (FORINA 2013).

As a result of these factors, further reintroduction of confiscated orangutans into forests containing wild populations became unacceptable, and was eventually prohibited in 1995 by a Ministerial decree (SK Menhut 280/1995), which also set out other requirements to be met by orangutan reintroduction and rehabilitation projects. Internationally, the World Conservation Union (IUCN) guidelines for the reintroduction of great apes suggest several factors that should be considered for the selection of a potential reintroduction site (Beck et al. 2007).

The success of a reintroduction can only be measured in terms of its goals and objectives. An obvious measure for initial reintroduction success is post-release survival and reproduction. However, a key question is how to achieve this. Thus, longer-term reintroduction success is best optimized through measures of providing useful results for influencing reintroduction management decision-making concerning a reintroduction programmed of a long-lived and slow reproducing Gorilla gorilla (King et al. 2012).
The main biological and ecological factors contributing to reintroduction outcome can be summarized as follows: habitat suitability, long-term food availability, the season of release, type of release (soft or hard) and the source (wild-caught or captive-born) of released animals. Researchers are interested in how the source of animals (i.e. whether they were obtained wild-caught from a sustaining wild population or from captive breeding stocks) might affect the success of a reintroduction project. In most cases of translocating game species, the stock comes from a stable wild population. However, reintroduction projects for the purpose of conservation are carried out because wild populations are declining; thus, founder stock are increasingly being sourced from captive populations (Wilson and Stanley Price, 1994).

One of these unresolved issues is the lack of legal technical guidelines and standardization for orangutan translocation, rehabilitation, reintroduction and post-release monitoring. Through the national meeting in 2011 (Monitoring and Evaluation of Orangutan Indonesia Conservation Strategies and Action Plan 2007-2017), researchers recommended to the Directorate General of Forest Protection and Nature Conservation, Ministry of Forestry, that they revise the Ministerial Decree No. 280 of 1995 on the Guideline of Orangutan Rehabilitation (Pongo pygmaeus) to become Ministerial Regulation on Orangutan Translocation, Rehabilitation and Reintroduction, and researchers consistently supported and helped the institution in the process of the revision. However, the revision process has not yet been completed. Researchers must collectively provide the major inputs to the improvement of these practical guidelines. To achieve this important goal, we need to thoroughly evaluate the current releases. Each currently active reintroduction programs wants to maximize their success (long-term survival and reproduction). Achieving this goal requires those researchers are able to explain why some individual fail and others succeed, and thus what properties of animals and what kinds of preparation measures maximizes their chances of success. No one properly monitored. This needs to be done and I will develop the procedure to do so.

Reintroduction in the past

Based on review literature by Fisher & Lindenmayer (2000), of 116 reintroduction from all species categories (mammals, birds and others), 30 (26%) were classified as successful, 31 (27%) were classified as failures, 55 (47%) was classified as unknown. They analysis of case studies showed there were three primary aims of animal relocations. These were (1) to solve human-animal conflicts, (2) to supplement game populations, and (3) conservation.

In the first orangutans rehabilitation center was in 1961 at Sarawak Malaysian Baklo National Park. In 1964 in Sabah, Sepilok Forest Reserve started with small scale experiment (de Silva 1968). Then, in 1971 started the rehabilitation center in Indonesia, Tanjung Puting National Park, Central Borneo), there are contains a wild population of orangutans. In 1971, the first rehabilitation center in Sumatera was set up in Gunung Leuser Reserve. In 1973, The Bahorok Rehabilitation Center was started too (see table 1 below).
<table>
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### Sumatra

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<td>FZS-SOCP/YEL</td>
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<tr>
<td><strong>Batu Mbelin</strong></td>
<td>Jantho Nature Reserve*</td>
<td>2011-present</td>
<td>No</td>
<td>Daily</td>
<td>No</td>
<td>SOCP-YEL</td>
</tr>
</tbody>
</table>

*Study site
The problem rehabilitation center were confronted with was confiscating orangutans. The next step is the rehabilitation itself, the complexity of factor that influence the success of rehabilitation including how many years an orangutan spent in the wild before capture, how badly it was treated in captivity. The risk of transmitting a disease between rehabilitant and wild orangutans was recognized in the rehabilitation center Ketambe Gunung Leuser Reserve in 1979 (Rijksen 1978). Based on this case, Rijksen (1978) concluded that rehabilitants should no longer be released in an area containing a wild orangutan population, but should instead be released in areas outside the present range of orangutans but with suitable habitat and far away from human population, hunting or habitat disturbances (MacKinnon 1974). Social stress can occur in wild orangutan population by introducing rehabilitated orangutans into an area with wild population. At Ketambe rehabilitation center (1970-1974), 31 orangutans were brought in, of which 13 died (Rijksen 1978) and only 2 (a female and a male) orangutans were observed to be accepted in the wild population (Rijksen 1978). Sepilok (1964-1969) received 41 orangutans, of which 10 died (de Silva 1971) and one female gave birth twice after mating with a wild male (MacKinnon 1977). From 1972-1980, Bahorok released 25 rehabilitated orangutans but none the orangutans were followed after release. 12 rehabilitant adult females in Tanjung Puting mated with adult males from the local wild population (Galdikas 1981).

The Wanariset Orangutan Reintroduction Project used a new method based on idea of H.D. Rijksen. The differences between the traditional approach and the new approach were:

Table 2 The difference of reintroduction strategies between traditional and new approach

<table>
<thead>
<tr>
<th>Variables</th>
<th>New</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarantine and medical care and complete record keeping.</td>
<td>Intensive medical screening and (after) care, including complete record keeping</td>
<td>Poor</td>
</tr>
<tr>
<td>Medical care for personnel involved</td>
<td>Yes</td>
<td>Poor</td>
</tr>
<tr>
<td>Contact between handlers and orangutans</td>
<td>Minimal contact</td>
<td>Yes</td>
</tr>
<tr>
<td>Quarantine cages are part of the forest release site</td>
<td>Formal quarantine facilities complete separated from the release sites in the forest</td>
<td>Yes</td>
</tr>
<tr>
<td>Release the rehabilitants into an wild orangutan population</td>
<td>No and areas which have geographical boundaries</td>
<td>Yes</td>
</tr>
<tr>
<td>Release rehabilitants into an area without assessing the carrying capacity</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Release of animal</td>
<td>Socialized groups</td>
<td>One by one</td>
</tr>
<tr>
<td>Tourism contact possible in the release area</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Orangutans from the Wanariset Project were released into the Sungai Wain Protected Forest, a lowland mixed dipterocarp rain forest with extensive swamp areas. 61 orangutans have been released in period 1992-1997, in 5 release groups, each on a different release site.

The Wanariset Orangutan Project had three stages: quarantine (one month for isolation cages, during this stage they are given a complete physical and medical examination), socialization (min. six months, with two sub-socialization cages, separate by age less than two years, between two and four years old, and older than three years on two big socialization cages) and release (Peters 1995). The Samboja Lestari rehabilitation center used the following steps:

- a. If individuals were still infants when confiscated (in this study, Mail), they were first placed in a nursery.
- b. If they were more than 3 years old and independent (in this study: Lessan, Cassey, Berlian, Hamzah and Abbie), they would be placed into an individual quarantine cage for up to 2 months.
- c. Subsequently, they were moved to forest school level 1 (Mail), which involves taking orangutans into the forest and engage them in forest both subsistence and social activities. There, they would be fed once daily and provided with solid food twice a day, but still slept in cages.
- d. If individuals were older than 5 years and were competent in building and using tree nests, they were moved to forest school level 2 (in this study: Lessan and Berlian), where they were expected to feed on natural food, and build nests, but were still provisioned with food and milk once per day.
- e. Individuals that were difficult to handle (in this study: Cassey, Hamzah, Abbie) were transferred to a half-way house or an island in a river, where they were not handled but received food (Mail joined them to island straight from forest school level 1).
- f. Finally, all individuals judged ready for release were transferred to forest school level 3 in preparation for release in Kehje Sewen Forest, a 53 ha forest area in which they could roam freely for 4 months and get used to forest life while still being provisioned.

Rehabilitation stages between sites are difference. Here, for instance, are the rehabilitation stages at Tanjung Puting (Figure 3):

```
Ex-captive Orangutans (Quarantine)  
(Problems identification)  

General Check-up/Isolation cage  

Release  

Post-release (monitoring daily activity, ranging, diets etc.) with provisioning (milk and fruits at platform)  
```

Figure 3 Rehabilitation stage at Camp Leakey, Tanjung Puting National Park - Central Kalimantan (Galdikas & Ashbury 2012)
Success of reintroduction in the past

One of the success indicator of reintroduction program was the ex-rehabilitant giving birth in the release site. Infant mortality rates have been reported to be higher for rehabilitants’ offspring (30-57%; Yeager 1997; Kuze et al. 2008) in Borneo than for wild orangutans’ offspring in Sumatra (7-17%; Wich et al. 2004; van Schaik Noordwijk and van Schaik 2005). The rate of mortality depends on the availability of forest production, human contact and food provisioning on release sites (Kuze et al. 2012). Wild Sumatran orangutans live in areas with higher and more consistent energy availability, so they continue to prioritize maintenance over reproduction when energy availability increases (Knott 2001).

Kelle et al. (2013) analyses indicated that a lack of information about released orangutans prevented accurate evaluation of the effectiveness of reintroduction procedures. The success of reintroductions, and predictions concerning the viability status of the resulting populations, remain vague (Russon 2009; Yeager 1997), because data concerning the fate of most of the released orangutans are lacking owing to insufficient post-release monitoring (Russon 2009). Once released, an orangutan is rarely seen again. Further releases can support population establishment by adding to the number of reproductive individuals. Releasing many apes within a short period of time or releasing few apes over a long period of time did not substantially influence viability in this simulation study.

158 individuals ex-rehabilitants in Reintroduction Orangutan Sumatra Station-Jambi have been released, 79 individuals had identified as 35% successful and living independent and 15% identified on failed. The remained 50% others were lost contact and no data (Siregar 2015).

Procedure for measuring adjustment

The variables measured on each released individual are monitored over time, to track its development following release and examine the extent to which they approach toward stable values (Figure 4). This approach yields two main pieces of information: (i) the change over time, and the degree to which consecutive monthly samples show stabilized values; and (ii) the extent to which these stabilized values have settled within the range of known orangutan populations (good compilations are available in Wich et al. 2009). The presence of stabilization (curves a and b) suggests, although it does not prove, adjustment to local conditions, especially if accompanied by other indicators considered below, such as physical condition and continued survival.

If values stabilize outside the known range for wild orangutans (the ‘green zone’, despite broad similarity in ecology, this could point to lack of habitat suitability of the release site, especially if other indicators suggest adjustment (e.g. stable values for translocated animals, accompanied by poor physical condition). Otherwise, it could indicate the presence of unusual ecological features in the release area. This possibility would be favored if many released animals stabilize on values outside the known range and they seem to be in good physical condition.
The basic procedure of documenting post-release progress toward local adjustment. Curve a depicts individuals stabilizing around values within the range of the values observed in wild populations, whereas curve b shows those who stabilize outside the known range. In case b, this may indicate that the habitat is not suitable for orangutans, if there are also other signs of adjustment (stabilization) but suboptimal physical condition or survival.

In general, the expect ex-rehabilitants will find it more difficult to adjust to forest conditions, and thus stabilize more slowly and to reach the known range of wild populations later than the translocated animals. This expectation is based on the findings of comparative studies that revealed that translocated animals are much more likely to survive than animals that were born and raised in captivity (Griffith et al. 1989; Fischer & Lindenmayer 2000).

Finally, it should be mentioned that the fact that the releases are “soft” will not affect the validity of the efforts to measure success, because such interventions indicate that adjustment has not been reached, and our main question is to estimate when adjustment has been reached for each of the relevant variables. One would simply expect that in soft releases would need more time to reach the green zone.

Variables measured
The post-release monitoring has three main components, but in this study focus on first and second components. The first component is to follow the animals upon release and study the changes in their behavioral ecology, with respect to:
1. Range use (movement patterns, habitat choice, stability of range over time, size of home range, possible seasonal movements).
2. Vertical distribution, including height of nest (in particular time spent near or on the ground).
3. Diet (number of species and food items taken, use of extractive resources, such as termites, mean feeding time per patch etc.).
4. Nest building (rates of constructing new nests and of reusing old nests, complexity, presence of day nests).
5. Activity budget (time spent traveling, feeding and resting).
The second component is to assess their social relationships with others, as follows:

1. Time spent in association relative to home range overlap and identity of partners, nature of social interactions (social play, feeding tolerance, sexual, agonism, one-sided following, etc.), especially degree of avoidance of contact with others.
2. Home range overlap, i.e. degree of spreading out over the landscape, relative to habitat quality.

These measures of behavioral ecology and social relationships will can be assessed against time, as in Figure 4, to estimate the extent of adjustment. In addition, researchers should continuously log data for each individual’s reliance on supplementary feeding by humans, and interactions with humans, be they caretakers or followers. This allows the study to assess the individual’s independence.

Monitoring this over time will allow researchers to assess the changes in all variables of behavioral ecology and social interactions not merely as a function of time since release but also of independence. Use of this independence measure requires that the reintroduction projects’ criteria for supplementary feeding will have to be uniform across different release sites.

The third component is the study of condition, survival and reproductive success. For females, this is relatively straightforward, since one would expect them to move away less far from the release site, allowing them to be re-contacted with relative ease and on a regular basis, and since it is easy to assess their reproductive state. For males, it may be more difficult to re-locate them after release, and their reproductive success will have to be established through genetic paternity analysis (although there may not be a great need for this, unless one is worried that paternity is unduly concentrated into a few males).

The physical condition of released individuals can be monitored using non-invasive measures obtained from urine and feces, and will include C-peptide levels, the presence of ketone bodies (short-term and long-term indicators of energy balance, respectively) and cortisol levels (to estimate stress levels). One would expect the same pattern in the changes in these measures with time as in Figures 4, thus also expecting a difference between ex-rehabilitants and translocated individuals. For a subset of animals, researchers should also consider possible changes due to changes in dominance or reproductive status.

For survival and reproductive success, one needs much longer time-scales than the adjustment time scale, in the order of several years. This therefore requires post-release monitoring over longer periods. Successful reintroduction will be defined as survival for at least 2 years post-release. If sample size allows, one could also do a survival analysis using the major variables recognized as affecting adjustment as possible grouping factors.

Selection of study areas

Several areas are available, and at least some data must be collected in each of them. However, for intensive study of the post-release adjustment, a release area must meet the following criteria, in order of descending priority:

1. The presence of animals with functioning radio transmitters. This is a sine qua non for a successful study.
2. A relatively short period since release (< 1 year), making it likely that one captures the adjustment process.
3. The availability of systematic pre-release information (see below) on the individuals, allowing for easier prediction of post-release success.
4. The presence of ex-rehabilitant individuals, which makes it possible to distinguish between lack of adjustment and unsuitable habitat.
5. The presence of previously released animals that could serve as a second benchmark for the new releases (in addition to the wild populations elsewhere).

Data analysis

In order to limit the number of statistical analyses that need to be done, they will be guided by the expectations generated in the previous sections. Specifically, I predict greater success for the first group in the following contrasts, in the expected order of effect size (although several contrasts may reflect the same effect):

a. Between individuals of ex-rehabilitants orangutan
b. Animals that spent less time in captivity versus those that spent longer in captivity
c. Animals that are less human-oriented versus those that prefer the company of humans
d. Animals that build nests and spend more time away from the ground versus those that don’t build nests and spend much time on the ground
e. Animals that avoid novel (strange) objects versus those that are neophobic
f. Animals that approach novel foods versus those that avoid novel foods
g. Animals that have great climbing skills versus those with poorer skills
h. Animals of immature age (6-12) versus younger and older ones
i. Animals captured as older infants or juveniles versus those captured as small infants

These predictors of success will be identified using multivariate statistical models. Because many uncontrolled variables are involved, one should consider using Generalized Linear Mixed Models (GLMMs, Faraway 2006), which will allow researchers to test the influence of multiple independent variables, which may be categorical or continuous, on a single categorical or continuous dependent or response variable. I will try to limit the number of both dependent and independent variables by examining their correlation structure before hand, and if necessary conducting a PCA (principal component analysis) to infer a new composite variable that reflects a putative causal influence. For instance, one might expect that time in captivity, age at capture, and various other behavioral variables will be highly correlated and can be summarized in a single principal component. The basic dependent variables are degree of adjustment, physical condition or survival. Degree of adjustment is either the slope of change (as in Figure 4), the time to reach the stable zone or the time to reach the expected zone, depending on which is more appropriate.

Finally, this procedure also allows researcher to control for random effects, such as identity of the site, year, etc. It is important to include the results of multiple sites, and thus release programs, in the analysis because only then will we be able to make sure the results are valid for orangutans in general.
Although there will be much uncontrolled variation (e.g. in details of release procedures, time spent in captivity, age of released animals, etc.), one should nonetheless expect that only a few variables will turn out to be largely responsible for the variation in adjustment and survival. Moreover, because one can combine the results from more reintroduction projects, in the form of a meta-analysis, the conclusions as to the causes of success should become firmer. It is important to point out, however, that these analyses can only be done after the results for a variety of sites have come in. They will therefore be outside the scope of my dissertation.

There will be two kinds of cases, those where researcher have been able to collect pre-release information ourselves in a standardized way, and those where our observations had to start post-release. In this dissertation, I evaluate the steps in the reintroduction process of 16 rehabilitants by monitoring how the individuals coped with forest life during their adaptation phase. I investigated their activity budgets, diet composition and nesting behavior.

Methodological issues

IOR (inter-observer reliability)

Almost everyone engaged in research recognizes the need for reliable measuring instruments. A reliable instrument is one with small errors of measurement, one that shows stability, consistency and depend-ability of scores for individuals on the trait, characteristic or behavior being assessed.

Mitchell (1979) explains that three coefficients that purport to reflect the quality of data collected in these observational studies are discussed: the inter-observer agreement percentage, the reliability coefficient and the generalizability coefficient. Researchers watching the same behavior at the same time will record the same data. These coefficients are offered as the reliability of the instrument being used. In very homogenous groups, observer agreement percentages are necessarily quite high because all scores given to all subjects a very close together.

The credence accorded estimates of inter-observer agreement. The behavioral measures cannot rely on the consistency with which observations are made based on the assessment device itself, given uniform conditions of administration. Conditions of observation require demonstration that behaviors are consistently recorded separately in each project. The well known concern for consistency and accuracy of observations is expressed in the notion of reliability in applied behavior analysis (Kazdin 1977). If two observers consistently show relatively high agreement, it is assumed that the observations reflect the subject’s performance relatively accurately (Johnson and Bolstad 1973).

Knowledge of reliability assessment and identity of reliability assessor affects inter-observer agreement. Awareness of assessing agreement as a source of bias. The problem of observer awareness stems partially from conducting reliability checks under different condition from those typically used to obtain the data.

Radio Transmitter

In chimpanzees rehabilitants successfully use radio collars (Goossens et al. 2005) but it is too dangerous for orangutans an arboreal animal, as the collars could
get stuck in vegetation and the animals might hang them selves. The ideal solution would be to use a chip that can send out a signal to satellites and can be detected by frequency using a transmitter. This is a new tool to help find the individual with greater ease; researchers must not forget that orangutans range widely in roadless habitats, especially males.

Subspecies of individuals

In the past, introducing a species within the known historic range of it genus, would be regarded as a conservation introduction if it were the only option to save the species/subspecies. The release site should not allow contact with another species or subspecies of the same genus. However, based on recommendation from the orangutan scientists and conservation practitioners assembled at a Symposium on Great Ape Reintroduction (IPS Conggres 2014), rehabilitant orangutans should not obligatorily be repatriated to different locations within Borneo, based on their genetic makeup.

Major threat habitat loss

Challenge to find suitable release areas but orangutan can live in a wide variety of forest habitats. Surveys have established the potential suitability of the release areas, even thought at present no one really knows exactly what determines the suitability of an area for orangutans. In this study, we worked in sites that had been identified through surveys as potentially suitable.

Time

Orangutans are primarily frugivorous (MacKinnon 1974; Rijksen 1978), and Sumatran orangutans consume predominantly fruits throughout the year (Morrogh-Bernard et al. 2009; Wich et al. 2006). Timing of the release may be as important as the selection of release site itself. Studies of seasonality of climate and vegetation of the proposed release site, including seasonal availability of water and foods (phenology studies), should ideally be conducted prior to the release. When releasing the orangutans, it is important to know the period of fruit season to provide the animals with the opportunity to acquire minimal knowledge of the local conditions before having to deal with serious food scacity.

Learning or exploration

Most orangutans are rescued when they are still infants, after being captured from the wild by killing their mothers (Frey 1978; Peters 1995). Orangutans gain expertise slowly, mainly by learning during immaturity. Mostly, ex-captive orangutans are wild-born and captured by killing their mothers. So, the forest expertise, which normally would be provided by mother, is no longer available for rehabilitants (Peter 1995) as they gain expertise slowly by learning during immaturity (Russon 2009). Ex-captives may be is even slower because of the disturbances, handicaps, and developmental disruptions caused by captivity. Social learning is likely to be more effective (Box & Gibson 1999), but difficult to orchestrate post-release. Orangutan tutor availability, however, depends on their relationships with each other (Russon 2000). Development can complicate the task for foods acquiring abilities attained only near maturity (Russon 2001).
It has been recommended that great apes less than six years old or lacking functional behavioral repertoires should be reintroduced only in group (Beck et al. 2007). Ideally, however, animals should be older when reintroduced.

Orangutan death

Orangutan deaths after released may be affected by some factor, to the extent to which rehabilitants succeed in the wild is relatively unknown, as is the degree to which their behavior and sociality differs from that of their wild counterparts. Identifying the best predictors of success should also lead to developing husbandry and training procedures that will produce in the animals characteristics known to underlie successful reintroduction. Researchers have to analyze the variables:

(1) Unsuitable Habitat

According to the IUCN/SSC Best Practice Guidelines for the Reintroduction of Great Apes (Beck 2007), the areas of release should be within the orangutans historical range, suitable for orangutans (including the determination of carrying capacity), involved in long term protection, and free of wild populations. Before releasing orangutans, researcher should know about the food season in the release site. Forest competence is important for each individual to explore and find food in new habitat. If an individual died, researcher have to look at these possible causes:

1. Poor habitat quality (lack of orangutan foods) are (a) phenology: fruit (ripe/unripe), leaves (young/mature leaf), flowers.  (b) orangutans food (compare with another location with same spp)
2. Threat is (a) human activity (conflicts with humans and hunting), (b) insufficient fear of or avoidance of humans and attraction to human habitation or human crops.

However, in this dissertation, the sites had already been selected. So this part is outside the scope of my dissertation.

(2) Unadjusted individuals

The releases should be planned systematically, it must be known who are going to be released next, and they can be prepared for their release. The ex-rehabilitants should be released in good forest (suitable habitat) and far away from any camp or village. They should be familiarized with the most important orangutan foods before they are released. Food should not be provided unless deemed necessary. In Bukit Tiga Puluh Reintroduction Station, successful and failed individuals can be identified using a noticeable difference their behavior during first week after release (Zweifel 2009). Individual background is also important to predict their survival. Rehabilitation provides an ecological and social environment drastically different from the relatively solitary, mother-focused developmental years of wild orangutans. If an individual died, researcher have to look based on their skills:

1. Poor ecological adjustment due lack of general technical skills
2. Poor ecological adjustment due to lack of habitat-specific knowledge
3. Pre release stage: (a) how long have they stayed with human?; (b) how long have they spent the time together with mother?; (c) Process of confiscated or rescue (traumatic/injury); (d) how long was their stay in rehabilitation or quarantine center?; (e) how long was spent with the baby sitter?; how long was the stay in the isolation/socialization cages?; (f) how long was spent in forest school/island?
(3) Release process

During the release process, researchers should monitor the following factors:

a. Predation

Recognizing predators and reacting to these appropriately is important to prey species. Wich et al. (2010) reported that wild Bornean orangutan does not differ from wild Sumatran orangutans to a tiger model in their experiment, many responded by kiss-squeak, and broke off brancheseven thoughtigers do not occur on Borneo but clouded leopards do (*Neofelis nebulosa*). Wild orangutan use nest to protect them selves. Common predators are teresterial animals, which are dangerous for orangutans when they travel on the ground. Too much time on the ground and lack of predator-avoidance skills or fear during encounters with predators are important to observe.

b. Disease: (1) poor physical condition due to poor ecological adjustment; (2) too much time on the ground (parasites); (3) poor rain-protection skills

c. Accidents: (1) poor locomotor skills and (2) Crossing roads

Based on the analysis above, one could assume the following. First, if they died because unsuitable habitat, one should find another area. Second, if they died because of their lack of skills, one should make a change in the preparation (teaching skills) or sharpen release criteria (unreleasables) or forest school. To measure of success variable are:

a. Feeding parameters (a) within range of wild orangutans, or (b) stabilized during at least 6 months, if outside this range.

b. At 6-month intervals, record whether individual survived/ died/ was removed / or fate was unknown.

c. At 6-month intervals, presence of absence of attempts to make contact with humans (unless sick).

d. At 6-month intervals, initiating contact with humans or human structures.

e. Reproduction, in case of female (pregnancy, birth, infant survival).

f. If death, context (accident, starvation, predation, fighting, killed by humans, disease, snake bite, poisoned, unknown).
3 MONITORING ORANGUTAN REINTRODUCTION: RESULTS OF ACTIVITY BUDGETS, DIETS, VERTICAL USE, NESTING BEHAVIOR AND ASSOCIATIONS DURING THE FIRST YEAR POST-RELEASE INKEHJE SEWEN FOREST, EAST KALIMANTAN

Introduction

Wild orangutans live in female-philopatric societies (Arora et al. 2012), in which infants grow up and learn many of the vital ecological skills through social learning (i.e., under the influence of conspecifics, ranging from simply following models around to copying actions or outcomes) from their mothers, maternal relatives and associating males (Jaeggi et al. 2008, 2010). Immatures may also learn from associates when they range independently after weaning. These suggest that an immature individual strongly relies on the presence of a tolerant and knowledgeable set of adults or older immatures to acquire the full set of its survival skills. The development of these skills takes years, and is only completed around age 10 (Russon 2006). Components are, in order of reaching adult values: locomotion skill, nest-building skills, diet selection, foraging techniques, ranging skills, and social skills (van Noordwijk et al. 2009).

Animals previously held in captivity (so-called rehabilitants) released into natural habitats (reintroduction) may thus need time to acquire these skills (Russon 2006). Many of these learned skills are geographically universal, and may therefore be acquired by maturing individuals even in the absence of models, but some foraging techniques (van Schaik et al. 2003) and elements of diet selection (Bastian et al. 2010) are site-specific. If these are cognitively difficult and thus may take time to become established, it is possible that populations of reintroduced individuals require time to accumulate the culturally based adaptations, very much like human populations would, or in the worst case even fail to establish themselves. Indeed, Russon (2002) showed that released ex-captives gradually expand their diet, but may remain stuck at lower diet breadth than their wild counterparts because they persistently work on existing techniques rather than try out new ones, and add fewer of the non-obvious fallback foods that are invisible and must be extracted (various kinds of pith, termites; see also Russon et al. 2009). However, Russon (2003) could also show that the presence of local experts that can serve as models makes a big difference.

Reintroduction of rehabilitant orangutans is the official government policy in Indonesia. Given the prominent role of learning there is some doubt that released rehabilitants or translocated wild individuals (moved directly from one habitat into a different one) will be successful. Unfortunately, there is surprisingly little information on the fate of released animals (Russon 2009) although the situation has recently been improving (see Riedler et al. 2010). This is understandable with rehabilitants since they either remain dependent on humans, preferring to be fed rather than explore the forest on their own, or disappear, possibly because they roam widely in search of suitable habitat in which to settle down, or get lost. Until recently, fitting orangutans with radio-collars was impossible. Now that reasonably reliable internal radio transmitters have become available (Burk 2012), monitoring of reintroduced animals has become
possible, although locating them in dense tropical forest in rugged terrain without roads or trails remains challenging.

**Study aims**

The aim, therefore, was to study the behavior of rehabilitant orangutans after their release into a novel natural habitat to assess their success at finding adequate food and their acquisition of general forest skills, such as nest building. The study examined changes over time since release in the presence of the animals in the study area and their behavior to identify trends in adjustment to their release forest, looked for individual variation in this process, and examined values of the various parameters such as activity budget, diet, nesting behavior, association relative to those of wild Borneo populations.

**Materials and methods**

**Study site**

The six ex-rehabilitant orangutans were released into the Ecosystem Restoration Concession (ERC) managed by PT. RHOI (Restorasi Habitat Orangutan Indonesia) – BOSF (Borneo Orangutan Survival Foundation). The area is known as Kehje Sewen. It is located in the East Kutai and Kutai Kartanegara Regencies (°6′36″ South - 1°40′48″ South; 116°1′12″ East – 116°28′12″ East), East Kalimantan (Figure 1). Kehje Sewen comprises an area of 86,890 ha, and is almost entirely covered in virgin primary forest (Landsat 7 ETM+ Path/Row 117/59 coverage on 3 October 2008). It has a steep topography (55% has slopes of 15-25%) and 82.5% is under 900 m asl. The release site (15.693 ha) is on the west of the Telen-Soh river. According to interpretation on the map, the area was previously evaluated as offering suitable orangutan habitat (19.377 ha). Vegetation assessment was based on 20m wide plots along transect lines (2 transect 1000m and 2 transect 1500m), comprising a total of 5 km (Figure 5)(Appendix 2) (BOSF 2010). These surveys identified 395 tree species in Kehje Sewen, of which 159 were food taxa known to be consumed by wild orangutans elsewhere (Russon et al. 2009): 104 tree species, 22 palm genera (including rattans), 20 shrub species and 13 epiphyte species. It had virtually no wild orangutans based on nest sighted (0.014 ind/km², BOSF 2010). It is also within the taxon’s historic range. It therefore fulfills all the IUCN reintroduction guidelines for suitable reintroduction areas (Beck et al. 2007).
Objects of the study

I studied six individuals, the first to be released into the area (Appendix 1). Objects had been under rehabilitation at the BOS Foundation Rehabilitation Center at Samboja Lestari for varied amounts of time. They were between eight to thirteen years old (Table 3). All of them had been confiscated after having spent time in captivity, so in most cases their backgrounds are largely unknown, except for Hamzah, who came straight from forest that was being converted into plantations. One of them, Cassey, had a physical handicap; she had an injured hand she could not use for climbing (http://orangutanforest.wordpress.com). On their arrival, their age was estimated using dental eruption patterns (SOCP-FZS 2014). Because permanent teeth erupt later in wild animals (Zihlman et al. 2004), researcher know these ages are underestimates, although it is unknown by how much. The ex-rehabilitant orangutans in Kehje Sewen were released in three groups. Cassey, Mail and Lessan were released first, then Berlian and Hamzah (transport by helicopter with a 2-week interval between the first to second release), and finally Abbie (four day later separately as a result of weather-induced constraints on helicopter trips).
Table 3 Observation times of study objects (immature individuals)

<table>
<thead>
<tr>
<th>Name of individuals</th>
<th>Sex</th>
<th>Age (released)</th>
<th>Length in rehab center (months)</th>
<th>History</th>
<th>Observation times (hours: minutes)</th>
<th>Total days followed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassey</td>
<td>F</td>
<td>9</td>
<td>59</td>
<td>Ex-captive</td>
<td>890:49</td>
<td>88</td>
</tr>
<tr>
<td>Mail</td>
<td>M</td>
<td>8</td>
<td>70</td>
<td>Ex-captive</td>
<td>371:40</td>
<td>46</td>
</tr>
<tr>
<td>Lessan</td>
<td>F</td>
<td>9</td>
<td>65</td>
<td>Ex-captive</td>
<td>746:00</td>
<td>78</td>
</tr>
<tr>
<td>Hamzah</td>
<td>M</td>
<td>9</td>
<td>60</td>
<td>Semi wild</td>
<td>345:52</td>
<td>38</td>
</tr>
<tr>
<td>Berlian</td>
<td>F</td>
<td>10</td>
<td>66</td>
<td>Ex-captive</td>
<td>793:15</td>
<td>86</td>
</tr>
<tr>
<td>Abbie</td>
<td>F</td>
<td>13</td>
<td>74</td>
<td>Ex-captive</td>
<td>70:59</td>
<td>8</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3218:35</td>
<td>344</td>
</tr>
</tbody>
</table>

Before being released, the objects had stayed at the Rehabilitation Center of Samboja Lestari, near Balikpapan, East Kalimantan, for a variable amount of time. The Samboja Lestari rehabilitation center uses the following steps (see Table 4):

a. If individuals were still infants when confiscated (in this study, Mail), they were first placed in a nursery.

b. If they were more than 3 years old and independent (in this study: Lessan, Cassey, Berlian, Hamzah and Abbie), they would be placed into an individual quarantine cage) for up to 2 months.

c. Subsequently, they were moved to forest school level 1 (in this study: Mail), which involves taking orangutans into the forest and engage them in forest both subsistence and social activities. There, they would be fed forest food once daily and provided with solid food twice a day, but still slept in cages.

d. If individuals were older than 5 years and were competent in building and using tree nests, they were moved to forest school level 2 (in this study: Lessan and Berlian), where they were expected to feed on natural food, and build nests, but were still provisioned with solid food and milk once per day.

e. Individuals that were difficult to handle (in this study: Cassey, Hamzah, and Abbie) were transferred to a half-way housing or an island in a river, where they were not handled but still received food (Mail joined them to island straight from forest school level 1)

f. Finally, all individuals judged ready for release were transferred to forest school level 3, in preparation for release in Kehje Sewen Forest, a 53 ha forest area in which they could roam freely for 4 months and get used to forest life while still being provisioned.

The animals were released in April 2012. No supplementary feeding was provided at the release site, except one first night in acclimatization cages and only one individual during the few days in the first weeks (Cassey).
Table 4 History of rehabilitation stages

<table>
<thead>
<tr>
<th>Name of Individuals</th>
<th>Released date</th>
<th>Age (years)</th>
<th>Intake</th>
<th>Released</th>
<th>Quarantine</th>
<th>Rehabilitation Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassey</td>
<td>Apr 24 12</td>
<td>3-4</td>
<td>9</td>
<td>√</td>
<td></td>
<td>√ √</td>
</tr>
<tr>
<td>Mail</td>
<td>Apr 24 12</td>
<td>2-3</td>
<td>8</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lessan</td>
<td>Apr 24 12</td>
<td>3-4</td>
<td>9</td>
<td>√</td>
<td></td>
<td>√ √ √</td>
</tr>
<tr>
<td>Hamzah</td>
<td>May 06</td>
<td>4-5</td>
<td>9</td>
<td>√</td>
<td></td>
<td>√ √</td>
</tr>
<tr>
<td>Berlian</td>
<td>May 06</td>
<td>4-5</td>
<td>10</td>
<td>√</td>
<td></td>
<td>√ √ √</td>
</tr>
<tr>
<td>Abbie</td>
<td>May 12</td>
<td>7-8</td>
<td>13</td>
<td>√</td>
<td></td>
<td>√ √</td>
</tr>
</tbody>
</table>

Sampling methods

To assess their readjustment to forest life, I followed the animals that could be located using focal animal sampling and compared the results with wild populations (see grey bar on result figure). Individuals were followed for 12 months post-release using focal animal sampling (Altmann 1974). Upon finding an animal, they were followed all day. During the first three months, individuals were followed whenever encountered. After that, they were not followed for more than 6 days per month, to reduce human impact. However, not all individuals could be followed each month. Over 3218 hours of total daily active time were collected from April 2012 to April 2013 (between 0 - 14 follow days per month).

Data were recorded using a standardized set of methods (http://www.aim.uzh.ch/Research/orangutannetwork/FieldGuidelines.html), which includes instantaneous scans every 2 minutes of activity, food item, and height. Activities included feeding (F), moving (M), resting (R) and others (Oths) (incl. nesting, socializing, playing). Whenever feeding occurred, we recorded the food item consumed: fruit, leafy material (included stem and pith), cambium/bark, invertebrates (ants, termites, and bees), flowers and others (human/trash food, water, soil). Height was scored as follows: 0 m (on the ground with at least one foot); <5 meters: when was between 0 and 5 m high; and >5 meters.

Social behavior and other remarkable events were recorded continuously. Nest building was a special focus. I recorded whether individuals built new nests from scratch, rebuilt existing nests, or simply used existing nests without modifications.

Data Analysis

For each day, activity, diet, and height classes were expressed as % of total time. This was done as follows. The active period was defined as the time between leaving the morning nest and lying flat on the evening nest. If the total active period was less than 12 hours, the remaining time was considered as spent resting (because the animal was on its nest) and percentages calculated over the full 12-hour period. If the total
active period was more than 12 hours, actual percentages were used. Partial days were included if at least 6 hours of focal follow time was available (following Harrison et al. 2009), and uncorrected percentages were used.

To examine trends with time, I lumped together observations into six consecutive 2-month periods, by calculating mean percentages over each individual’s observation days in that period (Harrison et al. 2009). However, some animals showed dramatic changes within this first 2-month block, so we broke the first period into 2 phases: the first 2 weeks since release (shock-phase) and the rest (adjustment-phase). To be included in a given 2-month period, the individual had to have been followed for at least 20 hours in this period. The study used rank correlations with time-period to assess the presence of continuous trends in an individual’s activities, diet composition, or use of the ground. Statistical significance for these tests was set at P<0.05.

To test for individual differences, the study preselected individuals whose values were systematically (at least 4 of 6 time periods) above or below those of others for a given variable. We then used non-parametric statistical tests (Mann-Whitney U, Kruskal Wallis and Friedman test) (from 2 month to 9-10 month phase), using a conservative level of significance (P < 0.01) because of our pre-selection criterion (Siegel & Castellan 1988). I resorted to this technique because, although our sample size was small, it was important to identify individual outliers.

To estimate the degree of adjustment to the local habitat, I used data from comparable wild populations living the same general region (central, eastern and northern Borneo). I chose this because P. p. morio is not monophyletic and the use of subspecies affiliation was therefore not warranted (Arora et al. 2011), but eastern Borneo differs in terms of climate and soil from western Borneo or Sumatra (Krützen et al. 2011). Because the reintroduced individuals were on average between 9 to 12 years old, I preferably compared our results with those of wild juveniles and adolescents, where possible. Orangutans in Mentoko and Danum Valley live in dry land forests, similar to Kehje Sewen, but data on adolescents were absent or scarce, respectively (Morrogh-Bernard et al. 2009; Kanamori et al. 2010). I therefore also included the swamp forests of Kinabatangan and Tuanan (Morrogh-Bernard et al. 2009) into the comparison. The ranges expected based on the relevant wild population (grey bar) are indicated in the graphs as colored background bands.

These assessments with wild populations were semi-qualitative: simply counting the number of individuals that was outside the expected range. For the latter, I mostly had to use annual averages although this is not optimal for seasonal activities, such as diet composition. However, because no reliable phenology data was available, it was impossible to compare periods of identical food abundance.

In the graphs, results are presented as mean ± standard deviation where possible. Data analysis was conducted using SPSS 11.5 and R software for Windows.

**Results**

**Presence in the area**

Presence in the study site during the first year post-release is provided showed in Table 5. During the first period, all individuals were recorded as present. Some newly released orangutans may roam widely in search of food, making it difficult to find
animals or to relocate them after they were lost during focal follows. This means it is
difficult to distinguish between animals being present but going unrecorded and animals
not present in the study area. This is unfortunate, because presence can also be used to
estimate survival.

Table 5 Presence individuals in the study site

<table>
<thead>
<tr>
<th>Ind</th>
<th>0.5-2 months</th>
<th>3-4 months</th>
<th>5-6 months</th>
<th>7-8 months</th>
<th>9-10 months</th>
<th>11-12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassey</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Mail</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lessan</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hamzah</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Berlian</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Abbie</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Of the four females, three remained in the area while Abbie, who was the oldest
individual at intake and release, was the exception. From the second half of the first
month onwards, she was not directly observed until the beginning of month three when
we encountered her on the opposite side of the River Soh (Figure 6), ±1500 meter from
the release point. This river is so wide that the canopies on both sides do not touch, and
thus not easily crossed by orangutans. In the beginning of February 2015, Lessan,
Cassey, Hamzah and Berlian still ranged around camp Lesik.

The two males explored the area more thoroughly, ranging as far as the
protected forest over 5 km to the north of the release point. During the third week, one
male, Mail, returned to our temporary camp, where observers stayed and cooked.
Because Mail was interested in human activity he was returned to the acclimatization
enclosure for the night. His transponder was damaged in the second month; the
veterinary team retrieved Mail and replaced the broken transponder, upon which he was
placed inside the acclimatization enclosure during the recovery process for a period of 2
weeks. Three months after being released again, Mail crossed the Lesik River, probably
using a water pipe, and at the end of the month was reported along the Lembu River by
local people, some 4 km from the release point (Figure 6). Although I could not find
him there, Mail showed up around our main camp almost a year after his first release. In
the beginning of July 2014, his signal was picked up more than 20 km north from the
release point, but we were unable to find him.
Figure 6 Ranging of ex-rehabilitant orangutans in study site
The other male, Hamzah, was difficult to track because he did not respond well to being tracked by humans. As a result, no detailed follow data could be recorded after the end of the second month. He was seen again around our main camp seven months after release. During 2013, Hamzah was seen near the release point again, in association with Lessan and Agus (the latter a newly released orangutan).

Activity Budgets

Based on a year’s observations at the research site, in general the six orangutans spent 53.5% of time feeding, 29.7% resting and 14.4% travelling (Figure 7). The individuals at Kehje Sewen showed strongly significant variation in their activities (Chi-Square-test feeding: Cassey (N=88), Mail (N=36), Lessan (N=78), Hamzah (N=38), Berlian (N=86), Abbie (N=8), df=5, $\chi^2=65.75$, P<0.001; traveling: $\chi^2=35.51$, P=<0.001; resting: $\chi^2=39.83$, P<0.001).

The study also tested for changes over time post-release. However, because all individuals showed a strong discontinuity during the first 2 week and the last 2-month period, which was almost certainly due to a major reduction in food availability, we restricted the analysis to the first 10 months. The study found significant variation only in the time allocated to travel (Friedman tests: feeding: $\chi^2_4= 6.67$, P = 0.15; resting: $\chi^2_4= 6.93$, P = 0.14; travel: $\chi^2_4= 9.87$, P = 0.04; and others: $\chi^2_4= 6.93$, P = 0.14). Thus, as also shown in Figure 3, over the course of the observation period animals gradually spent less time travelling.

Figure 7 Daily activities budgets for ex-rehabilitant orangutans in Kehje Sewen during the 7 post-release periods considered in this study.
Generally, the activity patterns of all observed rehabilitant orangutan showed a similar pattern but differed from those seen among wild immature Bornean orangutans. Feeding time accounted for the largest part of the released orangutans’ activity budget and often exceeded that of the wild populations. Resting and traveling time were correspondingly reduced.

Two individuals, Mail and Abbie spent slightly more time resting than feeding in the first two-week period (Figure 7). Mail’s high resting time can be attributed to the fact that he came to our camp and waited to be fed. Abbie spent much time on her nest and did not engage in any meaningful activity.

Hamzah, the wild orangutan, was the only orangutan whose activity budget (except travel) was largely in the range of wild population. Hamzah was remarkably fast and agile, and unhabituated. He once travelled very far from acclimatization area into a protected forest upstream the River Soh, which is located around 5 kilometers from the acclimatization area. All of this suggested he already possessed more forest experience than the others.

Cassey, a 9-year-old female, although suffering from a disability to her right hand, was able to climb and move through the trees with apparent ease, albeit at a slower rate than the others. Cassey initially moved less and remained close to the release point, oftensitting on the ground.

Comparison of the males and females in Kehje Sewen showed a significant difference in feed and travel (MWU-test feeding: Nfemale=240, Nmale=94, Z=-2.04, P =0.042; traveling: Z=-2.94, P =0.003). There is a trend for non-sexually active females to spend more time feeding, whereas males spent more time traveling. In addition, females were more selective in choosing food so that their mealtime was longer than males.

Diet composition

The released orangutans in Kehje Sewen clearly spent more time feeding on fruit (pulp, skin, seed, endocarp, exocarp) than on leaves (mature leaves, leaf shoots, stems, pith), bark (the cambium layer) or invertebrates (including larvae, ants, termites) and others (soil, water, grass, human food etc.) during the study period (Figure 8). In addition, the time spent feeding on bark was higher for two individuals, Abbie and Mail, who travelled on a larger area and explored the area, and also consumed a lot of Ficus sp. bark and leaves. There is some variation in time spent feeding leaves. The animals tried to eat every species of potential interest to them, such as the leaves of Spatholobus sp., the stems of Zingiberaceae, and the young shoots andpith of rattans and bamboos.

The percentage of feeding time varied significantly between individuals (Fig. 4) for fruits (Cassey (N=71), Mail (N=36), Lessan (N=78), Hamzah (N=38), Berlian (N=86), Abbie (N=8), df=5, $\chi^2=61.483$) leaves ($\chi^2=81.836$), bark ($\chi^2=21.468$), invertebrates ($\chi^2=13.678$), and other foods ($\chi^2=26.163$), but not for flowers ($\chi^2=8.031$). Compared to wild orangutans, they spent less time eating flowers and were in the lower range of time spent feeding on invertebrates (Figure 8). The animals released in Kehje Sewen were somewhat more frugivorous than their wild counterparts, and systematically spent less time on flowers and probably invertebrates. This condition may affected by composition food during rehabilitation center (Samboja Lestari). These items may require more forest experience for effective harvesting.
Analysis to examine trends over time since release showed that the proportion of fruit, flowers, leaves and bark significantly changed over the observation period (Friedman tests: fruits: \( \chi^2_{4} = 10.93, P = 0.03 \); flowers: \( \chi^2_{4} = 10.51, P = 0.03 \); leaves: \( \chi^2_{4} = 10.93, P = 0.03 \) and bark: \( \chi^2_{4} = 11.47, P = 0.02 \)). The proportion of fruit increased,
whereas that for flowers and leaves decreased and bark and invertebrates and others items did not reveal a clear pattern over time.

During the first two weeks, some individuals (Cassey, Mail, and to some extent Lessan) took food from the technicians, scavenged leftovers from campsites, or retrieved food remains from under the acclimatization cages occupied by Berlian and Hamzah, who were released two weeks later. After this period, there was virtually no consumption of human food. However, Cassey continued to occasionally search for food on the forest floor, taking the fruits that fallen to the ground while other individuals fed up in the canopy, and generally taking food from the forest floor. She may have had more trouble climbing due to her injured hand.

During the 344 follow days, I collected and identified 256 samples of rangutan’s food plants. Researcher identified food plants from 49 families, estimated to contain at least 200 species of tree (Artocarpus sp., Melastoma sp., Microcos sp., Ptenandra sp., Macaranga sp., Aglaia sp., Diospyros sp., Baccaurea sp., Shorea sp., Mangifera sp., Xanthophylum sp. etc), 20 species of Zingiberaceae, 13 species of liana, and 23 species of Palmae.

**Vertical use**

Ex-rehabilitants in Kehje Sewen spent over time 50% on >5 m, even though some individual spent much time on the ground (Figure 9). They sometimes came down from the trees to travel terrestrially, drink from the river or to get food.

![Figure 9 Proportion of time individuals spent at different heights over the first year since release](image)

Kehje Sewen animals spent somewhat more time on the ground than the wild population with good data on ground use (Tuanan), but this was quite variable. There were significant differences in height among the individuals: Cassey and Mail spent more time on the ground than the others, although not significantly(Cassey (N=88),
Mail (N=35), Lessan (N=75), Hamzah (N=37), Berlian (N=84), Abbie (N=7), df=5, Chi-Square=49.539, P=0.000; 0.5-5-meter: Chi-Square=48.938 P=0.000; >5m: Chi-Square=61.903, P=0.000. There was no clear sex difference in the use of tree strata (on the ground: Nfemale=225, Nmale=91, z=-0.20, P=0.843; 0.5-5meter: z=-1.57, P=0.177; >5m: z=-1.84, P=0.067).

Nest Building

All individuals were able to make a new nest, but also sometimes slept on liana tangles that they shaped like a nest. Cassey, during the first 2 weeks used old nests for 50% of nights, and Berlian refurbished existing nests on 75% of nights during the 9-10-months period (Table 6). In comparison with wild populations at other sites (in Tuanan, for instance, individuals rebuilt 10.8–13% % of nests, and reused 0.1% - 12.5%), the percentage of nest building by rehabilitants was lower (Prasetyo et al. 2009).

Table 6 Competence in nest building, as estimated by the percentages building new nests (N), refurbishing existing nests (R) or simply using old nests (U)

<table>
<thead>
<tr>
<th>Individual</th>
<th>First 2-week</th>
<th>0.5-2 month</th>
<th>3-4 months</th>
<th>5-6 months</th>
<th>7-8 months</th>
<th>9-10 months</th>
<th>11-12 months</th>
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<tr>
<td></td>
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<td>U: 12</td>
<td>U: 38</td>
<td>U: 18</td>
<td>U: 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mail</td>
<td>N: 43</td>
<td>N: 44</td>
<td>N: 46</td>
<td>N: 91</td>
<td>N: 54</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N: 29</td>
<td>R: 44</td>
<td>R: 36</td>
<td>R: 9</td>
<td>R: 39</td>
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<td>R: 17</td>
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<td>U: 22</td>
<td>U: 5</td>
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</tr>
<tr>
<td></td>
<td>R: 50</td>
<td>R: 4</td>
<td>R: 11</td>
<td>R: 17</td>
<td>R: 21</td>
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<tr>
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<td>U: 5</td>
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</tr>
<tr>
<td>Abbie</td>
<td>N: 43</td>
<td>N: 44</td>
<td>N: 46</td>
<td>N: 91</td>
<td>N: 54</td>
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<td>R: 11</td>
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<td>R: 21</td>
<td>R: 75</td>
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<tr>
<td></td>
<td>U: 25</td>
<td>U: 24</td>
<td>U: 22</td>
<td>U: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

?: individual didn’t found

Association and social interactions

Based on the result, in the first 2 weeks, Mail and Lessan traveled together to explore the new habitat, and often ate food in the same tree. In the second month, Lessan instead followed Berlian, and ate bark (*Ficus* sp.), pulp (*Mangifera* sp.) together, but Berlian chased Lessan, who subsequently spent time alone. Lessan, Berlian and Mail had been together in forest school 2 (FS2), where they were long-term close companions. Berlian also chased Cassey, especially in or near food patches. As a result, they spent only limited time in close association (< 10 m), usually meaning they were in the same food patch. However, all those six rehabilitants spent much more time in less
close association (< 50 m) (Figure 10) than is common in wild populations (van Noordwijk et al. 2009), even for adolescents.

**Fig 10 Months of release and percentage of time (a) <10 m and (b) < 50 m**

There was a clear sex difference in association pattern. Male-male association was rare, whereas female-female and male-female association was most common, similar to the patterns found in wild populations (Noordwijk et al. 2009).

**Discussion**

Post-release monitoring in adjusting to forest life is critical if researchers are to evaluate reintroduction success. In the past, post-release monitoring of reintroduction attempts was often weak and unsystematic, so evidence of reintroduction success rates has similarly been weak (Russon 2009). An additional contributing factor can be the difficulty of relocating rehabilitants once they have been released. However, it should be noted, that it is very difficult to fully assess the success of past reintroductions, because it was often impossible to relocate released orangutans, especially since some of them moved into remote areas without any road access.

I was able to relocate and follow five of the first six rehabilitants released because they had been implanted with radio telemetry. Released in April 2012, they were still known to be alive in July 2016, except for Abbie, who was last seen in January 2013, across the Soh river, the same area when we saw her in June 2012. All others, especially the males, travelled far, several km from the release point in both directions.

**Activity budgets**

During the first 2 weeks post-release (called the shock period), many spent most of their time resting and trying to obtain human food. After that, the animals changed their behavior, exploring their new habitat and trying to find familiar food. Hamzah was a clear exception. He appeared wild and immediately avoided humans, refusing to be tracked by observers. Abbie took the longest to become more active, perhaps because she was brought in overland rather than by helicopter, or because she was the oldest individual to be released and was rather oriented toward humans. When she was found
again after 3 months, she directly came down to approach the observers and tried to make contact with them. Mall explored the area around the acclimatization enclosure together with Lessan, and would also try to approach the observers. Cassey, Lessan and Berlian spent more time feeding than in any other activity.

During the subsequent months, I compared the changes in activity budgets and diets in relation to values found among their wild counterparts. There was a sharp break in the trend in the last 2 months-block, in which they fed less and rested more and ate mainly leaves and tree bark. This is the same response as wild orangutans show during a severe fruit shortage (Morrogh-Bernard et al. 2009; Kanamori et al. 2010). This last period was therefore excluded when the study examined changes over time.

Overall, most individuals spent more time feeding and less time resting than their wild counterparts. In contrast, Russon (2009) had found that ex-rehabilitant in Tanjung Puting, Sungai Wain and Beratus did not spend more time feeding than wild populations, as did Riedler et al. (2010) in Bukit Tiga puluh on Sumatra. One possible explanation for this difference lies in the nature of release, and thus the amount of post-release provisioning, but details are too scanty to evaluate this idea. Alternatively, although all release sites have a forest school, the one in Samboja Lestari is more extensive, which may have prepared candidates more fully for release. Overall, then, these reintroduced individuals were more like wild orangutans than others that had been released, suggesting that the forest school experience led to a good preparation for life post-release.

Diet

Although direct comparisons are impossible, it appeared that the reintroduced individuals had a broad diet. They fed on at least 75 species of plants in the first three months after release, including various well-known fruits orangutans fed on. They were often seen eating insects such as termites in rotten wood. This was possible because Kehje Sewen forest was a primary forest with a high diversity of flora and fauna. The reintroduced orangutans also consumed a variety of fallback foods, in the form of leaves, cambium, and pith. Several types of green leaves were identified from lianas (Spatholobus sp.) and trees, such as Xanthophylum sp. and Ficus sp. These are also targeted by as fallbacks by P. p. morio in Danum Valley (Kanamori et al. 2010).

In the absence of clear trends over time in diet, it is not certain that the changes in activity budgets reflect learning of more efficient techniques or the consumption of more nutritious foods over time. Overall, however, their diet choice appeared to be closer to that of natural populations than those of animals released elsewhere (e.g. Fredriksson 1995), perhaps because they had spent a long time in forest school before release. Continued monitoring of both diet choice and phenology will be needed to test this idea.

Ground use

Orangutans are the largest arboreal animals on the planet. Most of their lives are spent in trees where orangutans travel from branch to branch by climbing, clambering, and brachiating. Recent camera-trapping studies (Ancrenaz et al. 2014) suggest that orangutans in eastern Borneo spend more time on the ground than commonly thought, including in nearby Wehea forest (Loken et al. 2013). However, although all age-sex
classes are known to come down to feed, only males travel extensively on the ground, and immatures only reluctantly follow their mother to feed. Wild adolescents thus are not expected to spend much time on the ground.

Although mostly arboreal, ex-rehabilitant in Kehje Sewen occasionally traveled on the ground to move between stands of trees. The males, Mail and Hamzah often traveled on the ground near the river around the camp (103) and sometimes sat on a rock, looking towards the RHOI 2 forest across the river. Mail even tried to cross the river while on the ground, using a stick to check the water level. Even so, the individuals showed evidence of knowing that the ground was a dangerous place, responding to sudden sounds by climbing up into the trees. I have observed multiple instances, where individuals suddenly climbed up into the trees or even went back into the nest after hearing some suspicious sounds like wild hogs and deers. However, Abbie would come down from up high to be near the observer on the ground, where she clearly felt comfortable. This observation obviously implies that such individuals should be followed as little as possible post-release, to wean them from using the ground.

Cassey spent most time on the ground, perhaps because other individuals chased her from food patches. Such displacements are common among orangutans (Utami et al. 1997), but in most cases do not lead to feeding on the forest floor. It might be argued that the presence of Zingiberaceae in the study area, especially near the released point may have attracted the individuals to come down to feed. Studies by Frederiksson (1995), Grundmann et al. (2001) and Kuncoro (2004) all show that ex-rehabilitants extensively use foods from the forest floor (e.g., terrestrial invertebrates, shoots of grasses [Graminae spp.] and rattans, and stems of gingers [Zingiberaceae spp.]). This could result from their identifying foods by trial and error for lack of expert guidance or their tendency to be more terrestrial than wild (Peters 1995; Kuncoro 2004; Grundmann 2006). However, wild adolescents largely ignore these foods (e.g. Snaith 1999; Kanamori et al. 2010), suggesting that they exploited them because they were on the ground in the first place, rather than were attracted to the ground because of the food. Overall, then, some of the released individuals did not have enough fear of being on the ground and spent more time feeding on terrestrial foods than their wild counterparts.

Nest building

All wild orangutans build night nests, usually building a new nest each night (Prasetyo et al. 2009). Infants learn to build nests by watching their mother and others in their neighborhood. The rehabilitants in Kehje Sewen were able to build nests (Table 4), almost certainly because they had learned to do so in forest school. However, the proportions of new nests were lower than in wild populations, perhaps because they were less motivated or lacked the energy to build fresh nests: across populations, reuse is most common where food is most scarce (Prasetyo et al. 2009). Further observations are needed to distinguish between these possible explanations.

Association and social interactions

As expected for non-adult individuals (Mitra Setia et al. 2009), the released orangutans in Kehje Sewen frequently engaged in associations, although the time wild immatures spend in associations varies considerably among populations (van Noordwijk
et al. 2009), and even within populations over time. This variability makes it hard to compare the total association time with wild adolescents.

These associations were almost certainly used to learn feeding skills. During the first months post-release, many associations involved co-feeding. Lessan, for instance, often followed Mail or Berlian around, and copied their feeding choices. Females were more likely to associate than males, but their tolerance nonetheless varied. Berlian was dominant to Cassey and Lessan. However, whereas Berlian generally tolerated Lessan in food trees, Cassey always stayed away, waiting for Berlian to leave the food tree. This selective tolerance may reflect pre-release friendships.

**Conclusion**

In conclusion, all the released rehabilitants studied survived their first year and adjusted to forest life. Although comparisons with existing wild populations are difficult, I suggest the main differences were that the reintroduced individuals spend more time feeding overall, spent more on fruit and less on flowers and insects than expected (as seen in other reintroduced apes: Stoinski & Beck 2004), built fewer fresh nests and spent more time than expected for their age. Finally, the individual with an injured hand (Cassey) showed various deviations from expectation. Such individuals have trouble climbing and by spending more time on the ground may have lower survival prospects.

These results are obviously preliminary. First, longer-term data on the same individuals are needed. Second, although at present, comparisons are still difficult, it is important in future work, to assess the effects of different strategies of pre-release preparation, so as to identify the factors affecting reintroduction success.
4 Preliminary result on ranging behavior of orangutans reintroduced into Jantho Sumatran Orangutan Reintroduction Station – Aceh Province

Introduction

Wild Sumatran orangutan (Pongo abelii) populations have suffered drastic declines in recent decades (Eudey et al. 2000). Reintroduction can be considered as an important tool in conservation management (Rijksen & Meijaard, 1999). Indeed, as a result of law enforcement concerning the illegal trade of orangutans, confiscated animals are reintroduced to suitable and protected areas following international guidelines (Guidelines for Nonhuman Primate Reintroduction of the IUCN/SSC Reintroduction Specialist Group; Baker, 2002). Successful reintroduction is the ultimate aim of such rehabilitation processes. However, past reintroduction practices have sometimes been sub-optimal (Russon 2009). Therefore, even though it is a critical component of law enforcement, further research on the success rate of past orangutan reintroduction (Russon 2009) is important. In this study I address this by investigating the ranging behavior of ex-rehabilitant orangutans.

Ex-rehabilitant orangutans are usually rescued as orphaned infants of under four years of age (Swan & Warren 2000). Although, some may recall expertise that they had acquired in the wild before capture, others may start more naïve (Rijksen 1978). These orphaned infants, thus, often still need to (re-)learn forest skills crucial for survival before they can be reintroduced (Russon 2002). Learning such survival skills during the readjustment process may, in addition, even take longer than it would under natural circumstances, due to potential handicaps and developmental disruptions caused by captivity and rehabilitation. Interactions between individuals (but also between orangutans and humans) are especially important for these rehabilitant orangutans that, without their mothers, lack access to the knowledge they need to survive in the forest. However, socially facilitated learning from such interactions is difficult to orchestrate as it depends on social tolerance and relationship with other individuals (Russon 2000, 2001). Furthermore, the behaviors that are to be learned are subject to changes due to environmental, social or individual parameters. Reintroduced juvenile orangutans are of special interest in this regard, because in the wild they would still be in company and at least partly depended on their mother (MacKinnon 1974).

Animals are continuously faced with tasks to find and acquire food, and decisions concerning which foods to eat and which to avoid. Therefore, especially acquisition of foraging skills and the ranging skills required for these are crucial for survival. To study rehabilitation success, I therefore investigated ranging behavior in Sumatran orangutans at Jantho and how these relate to the presence of ecological resources. Home range characterizes an individual’s ranging decisions in this regard, and may therefore be an important characteristic to look at. Burt (1943) defined a home range as the area traversed by the individual in its normal activities of food gathering, mating and infant care. Singleton and van Schaik (2001) consider the home ranges estimated by studies that are not very intensive, short, or restricted to a small area, to reflect core areas, as opposed to complete home ranges. In wild populations, Mitani (1989) and Suzuki (1992) both reported female ranges of over 150 ha at Mentoko,
whereas Rodman (1988) suggested they were only 40–60 ha. Male ranges are larger than those of females: up to 200 ha in Ketambe, 60–700 ha in Mentoko and 462–612 ha in Suau Balimbing (the latter only involving subadult males) (Delgado and van Schaik 2000; Singleton 2000, Singleton & van Schaik 2001). Although orangutans are relatively solitary animals and usually range alone; home ranges of several individuals may overlap to a considerable extent (MacKinnon 1974; Rijksen 1978; Rodman & Mitani 1987). Intraspecific variation in home-range size has been shown to be influenced by resource availability (Lariviere & Messier 2001), population density (Kjellander et al. 2004), social factors (Boydston et al. 2003), and anthropogenic influences such as habitat fragmentation (Beckmann & Berger 2003). Rijksen and Meijaard (1999) divided wild orangutans, into three classes of individuals based on dispersal activity: residents are found for many years to be present for most of each year in one particular area. Commuters are seen regularly in one particular area for several weeks or months each year for many years. Wanderers are seen very infrequently (or once) in a period of at least three years in a particular area. Research on the range use of ex-rehabilitant orangutans is important to assess their survival potential after reintroduction. Accordingly, this study focuses on investigating home range size and daily journey length, as well as their direct relevance for finding and choosing food resources, in individual ex-rehabilitant orangutans in Jantho Sumatran reintroduction station, to be able to assess actual reintroduction success and provide us with recommendations for future reintroduction efforts.

**Study aims**

The aim of this study are first is to investigating home range size and daily journey length, as well as their direct relevance for finding and choosing food resources, in individual ex-rehabilitant orangutans in Jantho Sumatran reintroduction station. Second, be able to assess actual reintroduction success and provide researcher with recommendations for future reintroduction efforts.

**Materials and methods**

**Study Sites**

The ex-rehabilitant orangutans were released into Jantho Sumatran Orangutan Reintroduction Station, Aceh Province, at the Jantho Nature Reserve (05°13’08LU-95°40’54BT) and managed by Sumatran Orangutan Conservation Programme (SOCP) – YayasanEkosistem Lestari (YEL). The Jantho area is situated in the far North of the province, at considerable distance from the northernmost existing wild orangutan populations in the Leuser Ecosystem (Wich 2009). The nature reserve covers 16,640ha of forest and grasslands. The forest in the Jantho Nature Reserve ranges from 100-1800 meter in altitude and consists of relatively flat areas with some steep slopes (48% of the area is 15-40°). In Jantho forest at least 40 species of orangutan food trees are found (Wich 2009).
Objects of the study

I studied 10 individuals and they were classified (van Noordwijk et al. 2009) into the following age-sex classes: 4 immature females, 1 sub adult male and 5 immature males (Table 7). All of them had been confiscated. In most cases their backgrounds are largely unknown. One of them, named Seumayam, had a minor physical handicap (Appendix 4). Ages were estimated at time of intake using dental eruption patterns (SOCP private communication 2014). Because permanent teeth erupt later in wild animals (Zihlman et al. 2004), researcher know these ages are underestimated, although it is unknown by how much.

Before being released, the objects had stayed at the Quarantine Center of Batu Mbelin, near Medan, North Sumatera, for a variable amount of time. Before they became the candidate of this study, they were housed in social cages to learn from and socialize with other rehabilitants. The rehabilitant orangutans that became candidates for reintroduction were moved to isolation cages (without a forest school stage) for a few days or weeks. Then, the animals were released between April and August 2012. Supplementary feeding was provided during their stay in the acclimatization cages, and when they came back to the acclimatization cages due to their own ranging decisions or illness.

Table 7. History of the objects

<table>
<thead>
<tr>
<th>Release Dates</th>
<th>Name of individuals</th>
<th>Class age</th>
<th>Age (release)</th>
<th>Length in rehab center (months)</th>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-Mar-11</td>
<td>Pibi (♀)</td>
<td>I</td>
<td>8</td>
<td>29</td>
<td>Ex-captive</td>
</tr>
<tr>
<td>29-Jun-11</td>
<td>Mongky (♀)</td>
<td>I</td>
<td>5.5</td>
<td>14</td>
<td>Ex-captive</td>
</tr>
<tr>
<td>13-Sep-11</td>
<td>Sangir (♂)</td>
<td>I</td>
<td>8</td>
<td>22</td>
<td>Ex-captive</td>
</tr>
<tr>
<td>28-Sep-11</td>
<td>Dewa (♂)</td>
<td>I</td>
<td>8</td>
<td>32</td>
<td>Ex-captive</td>
</tr>
<tr>
<td>21-Mar-12</td>
<td>Dennis (♂)</td>
<td>I</td>
<td>7</td>
<td>24</td>
<td>Ex-captive</td>
</tr>
<tr>
<td>14-Apr-12</td>
<td>Amin (♂)</td>
<td>I</td>
<td>6</td>
<td>5</td>
<td>Ex-captive</td>
</tr>
<tr>
<td>1-Jun-12</td>
<td>Seumayam (♂)</td>
<td>Sa</td>
<td>9</td>
<td>26</td>
<td>Ex-captive</td>
</tr>
<tr>
<td>1-Aug-12</td>
<td>Mawasudin (♂)</td>
<td>I</td>
<td>9</td>
<td>7</td>
<td>Ex-captive</td>
</tr>
<tr>
<td></td>
<td>Yusniar (♀)</td>
<td>I</td>
<td>5</td>
<td>38</td>
<td>Ex-captive</td>
</tr>
</tbody>
</table>

Note: I: immature; Sa: sub adult

Sampling methods

Individuals were followed for 6-12 months post-release using focal animal sampling and nest-to-nest follows (Altmann 1974). Upon finding an animal, they were followed all day until they built their evening nest. The following day we would start the follow after they wake up and leave their (morning) nest. The study examined data on movements during focal follows from April 2011 until December 2012. During the first three months, individuals were followed whenever encountered. After that, they were not followed for more than 6 days per month. However, not all individuals could be followed each month. The active day length differed considerably (7-13 hours). Every 15 minutes, we recorded the geographic position of the focal subject by GPS (Garmin 78s) and each position of food patches that they were seen eating from, as well
as the food item consumed. I distinguished between fruits, figs, leaves and others (epiphytes, soil, insect, flowers etc.). Subsequently, we divided these into 3 major food types; woody tree, figs or lianas.

Data Analysis

I transferred all follow data from GPS to ARC/INFO GIS software as routes (lines) to be measured to estimate range sizes polygons. Plotting all points at which an individual was ever seen, given a sample of points known to be within range. The peripheral points were then linked using straight lines, to produce a minimum area polygon (Kenward 1987), also called the minimum home range method (Trevor-Deutsch & Hackett 1980). The polygon method produces a more reasonable total home range estimates than the grid cell method because it ignores internal gaps in range use (Singleton & van Schaik 2001). Food patch coordinates that we recorded in the field, were also transferred and stored in ARC/INFO GIS software as points. I categorized them into wood plants, figs and liana layers.

After that, I assessed day journey length (DJL), from start (i.e. from the moment the individual leaves the nest in the morning or point where researcher found the individual) to end of follow (i.e. evening nest when the individual lies down). Food patch was measured as total number of each tree or liana or ficus seen eaten by ex-rehabilitant orangutans divided average of day journey length.

Results

Day Journey Length (DJL)

During a years study period, the animals movements per day was various in form, such as curves, zig-zags back and forth to the cages, circles or straight lines. The mean day journey length of immature female ex-rehabilitant orangutans was 800 m (range, 428 - 1106 m) and 867 m for males (range, 271-1281 m) (Table 8). MacKinnon (1974); Brock-Clutton (1977); Basalamah (2009); reported that wild adolescent orangutans have day journey lengths between 500 m - 882 m for females and 494 - 1106 m for males. Day journey length results in this study show that the shortest length was 217 m (Amin) and the longest was 1280 m (Dewa). Dewa and Denis tended to travel longer distances than Seumayam, Mawasudin and Amin. Pibi and Nelly traveled farther than other females. However, these differences in day journey lengths from ex-rehabilitants were not consistent and unclear in some cases, probably because food provisioning and the presence of acclimatization cages may have affected the daily travels. Nelly and Mawasudin were released in different periods but showed similar DJLs because after Mawasudin was released Nelly was still presence around the acclimatization cages and therefore he could follow her.

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Table 8 Average of daily journey length and home range sizes of ex-rehabilitant orangutans

<table>
<thead>
<tr>
<th>No.</th>
<th>Individu</th>
<th>Sex</th>
<th>Home Range (Ha)</th>
<th>Class age</th>
<th>Average of DJL</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pibi¹</td>
<td>Female</td>
<td>32,01</td>
<td>Immature</td>
<td>1103.25</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Monkey¹</td>
<td>Female</td>
<td>21,75</td>
<td>Immature</td>
<td>560.94</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Sangir¹</td>
<td>Male</td>
<td>73,36</td>
<td>Immature</td>
<td>983.26</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Dewa²</td>
<td>Male</td>
<td>77,15</td>
<td>Immature</td>
<td>1280.48</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>Denis²</td>
<td>Male</td>
<td>72,96</td>
<td>Immature</td>
<td>1279.72</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>Amin³</td>
<td>Male</td>
<td>0.61</td>
<td>Immature</td>
<td>271.33</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>Nelly⁴</td>
<td>Female</td>
<td>29,13</td>
<td>Immature</td>
<td>1106.36</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>Seumayam⁵</td>
<td>Male</td>
<td>54.81</td>
<td>Adolescent</td>
<td>594.86</td>
<td>27</td>
</tr>
<tr>
<td>9</td>
<td>Mawasudin⁶</td>
<td>Male</td>
<td>37.52</td>
<td>Immature</td>
<td>791.63</td>
<td>11</td>
</tr>
<tr>
<td>10</td>
<td>Yusniar⁵</td>
<td>Female</td>
<td>2.72</td>
<td>Immature</td>
<td>427.92</td>
<td>9</td>
</tr>
</tbody>
</table>

Day journey length results in this study show that the shortest length was 217 m (Amin) and the longest was 1280 m (Dewa). Dewa and Denis tended to travel longer distances than Seumayam, Mawasudin and Amin. Pibi and Nelly traveled farther than other females. However, these differences in day journey lengths from ex-rehabilitants were not consistent and unclear in some cases, probably because food provisioning and the presence of acclimatization cages may have affected the daily travels. Nelly and Mawasudin were released in different periods but showed similar DJLs because after Mawasudin was released Nelly was still presence around the acclimatization cages and therefore he could follow her.

Figure 11 shows that some individuals were foraging for food more independently. Seumayam, despite his limitation to be able to use only one hand was successful in acquiring food and even encountered other individuals in a party on a fig tree and liana, after crossing the Linteng River by a continued canopy. 11 months later, Seumayam was founded with injuries on the same hand, than put him on the acclimitization cage. The average length of his day journeys was 575 m. Mawasudin had an average DJL of 792 m; he frequently crossed the Linteng River (to the camp) using a rope that was used by the technicians to cross by boat.
These journeys were compared between sex, but there was no significant difference (MWU-test: Nfemale= 32, Nmale= 110, Z=-0.635, p=0.526). The distance that was covered during the day journey length differed significantly between individuals (NPibi=10, NMonkey=4, NSangir=5, NDewa=16, NDenis=21, NAmin=30, NNelly=9, NSeumayam=27, NMawasudin=11, NYusniar=9, df=9, $\chi^2=67.655$, p<0.05). Since the individuals were still immature but weaned, and thus naturally would assume a semi-independent life period when reintroduced in the new habitat, their different historical backgrounds (quarantine duration, confiscated from humans or separated from their mother, etc.).

Estimation of home range sizes

The total home range size for ex-rehabilitant orangutans in Jantho during a year’s study was around 0.6-77.2 ha. The results presented here show that most of the females’ movements were around the acclimitization cages (Figure 11). Pibi had a larger home range than the others females. The males traveled by canopy north-east from the acclimitization cages until the Linteng River crossing. Dennis, Dewa and Sangir had large home ranges range 72-77 ha (Table 6 our results, however, were within range with adolescent orangutans in Ketambe (range, 51-152 ha; Basalamah 2009). The ranges of some males were large, but the females may have had rather smaller ranges.
In wild orangutan populations, adult male ranges are larger than those of female (MacKinnon 1974; Galdikas 1988; Singleton 2000). Researcher assume that after being reintroduced to their natural habitat during a year, ex-rehabilitants still hang around the release cage, and some individuals disappear at the end of study period, which likely has affected these results and differences relative to other studies.

Based on our analysis, home ranges of individuals overlap; range 1.04% – 92.30% (Table 9). Dewa, which is an individual with a large home range, 77 ha, overlapped 92.30% with Denis. Amin used 2.06% of the home range of Nelly, same size of his home range. He has a smaller home range than other individuals. Mawasudin and Nelly showed similar home range patterns, with the total home range size of Mawasudin, 37.5 ha, overlapped 67.11% of the area used by Nelly. All studies on wild population also noted that female ranges overlap those of other females and sub adult male ranges overlap those of other sub adult males (MacKinnon 1974; Horr 1977; Galdi kas 1979), which looks similar to the preliminary results in this study.

These results show that there was no clear pattern of the home range use yet. Therefore, we suggest that almost all individuals utilize the cages area during the study, at which they were released. Males travel more inside to the forest. Some individuals spent time to search food for a few or weeks before moving to a new part. This might be due to the fact that they were still learning or did not know where he or she would need to go to find the resources.

Table 9 Overlapping size between ex-rehabilitant orangutans (%)

<table>
<thead>
<tr>
<th></th>
<th>Pibi</th>
<th>Monkey</th>
<th>Sangir</th>
<th>Dewa</th>
<th>Denis</th>
<th>Amin</th>
<th>Nelly</th>
<th>Seumayam</th>
<th>Mawasudin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pibi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monkey</td>
<td>38.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sangir</td>
<td>18.72</td>
<td>25.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewa</td>
<td>41.14</td>
<td>26.66</td>
<td>36.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Denis</td>
<td>39.67</td>
<td>29.81</td>
<td>4.62</td>
<td>92.30</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Amin</td>
<td>22.95</td>
<td>62.30</td>
<td>88.52</td>
<td>78.69</td>
<td>86.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nelly</td>
<td>52.90</td>
<td>24.06</td>
<td>42.57</td>
<td>75.11</td>
<td>71.03</td>
<td>2.06</td>
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<td></td>
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<tr>
<td>Seumayam</td>
<td>49.61</td>
<td>13.10</td>
<td>20.96</td>
<td>62.78</td>
<td>50.92</td>
<td>1.04</td>
<td>21.86</td>
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<td></td>
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<tr>
<td>Mawasudin</td>
<td>51.60</td>
<td>19.00</td>
<td>39.31</td>
<td>70.42</td>
<td>65.17</td>
<td>1.60</td>
<td>67.11</td>
<td>43.55</td>
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<td>Yusniar</td>
<td>69.49</td>
<td>10.29</td>
<td>24.63</td>
<td>73.16</td>
<td>74.63</td>
<td>14.71</td>
<td>91.54</td>
<td>76.47</td>
<td>75</td>
</tr>
</tbody>
</table>

Food patches

To investigate the new habitat use during a year’s study, researcher examined the total number of food patch for ex-rehabilitant orangutans. Data on feeding tree patches, from ex-rehabilitant orangutan focal follows at Jantho involved 58 trees species, 8 fig species and 4 liana species was identification. Wood tree patches were most often fed from, followed by fig trees and then lianas (Figure 13). During the study, Dewa, Mongky and Pibi used mostly trees as food resource, ranging between 6.7-7.3 patches/km. Yusniar and Seumayam were more likely to eat from figs trees, with 4.2 patches/km and 2.1 patches/km, respectively. During the study, Seumayam were seen spent time feeding bark of figs together with Nelly. Ex-rehabilitant orangutans in this study were seen to feed not only on the tree but also consumed the low herbaceous
plants, example Zingiberaceae (percos) on the ground. Amin, Yusniar and Seumayam additionally fed from lianas in their home ranges, respectively 12.3, 4.4 and 4.3 patches/km (Table 10). Amin and Yusniar have been seen to fed on Akar kacang and akar lengen. All individuals that remained explored resources around the cage area, such as Piper aduncum and Aglaia sp. which were widely spread around cages. The focal data furthermore indicated that trees of a few species (e.g. Aglaia korthaisii, Aglaia odoratissima, Eugenia sp., Lithocarpus sp., Litsea monopetala, Litsea robusta, Nephelium lappaceum etc, Ficus raseomosa, Ficus variegate, Rambung obscura, Ficus sundaica, Arthocar puselastics, Durio sp., Mallotus sphaeracarpus, Neonauclea sp., Piper aduncum, Dendrcineide stimulans etc.) are the largest component of the diet of ex-rehabilitants orangutan.
Table 10 Patches food used by ex-rehabilitant orangutans in Jantho

<table>
<thead>
<tr>
<th>No.</th>
<th>Individu</th>
<th>Sex</th>
<th>Σn Follow</th>
<th>Liana</th>
<th>Ficus</th>
<th>Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>patch/km</td>
<td>Σ Min max</td>
<td>patch/km</td>
</tr>
<tr>
<td>1</td>
<td>Pibi</td>
<td>F</td>
<td>10</td>
<td>1,72</td>
<td>19 1 10</td>
<td>1,18</td>
</tr>
<tr>
<td>2</td>
<td>Monkey</td>
<td>F</td>
<td>4</td>
<td>4,46</td>
<td>10 2 4</td>
<td>0,00</td>
</tr>
<tr>
<td>3</td>
<td>Sangir</td>
<td>M</td>
<td>5</td>
<td>0,81</td>
<td>4 1</td>
<td>1,02</td>
</tr>
<tr>
<td>4</td>
<td>Dewa</td>
<td>M</td>
<td>16</td>
<td>0,49</td>
<td>10 1 2</td>
<td>1,17</td>
</tr>
<tr>
<td>5</td>
<td>Denis</td>
<td>M</td>
<td>21</td>
<td>1,08</td>
<td>29 1 7</td>
<td>1,12</td>
</tr>
<tr>
<td>6</td>
<td>Amin</td>
<td>M</td>
<td>30</td>
<td>12,29</td>
<td>100 1 15</td>
<td>1,97</td>
</tr>
<tr>
<td>7</td>
<td>Nelly</td>
<td>F</td>
<td>9</td>
<td>2,61</td>
<td>26 1 12</td>
<td>0,80</td>
</tr>
<tr>
<td>8</td>
<td>Seumayam</td>
<td>M</td>
<td>27</td>
<td>4,23</td>
<td>68 1 12</td>
<td>2,05</td>
</tr>
<tr>
<td>9</td>
<td>Mawasudin</td>
<td>M</td>
<td>11</td>
<td>3,10</td>
<td>27 1 5</td>
<td>1,15</td>
</tr>
<tr>
<td>10</td>
<td>Yusniar</td>
<td>F</td>
<td>9</td>
<td>4,41</td>
<td>17 1 9</td>
<td>4,15</td>
</tr>
</tbody>
</table>
Figure 12 Distribution maps of food patch based on follow days (a. tree, b. fig, c. liana)
Discussion

Orangutans are predominantly frugivorous primates and variations in fruit and fig availability potentially have a great impact on their diet and behavior (MacKinnon 1974, Rijksen 1978). Knowledge on the availability of resources in an individual’s home range is therefore crucial for survival (Bryne 2009). Since all reintroduced individuals were captured at a young age before becoming competent foragers, adequate home range use may not be as straightforward for the reintroduced ex-rehabilitant orangutans at Jantho. Indeed, based on 142 days of ranging behavior, home range sizes of the reintroduced orangutans at Jantho varied from 0.61-78 ha. In Suaq Balimbing (peat swamp forest), the home ranges of orangutans was larger (flange male >2500 ha, female >850ha, Utami-Atmoko et al. 2009). All data on wild population study sites furthermore indicate that male ranges are larger than those of females, and that individuals of both sexes have overlapping ranges (MacKinnon 1974; Galdikas 1995; Delgado & van Schaik 2000; Singleton & van Schaik 2001). The most likely explanation for the different interpretations of orangutan movements need not necessarily be a result of differences between locations, but could equally be an artefact of study area size. It is certainly interesting to note that the largest range estimate also comes from the largest study area (Singleton 2000). Differences sizes of home range in eastern Gorillas suggest that they require more space to meet their nutritional needs (Robbins et al. 2006). Our data furthermore indicated that ranging behavior (ranging patterns and DJL) of at least 3 (Yusniar, Mawasudin, Amin) of the individuals was affected by the presence of cages, food provisioning and human oriented. DJL of these individuals differed from individuals who independently explore their new habitat and independently searched for food resources, thereby getting in contact with new individuals present at Jantho. Wild animals navigate adaptively through familiar spaces (Shettleworth 1998), so there is still much to learn about how spatial relationships are encoded (Byrne 2000), and how animals learn the renewal rate of resources (Schwagmeyer 1995). In most cases, to answer these questions, Johnson and Bryne (2007) suggest wild animals depend on inferring process from patterns of movements between unmanipulated resources, in this case provisioning foods.

Although previous studies on wild orangutan indicate sex differences in ranging behavior, the absence of such differences in our data may be due to the young age of orangutans observed during this study. Rodman (1984) explains that young males of wild orangutan appeared to be wanderers without attachment to a specific range. Additionally, the quarantine period and acclimatization cages may have affected our results. Yusniar, who stayed longer in quarantine than the others, spent more time near the cages and more time begging when the technician preparing the foods for individual in these cages than the other individuals who stayed relatively shorter times in quarantine. On one occasion, Yusniar came back to the cages even after initially following another individual exploring the forest. Amin also spent the first three month after release just around the cages. Only during the fourth month she went more into the forest, together with another individual, after which researcher then did not find her again until the end of study. Also wild great apes’ complete competence in foraging skills, especially to obtain the most demanding foods, may not be fully acquired until near adulthood (Boesh & Boesch-Achermann 2000). Juvenile and adolescents should be
prime agents of refinements given the developmental changes they continue to experience (Russon 2006). The results of this study seem to confirm these patterns.

I predicted a high home range overlap in this study because we assessed ranging behavior during the first year after release. Unfamiliarity with surrounding forest, opportunism with respect to their food, and perhaps anticipating possible agonistic encounters with their wild counterparts (trans-located individuals in this case), apparently restricted their feral activities to an area not further than 30 ha around the feeding place (acclimatization cages in this case) (Rijksen 1978). The study suggests the orangutans in our study are still learning and readjust to a more natural forest life. Therefore, I recommend a more longitudinal study, to get a clear perspective on home range use and overlap. Because food provisioning, presence of acclimitization and human oriented was affected for their ranging. These results similar than ex-rehabilitants in Tanjung Puting and ex-captive in Bukit Lawang. Ex-rehabilitant orangutans more interest came to camp, while there is human live and food. The daily ranging patterns of the immature individuals in Tanjung Puting, Bukit Lawang were centered around the feeding platform and overlapping ranges in the areas near the feeding platform and to some degree near the main camp (Snaith 1999; Yuliarta 2009). After all, learning is known to be life-long in primates and especially important at a juvenile age, during which parents act as important role models, as such contributing to juvenile great ape skill acquisition (Boesch 1993).

The ex-rehabilitant orangutans used different numbers of food patches per day and they consumed more fruits from wood tree species than fig and liana. Also here a difference between sexes has been reported in that male orangutans may eat less fruit and more bark than females (Clutton-Brock 1977), the wild orangutans in Ketambe being the exception as they like fig there. The reproductive females in Ketambe show a trend to feed more on nonfig fruits during months with higher fruit availability. In addition, orangutans in Ketambe are able to maintain a high percentage of fruit and figs in the diet year around (Wich et al. 2006). The differences of results in our study are probably due to a lack of knowledge on habitat and foraging skills in the ex-rehabilitant orangutans observed in this study. Ex-rehabilitant orangutans might be still learning to utilize the food items that were consumed by trans-located individuals who were released before them or by others ex-rehabilitant who was more ‘wild’. In contrast, many discussions of ecological cognition seem to assume that the only foraging challenge that primates face is finding the closest fruit tree (Cunningham et al. 2007). In mammals, in this case orangutan, the challenge is the ability to remember important locations (Shettleworth 1998). Furthermore, the patchy distribution of fruits may act to extend their travel distances to forage for food. Yamagiwa and Mwanza (1994) reported that day travel distance differs seasonally (rainy or dry season), although more data is needed to confirm this effect. Our results suggest that ex-rehabilitant orangutans may learn their forest survival skills during development using natural strategies. Juveniles, adolescents, and young adults, in particular, should generate such refinements given the developmental changes they experience in learning needs and opportunities, physical and cognitive abilities, and socially (Russon 2006). A primate’s decision to leave a patch and forage elsewhere, or how long it feeds in a patch, may be a response to patch depletion, interference from other consumers that prevents access to foods, or satiation. Foraging activity produces a rate of patch depletion, and this is coupled with
knowledge about availability of food elsewhere (Cant & Temerin 1984). Foraging, thus, is an ongoing process, involving repeated solutions to problems that are constantly changing in nature.

**Conclusion**

a. The presence of acclimitization cages, supplementary feeding affected the composition of diet and home range on Mawasudin (male), Amin (male) and Yusniar (female).

b. The differences of results in this research are probably due to a lack of knowledge on habitat and foraging skills in the ex-rehabilitant orangutans observed
5 GENERAL DISCUSSION

Survival of a reintroduced ex-captive is linked to three factors: the age at which the individual was captured and therefore separated from its mother; the eventual traumas linked to captivity before confiscation; and the type of rehabilitation procedures. The ideal candidate for successful reintroduction would therefore be a wild-born orang-utan, captured when at least three years old and having undergone a very brief captivity period (Grundmann 2006). During the reintroduction process ex-captive orangutans must learn to handle forest life (Russon 2003), with range 5-9yo (on this study), which includes developing appropriate foraging strategies as a central theme. Learning is known to be life-long in primates (Russon 2006). Post release monitoring is important to evaluate success or failures of readjustment of individuals, whose maternal bond has been broken at various ages, interrupting their learning phase. To be the candidates’ reintroduction, ex-rehabilitants should show the forest skills like could build a new nest, not depeent on provisioning food, avoid the humans and socialization interaction etc. during the rehabilitation process (the informations of pre-release for, see Appendix 5).

A new approach attempted on this reintroduction is that all individual had been implanted with radio telemetry, which makes it easier to find them, as we know that orangutans have a large area of movement, especially the males. This is can guide observers to find them, as it ideally will be active for two years. Also as they are released on a group with two female and one male at least, so they could learn each other and more saving from the predator. They could learn when they are stay at forest school. Based on followed by IUCN/SSC, new approach criteria of reintroduction strategy was release the ex-rehabilitations into an area with no wild orangutan population and areas which have geographical boundaries, and separted between quarantine and release site (see Appendix 5).

Tabel 11. The variables of pre-release

<table>
<thead>
<tr>
<th>Variables</th>
<th>Jantho</th>
<th>Kehje Sewen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (entered quarantine)</td>
<td>2-7 yo</td>
<td>2-8 yo</td>
</tr>
<tr>
<td>Age (released)</td>
<td>4-9 yo</td>
<td>8-13 yo</td>
</tr>
<tr>
<td>Semi wild or rehabilitant</td>
<td>Rehabilitant</td>
<td>5 rehabilitant, 1 semi-wild</td>
</tr>
<tr>
<td>Quarantine /island Time</td>
<td>0,5-3 years</td>
<td>5-6 years</td>
</tr>
<tr>
<td>Forest School</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>Habitat Type</td>
<td>Dry Land</td>
<td>Dry Land</td>
</tr>
<tr>
<td>Support Food</td>
<td>Yes</td>
<td>only 1 night</td>
</tr>
</tbody>
</table>
The acclimatization cage and interval of release was had a negative effect on movement of orangutans. Except as release point (assume natal point), provisioning food to individual on the cages by human made other individual interested has been released to always be near and feed it. The post-release variables to measure the success were activity budget, diet, dietary diversity, height, nesting behavior, DJL, association time, response to human need to record every follow the ex-rehabilitants. The pre-release variables (Tabel 11, see appendix for more details variables pre and post-release monitoring) also important to had been for measuring the success of the candidates.

Foraging is often determined by learned behaviors, such as where to go and what to eat, so if an animal exhibits these behaviors less frequently, they become less efficient at them (Orams 2002). Snaith (1999) mention that daily activity budgets, population dynamics and the behavioural repertoires of primate groups are affected by food provisioning. Studies consistently show that provisioned primates spend less time feeding and more time resting than unprovisioned groups (Altmann and Muruthi 1988).

The daily activities of the ex-rehabilitants in Kehje Sewen showed similarities, but also had differences between them. Proportion of feeding activities some individual was increasing into the green zone (wild population). This result was different with ex-rehabilitants in Tanjung Putting, Sungai Wain and Beratus (Russon 2009), but similar to Bukit Tiga Puluh (Riedler et al. 2010). The reintroduction and the study were conducted during the fruiting season; it might have affected the proportion of activity budget. Another reason was that they were free to live for at least 3 months in forest school before released, so they learned how to forage in the forest. They tried to eat various species of potential interest to them, such as the leaves of Spatolobus sp., the stems of Zingiberaceae and pith of rattans and bamboos. Generally, these species were familiar for them when they were in the forest school. Mail was the individual who explored the large Mangifera sp. tree behind our Camp. The main reason for Mails presence was more interested in the human activity with more time spent on resting. He also wanted to be fed or just took the trash of human food. Differen proportion of activity budget between individual was maybe influenced by their skill, experiences and background. Hamzah, the male orangutan who has maintained much of his wild behavior, did not seek human contact and forage like wild orangutans. During his time at the rehabilitation center, he stayed in quarantine (for general check-up), island and forest school 3. He did not spend time together with humans (keepers) (see chapter 2). However, on the first month, the proportion of his travel time was out of green zone. He travelled relatively far and quickly from the acclimatization cages. This behavior according to the result of a study by Singleton (2000), argues that the males travel further than female.

Juveniles in Kehje Sewen not only ate significantly more fruit than their conspecific’s, their diet was almost exclusively composed of fruits, and they spent less time eating flowers and spent the lower range of time feeding on invertebrates. They resemble the food choice of wild orangutans during the fruiting-season (Knott, 1998; Delgado & van Schaik, 2000). The ex-rehabilitant was somewhat more frugivorous than the wild population. Their diet choice appeared to be closer to that of natural populations than those of animals released elsewhere (e.g. Fredriksson 1995), perhaps because they had long been in forest school before release. This was assumed to be important to subsist in environments where fruits are patchily distributed in high and
low fruits (MacKinnon 1974; Knott 1998). For the next study, I recommended to collect the phenology data during high and low season. Fleage (1984) argues that food is the main reason for primates to stay in the trees and had a major influence on their movements. With orangutans being the most arboreal of apes, the ability to function optimally in three dimensional environments has been defined as a crucial point of re-adaptation to forest life, allowing the individual to locate a variety of food sources and protection from predators (Russon 2002).

To develop appropriate foraging strategies, orangutans’ ability of predator-avoidance is essential for survival and the success of reintroduction (Rijksen 1978). The ex-rehabilitants seemed to have it, as evidenced on the first observation, when Lessan and Mail were still inside acclimatization cages they climbed the cage when they heard a hornbill sound. Hamzah returned into his nest when he saw a pig on the ground. At the first day after being released, Abbie directly built a nest after bees attacked many times, as she possibly still need to explore more to choose the exact tree to build a nest. Cassey, a physically handicapped individual suddenly climbed a tree when she heard a pig sound around her. Although suffering from an accident to her right hand, she was still able to climb and move around the trees but she spent much time on the ground than others. I concluded that ex-rehabilitants avoid predators similar to wild orangutans even if they are frequently present on the ground.

At the beginning of the observation period, some ex-rehabilitants, especially Cassey preferred to stay on the ground. Somewhat, the other ex-rehabilitants also came down from the trees, occasionally to travel terrestrially, drank from the river (Lessan) or to get food (Cassey). Berlian frequently chased Cassey and Lessan from food patches. It showed the competition and dominance between the females. The presence of food and acclimatization cages also affected the ex-rehabilitants to spend time on the ground to feed. Releasing separately perhaps affected too, as it made the individuals who have been released first to come back again to acclimatization cage because humans fed other individuals inside the cages, especially Cassey (in Kehje Sewen) and Yusniar, Mawasudin (in Jantho). Another reason was possibly the presence of observers may also affect the human oriented individuals, as a consequence of their bonding to humans. MacKinnon (1974) noticed that wild orangutans use arboreal ‘highways’ while travelling, where animals follow almost branch-for-branch routes taken by different orangutans. The variations suggest that not all animals learn to climb trees at a same rate. The possible positive impacts of this learning tendency is reduction of predation-risk, but also easing the close bonding to humans, increasing opportunities to socialize with and learn from more experienced animals, and the potential influence on detecting fruit-trees, which in turn may be crucial for their choice of food items and diet breadth (Riedler 2007). Berlian and Hamzah avoided the ground, as do wild immature orangutans (MacKinnon 1974).

Galdikas (1995) suggests that grouping for immatures provides a context to increase foraging efficiency and predator avoidance, with sex ratio 2 female : 1 male. While travelling in a group, the juveniles follow the more experienced animals. Skills in communicating, building relationships, and integrating into a community are then important to re-adaptation (Russon 2000), they are learn quickly by social learning. During the study, Lessan and Mail spent the first month after being released to travel and feed together until eventually they went their separate ways. Lessan then joined
Berlian while Mail explored the forest alone. Mail frequently led the travel and chose the food patch. One example observed occurred during a honey feeding episode, where Mail tried the honey first and Lessan followed suit. This particular feeding observation led to a bee attack resulting in both orangutans quickly descending from the tree and fleeing. Lessan spent time with Berlian, feeding on mangoes and *Dyospyros* sp., this continued for around a month when mango fruiting season petered out and Lessan explore a little further, then separating from Berlian. Then, Lessan meet Cassey and they showed spent time together until end of study. Being together during the rehabilitation process made a relationship between the individuals. Berlian, Mail and Lessan had been together in forest school 2. Mail and Hamzah rarely met and travelled together. Mail and Cassey frequently spent time together; even they have been in one nest for few minutes. Existing relationship may disintegrate after release, perhaps because the transition stressed partners in a different way (Russon 1996). Interval distance <50m is common in wild population (van Noordwijk *et al.* 2009). Social feeding, especially in times of high fruit abundance, is not uncommon in wild orangutans (te Boekhorst *et al.*, 1990; Utami, 1997; Knott, 1998). Social rehabilitation is clearly needed, as early as possible, and is difficult to achieve (Rijksen 1978). Socially guided learning helps to acquire nest building skills in some reintroduced individuals (Russon *et al.* 2007).

Generally, all ex-rehabilitant orangutan in Kehje Sewen were able to build a nest, as do wild nonspecifics of this age (MacKinnon 1974; Rijksen 1978; van Noordwijk and van Schaik 2005). The most commonly happened thing is that a new nest in a tree or combineding trees or improve, rebuilt or reused an old nest as the night or day nest. The proportion of new nests were lower than the wild population, perhaps they were less motivated or lacked energy to build fresh nest or does not have the skill to choose the right tree to be a nest yet. Nesting behavior is important for reintroduced individual. There is little formal investigation but nests probably provide comfort in resting, protection from predation, protection from heat loss and protection from parasites such as mosquitoes (McGrew 2004). On some occasions, Cassey built a nest on the ground or < 5 meter with Zingiberceae leaves during one night with lower quality. Researcher still don’t know another reason why she slept on those nests, but she always watched Berlian who built a nest on a dipterocarp tree only less than 50m from Cassey. During her time in forest school, Cassey mostly reused old nest.

In soft release stage (acclimatization cages), best way that let individuals leave or back on the acclimatization cages depending on their natural instinct. But some case in Jantho, many individuals try to break the facilitation of station, so the keeper put them back to the acclimatization cages. It is important that soft release area far away or had barrier with main camp.

Generally in Jantho, DJL of these individuals differed from individuals who independently explore their new habitat and independently searched for food resources, thereby getting in contact with new individuals present at Jantho. DJL of ex-rehabilitants clearly overlap each others, and seem to be consistent over time. Unfamiliarity with surrounding forest, opportunism with respect to their food, and perhaps anticipating possible agonistic encounters with their wild counterparts (trans-located individuals in this case) apparently made them to restrict their activities to an area not bigger than 30 ha around the feeding place (acclimatization cages in this case).
Total home range estimates for them are still less than those reported from all other study on wild population. The individual in Jantho frequently returned to the acclimatization cages and spent a large amount of time there. The influence of acclimatization cage, presence of humans, and social relationship affected their foraging. Schedule of feeding time for individual inside cages attracted the individuals who are lazy or lacked skills to get food from the forest or human oriented. Accidentally, some individual who spent time near cages got more supplementary feeding than their conspecifics, which may also be influential for their choice of altitude. Previous results on other reintroduced animals suggest that supplementary feeding favors the occurrence of orangutans on the ground (Goller, 2004; Meyer, 2005). The presence results show that Mawasudin and Yusniar tend to frequently had contact with human than the others, were exploring the new environment, even cross the river use canopy which is continued (the males: Seumayam, Dewa, Dennis, Pibi). They feed together on Ficus sp., frequently with Pibi and Mawasudin too. Dewa, Dennis frequently spent time travel together and sometimes Pibi joined them to explore the Jantho forest until more than one kilometer from acclimatization cages. Deficits in foraging behavior seemingly reflected a lack of expertise and knowledge about food resources, as reported from other ex-captive orangutans (Russon 1998). The opportunities to get close to humans in this study, might affected foranging of ex-rehabilitants orangutans. So, the application of telemetry used and the distance when follow ex-rehabilitants (based distances on this study was minimum 10 meter) should be considered on the post-release monitoring.

The habitat will follow their foraging; less food availability for a species might consequently make a smaller foraging area than habitats with high food availability. But assessing food availability is difficult, on this study using the behavior animals by the concerned primate species forage using food patch size. Dewa, Dennis, Pibi are individu whos range wide than the others and mostly used as a food patch 75-151 tree. The other individu, such as monkey, she did not eat ficus for 3 years however she eat ficus leaf after 3 years release. Yusniar had a larger average of patch/km but she only used 3.9 trees. This approach indeed gives measures how animals handle their environment (Wich et al. 2002).

The background of ex-captive Orangutans seems to influence their abilities to readapt to forest life. The results of this study suggest that strong bonding to humans and presence of acclimatization cages and food provisioning will give negatively effects on there diet composition and foraging. Regular social contact to experienced orangutans on the other hand, may positively affect the acquisition of skills that are important for survival. To be at the forest school before release helps them to practice the forest skills that allows them to survive in new environment. Today, Berlian, Cassey, Lessan, Hamzah are still alive in Kehje Sewen forest and Lessan gave birth on May 2016. According to Beck 2007 and The Orangutan National Meeting in 2011 (Monitoring and Evaluation of Orangutan Indonesia Conservation Strategies and Action Plan 2007-2017), one success criteria of reintroduction orangutans is that ex-rehabilitants gave birth and made a new population. This is a good result to show that she can survive and reproduce, however assessing survival also entails long-term, systematic tracking of highly dispersed, cryptic individuals.
6 CONCLUSIONS AND RECOMMENDATIONS

Several releases have been implemented in the past, but their results have not been adequately monitored, analyzed and evaluated. One of these unresolved issues is lack of legal technical guidelines standardization for orangutan reintroduction and post-release monitoring. In general, this dissertation is devoted to address the “Indonesian National Orangutans Conservation Strategy and Action Plan 2007-2017”, particularly to complete and revise the section of “Strategies and management programs of orangutans conservation”

To review the findings in this dissertation, post-release monitoring still needed to be done longer to know the readjustment process to forest life, until they could survive and are able to reproduce.

Among the objects of observation including the handicap individual in both sites showed promising readjustment to forest life at this early readjustment stage. Through, spending more time feeding (on fruits), and were able to build a new nest. The presence of acclimatization cages, the food provisioning and human oriented affected the composition of diet, height of movement, and home range. The existence of direct interaction with humans will slow the process of self-reliance. Orangutans must not be encouraged to seek human attention and must be actively discouraged from visiting camp. This is not through physical abuse, but certainly through making loud noises and other attempts to discourage them from visiting the camp area. The absence of a natural boundary between the camp and the release area also exacerbates this situation.

Overall, these reintroduced individuals were more like wild orangutans than others that had been released, suggesting that the forest school experience led to a good preparation for life post-release. This information will contribute to attempts to evaluate factors affecting the adjustment process, and thus to optimizing future reintroduction procedures.

Orangutans with little expertise may need some training, but the following points are recommended to be considered: long-term data on same individuals are needed, reducing the human contact to a minimum, regulation and/or complete stop of supplementary feeding after released, relocation of reintroducing-areas in greater distance to the station, and release camps be made temporary. Future studies should focus in more detail on social learning as a crucial factor in acquiring knowledge about foraging and anti-predation skills during reintroduction; and to assess the effects of different strategies of pre-release preparation to identify the factors affecting reintroduction success.

**Recommendations**

a. Post-release is important while needed more time to observe the readjustment process (minimum 2 years).

b. Reducing the human contact to a minimum, regulation and/or complete stop of supplementary feeding after release, and position of the acclimitization cages should be separate from release site.
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Appendix 1 The objects study in Kehje Sewen (Doc. Basalamah 2012)
Appendix 2 (a) The forest, and (b) main camp in Kehje Sewen (Doc. Basalamah 2012)
Appendix 3 The radio telemetry model (Doc. PT.RHOI-BOSF)
Appendix 4 (a) The acclimatization cages, (b) main camp, and (c) the forest in Jantho (Basalamah 2012)
Appendix 5 Key variables for measuring success of reintroduction (Forina 2013)

Pre-release variables

- Forest habitat of origin (dryland/peat swamp/both)
- Age at capture from forest (in years, estimated if necessary)
- Direct wild capture
- Sex (male/female)
- Age at arrival at center (years)
- Arrival with mother
- Attitude to humans (tame, wild (different aggressive behavior than abused ones), abused (scars, specific fears, indication of trauma)
- Body weight (kg) on arrival
- Body condition on arrival (emaciated, normal, fat)
- Health on arrival (healthy, intermediate, very poor condition/seriously ill)
- Physical injury on arrival
- Duration in medical quarantine (date in, date out)
- Duration in center (date [first] arrival, date [first] transfer to reintroduction site)
- Duration in forest school (date in, date out)
- Forest school inside release area
- Age at release (years)
- Born in center
- Duration in cage alone
- Duration in socialization cage
- Number of visits to clinic while at center
- Basic competence right before release (nest building competence [makes own nest, sleeps in it, not on ground]; staying off the ground >90% of time; basic foraging competence: eating the major available food classes; social competence: Y, N [bonded, dominance-competent]; response to humans: avoid people, ksq/display at people, attack people, engage with people, or ignore people)
- Exposure to tourists
- Physical handicap at time of release

Post-release variables

- Activity Budgets
- Diet
- Dietary diversity (N food items6 in diet per 6 months)
- Height (especially time on ground)
- Nest building rate (N of newly built nests per day)
- Sleeping height (m, and % on ground)
- Daily path length (m) (30-min location track-log)
- Association time (% time) & mean party size
- Response to human observers
- Appropriate response to predators
- Sudden shift in home range in a given year
<table>
<thead>
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<th>Release site background</th>
<th>Presence of wild orangutans in area</th>
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<td>Release strategy (big clusters/ dispersed)</td>
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<td>Habitat Type</td>
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CURRICULUM VITAE

Author was born in Jakarta on 26th of December 1982 as the second child of three from the parent, Zein Basalamah and Laties Hidayati.

In 2001, author graduated from SMUN 67 Halim Perdana Kusuma and enrolled the Faculty of Biology, Universitas Nasional and graduated in 2005. Three years later, in 2009, author enrolled in the Graduate School, Study Program of Biology, Faculty of Mathematics and Natural Science, Indonesia University. In 2010, author enrolled her Doctoral Course at Bogor Agricultural University, majoring in Animal Bioscience under the “Joint Degree” program with a full PhD’s Scholarship from Swiss National Foundation and working with orangutans’ conservation program since 2006. This program was an international collaboration between Universitas Nasional, Bogor Agricultural University and University of Zurich, Switzerland.

Author was working with Sumatran Orangutan Conservation Program North Sumatera on 2006 and PT. Restorasi Habitat Orangutan Indonesia - Borneo Orangutan Survival Foundation since 2015 until now.