Short Communication

Opportunistic behaviour or desperate measure? Logging impacts may only partially explain terrestriality in the Bornean orang-utan *Pongo pygmaeus morio*

Brent Loken, Chandradewana Boer and Nunuk Kasyanto

Abstract There is a lack of information on how the Endangered Bornean orang-utan *Pongo pygmaeus morio* moves through its environment. Here we report on a camera-trapping study carried out over 2.5 years to investigate the orang-utan's terrestrial behaviour in Wehea Forest, East Kalimantan, Indonesia. We set 41 camera trap stations in an area of secondary forest, 36 in recently logged forest immediately adjacent to Wehea Forest, and 20 in an area of primary forest in the heart of Wehea Forest. A combined sampling effort of 28,485 trap nights yielded 296 independent captures of orang-utans. Of the three study sites, orang-utans were most terrestrial in recently logged forest, which may be only partially explained by breaks in the canopy as a result of logging activity. However, orang-utans were also terrestrial in primary forest, where there was a closed canopy and ample opportunity for moving through the trees. Our results indicate that orang-utans may be more terrestrial than previously thought and demonstrate opportunistic behaviour when moving through their environment, including using newly constructed logging roads for locomotion, possibly indicating some degree of resilience to human disturbance. This finding is important because of the potential role of sustainably logged forests for orang-utan conservation.

Keywords Borneo, camera trapping, conservation, orang-utan terrestriality, *Pongo pygmaeus morio*, sustainable logging, Wehea Forest

The Bornean orang-utan *Pongo pygmaeus* is one of the most iconic species, yet formal studies of its terrestriality have been conducted only recently (Loken et al., 2013; Ancrenaz et al., 2014). Understanding the factors that influence orang-utan terrestriality has important implications for the conservation of this Endangered great ape (Loken et al., 2013; Ancrenaz et al., 2014) but the extent and context of orang-utan terrestriality remain poorly understood (Ancrenaz et al., 2008).

Camera trapping has revolutionized the study of wildlife (Hance, 2012) and provided a method for studying cryptic behaviour such as terrestriality in orang-utans. Loken et al. (2013) reported that orang-utans in Wehea Forest, East Kalimantan, Indonesia, were almost as terrestrial as the pig-tailed macaque *Macaca nemestrina* (Caldecott, 1986) and that there was no clear relationship between canopy connectivity and terrestriality. Ancrenaz et al. (2014) conducted a large-scale analysis of camera trap data from across Borneo and Sumatra and concluded that human disturbance does not appear to be the main driver of terrestriality. These studies indicate that orang-utan terrestriality may be more common than previously thought, and that orang-utans may be capable of using landscapes that necessitate terrestriality.

We report a 2.5-year camera-trapping study of terrestriality in the north-east Bornean orang-utan *P. pygmaeus morio* in three forest types (secondary, recently logged and primary) in and near Wehea Forest (38,000 ha), which comprises mostly undisturbed forest bordered by active logging concessions (Fig. 1). A number of studies have investigated the impact of logging on orang-utans (Hardus et al., 2012). Most of these studies have focused on the effects of logging on populations (e.g. density), however, and there remains a gap in our understanding of how individuals and various species and subspecies react to logging.

In 2012 we established 41 camera trap stations, covering c. 110 km², along old logging roads in the area of secondary forest, which was last logged in 1996. Data collected at two mineral licks (sepans) were not included in the analysis. These results were reported in Loken et al. (2013) and have been modified slightly to standardize comparisons across the three forest types.

In October 2012 we set camera traps in an active logging concession adjacent to Wehea Forest. Twenty-two 100-ha compartments were logged, but not intensively, during April 2012–April 2014. Previously this logging block had contained primary forest and had no logging roads except

Brent Loken* (Corresponding author) School of Resource and Environmental Management, Simon Fraser University, Burnaby, British Columbia, Canada
E-mail brentloken@gmail.com

Chandradewana Boer Forestry Faculty, Mulawarman University, Samarinda, East Kalimantan, Indonesia

Nunuk Kasyanto Integrated Conservation, Oak Harbor, Washington, USA

*Also at: Integrated Conservation, Oak Harbor, Washington, USA

Received 22 August 2014. Revision requested 7 October 2014.
Accepted 21 October 2014. First published online 22 January 2015.

https://doi.org/10.1017/S0030605314000969 Published online by Cambridge University Press

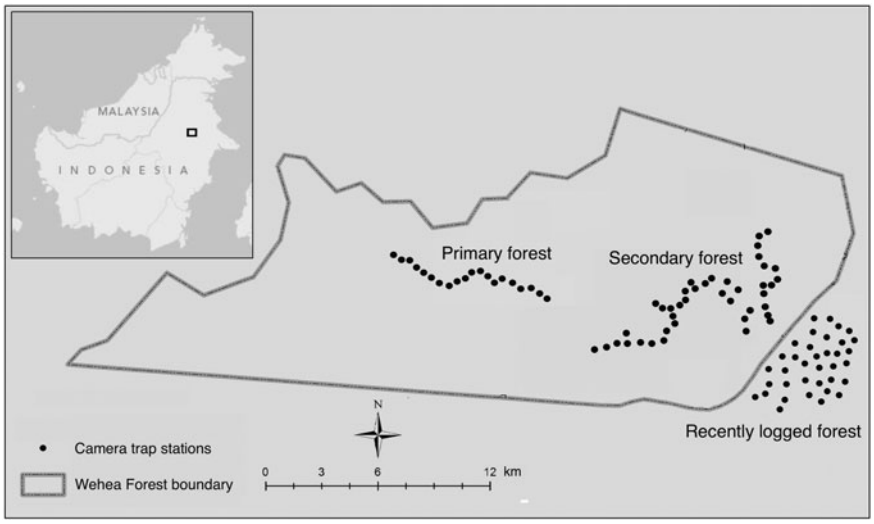

FIG 1. Locations of camera trap stations in areas of secondary, recently logged and primary forest in and near Wehea Forest, East Kalimantan, Indonesia. The rectangle on the inset shows the location of the main map on the island of Borneo.

TABLE 1 Capture history and level of terrestriality of orang-utans *Pongo pygmaeus morio* in and near Wehea Forest, East Kalimantan, Indonesia (Fig. 1), with forest type, number of trap nights, total number of captures, percentage of camera trap stations with captures, relative abundance index and ground-use score.

Forest type	Trap nights	Total captures	% of stations with captures	Relative abundance index	Ground-use score
Secondary forest*	7,661	63	58.54	0.82	0.79
Recently logged forest	15,775	189	91.67	1.20	1.87
Primary forest	5,049	44	75.00	0.87	0.87

*Data from secondary forest were originally reported in Loken et al. (2013).

for an access road used to enter Wehea Forest. We set 36 camera trap stations along newly constructed secondary logging roads in 13 compartments, immediately following the cessation of logging activities there. All stations remained in place until April 2014. In July 2013 we set 20 camera trap stations in primary forest in the heart of Wehea Forest (Fig. 1). All stations were set along ridgelines that were part of a middle transect developed in Wehea Forest for research purposes. These stations remained in place until June 2014. In each area we used Bushnell Trophy Cam camera traps (Bushnell, Cody, USA), which were fixed to trees, c. 50 cm from the ground, and fitted with a plastic cover above and a bed of leaves below to protect against rain and mud. Each camera was set to take three pictures per trigger, with a reset time of 1 s.

Our study comprised 7,661 trap nights in secondary forest, 15,775 trap nights in recently logged forest and 5,049 trap nights in primary forest. Photographs from each area were sorted by species, and the time and date of each independent capture (photographs taken > 1 hour apart) were recorded. Amongst c. 300,000 photographs we recorded 63 of orang-utans in secondary forest, 189 in recently logged forest and 44 in primary forest.

We used two parameters as estimates of orang-utan terrestriality across study sites. The first parameter, relative abundance index, was used to compare orang-utan-trapping success (Ancrenaz et al., 2012) and is a good indicator of the amount of effort (total captures per trap night) required to obtain photographs of orang-utans. The second parameter was ground-use score, which was calculated as the ratio of independent photographs of orang-utans to the total number of independent photographs of all species at each study site, multiplied by the percentage of stations that recorded orang-utans. Together, these parameters are a good indicator of the level of orang-utan terrestriality at each of our study sites (Table 1).

Orang-utans were more terrestrial in the recently logged forest (relative abundance index 1.20, ground-use score 1.87), which is consistent with Ancrenaz et al. (2014) and indicates that anthropogenic canopy disturbances may increase orang-utan terrestriality (Rijksen & Meijaard, 1999). However, our results also indicate a high level of terrestriality in both primary (relative abundance index 0.87, ground-use score 0.87) and secondary forest areas (relative abundance index 0.82, ground-use score 0.79), indicating that anthropogenic canopy disturbances are not the only

https://doi.org/10.1017/S0030605314000969 Published online by Cambridge University Press

TABLE 2 Number of records of orang-utans in each age/sex class, from secondary, recently logged and primary forest in and near Wehea Forest (Fig. 1).

Age/sex class	Secondary forest	Recently logged forest	Primary forest
Flanged male	23	44	16
Unflanged male	8	31	2
Female without juvenile	10	16	5
Female with juvenile	16	61	13
Juvenile of indeterminate sex	3	16	0
Adult of indeterminate sex	3	21	8

driver of terrestriality. Loken et al. (2013) demonstrated that orang-utans were also terrestrial in areas with high canopy connectivity. This is consistent with our findings: orang-utans also demonstrated terrestrial behaviour in the primary forest, which had a closed canopy and ample opportunity for moving through trees.

Possible explanations for the varying levels of terrestriality are differences in abundance and visibility of orang-utans across the study sites. However, we believe these are not the primary causes of differences between our estimates. Firstly, encounter rates with orang-utans were highest in the secondary forest and lowest in the recently logged forest. If used as a naive estimate of relative abundance (Loken et al., 2013), we would expect encounter rates to be highest in the recently logged forest. Secondly, visibility was the same in each forest type, as cameras were set along similar types of features (e.g. roads, ridge lines, trails).

Previously, terrestrial behaviour in orang-utans was considered uncommon and used only as a means of acquiring resources (MacKinnon, 1974). Our results indicate that terrestriality may be a regular strategy, employed almost equally by males and females as a means of locomotion (Table 2). In the recently logged forest, where orang-utans demonstrated the highest degree of terrestriality, most photographs of orang-utans appeared to show the primates walking along the road rather than across it, which would be the case if they were forced to the ground by a break in the canopy. This is consistent with photographs from the other forest types, and indicates that orang-utans may be taking advantage of both anthropogenic (e.g. roads) and natural (e.g. ridgelines) features in their environment, thus demonstrating opportunistic and resilient behaviour.

Orang-utans may be using newly created roads opportunistically but the level of disturbance they can tolerate is still unknown. Orang-utan populations can be maintained in sustainably logged forests (Knop et al., 2004; Husson et al., 2009; Ancrenaz et al., 2010) and these forests should be incorporated into orang-utan conservation strategies (Meijaard et al., 2010; Wich et al., 2012; Wilson et al., 2014). We must be careful, however, not to reinforce the notion that orang-utans can survive in any human-altered landscape. Orang-utans still need trees, and lots of them, and protection of Borneo's remaining forests should continue to be of highest priority for both Indonesia and the global community.

Acknowledgements

We are grateful to the Wehea Management Body and Lembaga Adat of Nehas Liah Bing for allowing us to conduct research in Wehea Forest, and to the State Ministry of Research and Technology of Indonesia for granting us permission to conduct research. We thank Lee Qi for providing maps of Wehea Forest. We are also indebted to the individuals and organizations that provided logistical and organizational support in the field: the Wehea Rangers and the Department of Forestry at Mulawarman University. Financial support was provided by the following institutions and funding agencies: Vanier Canada Graduate Scholarship, Pierre Elliot Trudeau Foundation, LUSH Cosmetics, Disney Worldwide Conservation Fund, Integrated Conservation, and The Rufford Small Grants Foundation.

References

ANCRENAZ, M., AMBU, L., SUNJOTO, I., AHMAD, E., MANOKARAN, K., MEIJAARD, E. & LACKMAN, I. (2010) Recent surveys in the forests of Ulu Segama Malua, Sabah, Malaysia, show that orang-utans (*P.p. morio*) can be maintained in slightly logged forests. *PLoS ONE*, 5(7), e11510.

ANCRENAZ, M., HEARN, A.J., ROSS, J., SOLLMANN, R. & WILTING, A. (2012) *Handbook for Wildlife Monitoring using Camera-traps*. BBEC II Secretariat, Kota Kinabalu, Malaysia.

ANCRENAZ, M., MARSHALL, A., GOOSSENS, B., VAN SCHAIK, C., SUGARDJITO, J., GUMAL, M. & WICH, S. (2008) *Pongo pygmaeus*. In *IUCN Red List of Threatened Species v. 2014.2*. Http://www.iucnredlist.org [accessed 22 August 2014].

ANCRENAZ, M., SOLLMANN, R., MEIJAARD, E., HEARN, A.J., ROSS, J., SAMEJIMA, H. et al. (2014) Coming down from the trees: Is terrestrial activity in Bornean orangutans natural or disturbance driven? *Scientific Reports*, 4, 4024.

CALDECOTT, J.O. (1986) *An Ecological and Behavioural Study of the Pig-Tailed Macaque*. Karger, Basel, Switzerland.

HANCE, J. (2012) The camera trap revolution; how a simple device is shaping research and conservation worldwide. In *Life is Good: Conservation in an Age of Mass Extinction*, pp. 59–75. Mongabay, Menlo Park, USA.

https://doi.org/10.1017/S0030605314000969 Published online by Cambridge University Press

Hardus, M.E., Lameira, A.R., Menken, S.B.J. & Wich, S.A. (2012) Effects of logging on orangutan behaviour. *Biological Conservation*, 146, 177–187.

Husson, S.J., Wich, S.A., Marshall, A.J., Dennis, R.D., Ancrenaz, M., Brassey, R. et al. (2009) Orangutan distribution, density, abundance and impacts of disturbance. In *Orangutans: Geographic Variation in Behavioral Ecology and Conservation* (eds S. Wich, S.S.U. Atmoko, T.M. Setia & C.P. van Schaik), pp. 77–96. Oxford University Press, New York, USA.

Knop, E., Ward, P.I. & Wich, S.A. (2004) A comparison of orang-utan density in a logged and unlogged forest on Sumatra. *Biological Conservation*, 120, 183–188.

Loken, B., Spehar, S. & Rayadin, Y. (2013) Terrestriality in the Bornean orangutan (*Pongo pygmaeus morio*) and implications for their ecology and conservation. *American Journal of Primatology*, 75, 1129–1138.

MacKinnon, J. (1974) The behaviour and ecology of wild orang-utans (*Pongo pygmaeus*). *Animal Behaviour*, 22, 3–74.

Meijaard, E., Albar, G., Nardiyono, Rayadin, Y., Ancrenaz, M. & Spehar, S. (2010) Unexpected ecological resilience in Bornean orangutans and implications for pulp and paper plantation management. *PLoS ONE*, 5(9), e12813.

Rijksen, H.D. & Meijaard, E. (1999) *Our Vanishing Relative: The Status of Wild Orang-utans at the Close of the Twentieth Century*. Kluwer Academic Publishers, Dordrecht, Netherlands.

Wich, S.A., Gaveau, D., Abram, N., Ancrenaz, M., Baccini, A., Brend, S. et al. (2012) Understanding the impacts of land-use policies on a threatened species: Is there a future for the Bornean orang-utan? *PLoS ONE*, 7(11), e49142.

Wilson, H.B., Meijaard, E., Venter, O., Ancrenaz, M. & Possingham, H.P. (2014) Conservation strategies for orangutans: reintroduction versus habitat preservation and the benefits of sustainably logged forest. *PLoS ONE*, 9(7), e102174.

Biographical sketches

Brent Loken is interested in the ecology and conservation of rare and threatened animals, with a particular focus on mammals from Kalimantan. He also studies how ecological and social variables can combine to yield sustainable (or unsustainable) outcomes in complex social–ecological systems. In 2009 Brent founded Integrated Conservation, an NGO committed to advancing education, research and development, mainly in Kalimantan. Chandradewana Boer has been conducting research on various species in Kalimantan for over 30 years and is interested in issues involving conservation and sustainable management of wildlife, with a particular interest in birds. Nunuk Kasyanto has been involved in education, research and conservation in Kalimantan for over 20 years.

https://doi.org/10.1017/S0030605314000969 Published online by Cambridge University Press