



## TRAVEL ADAPTATIONS OF BORNEAN AGILE GIBBONS *HYLOBATES ALBIBARBIS* (PRIMATES: HYLOBATIDAE) IN A DEGRADED SECONDARY FOREST, INDONESIA

Susan M. Cheyne<sup>1</sup>, Claire J.H. Thompson<sup>2</sup> & David J. Chivers<sup>3</sup>

<sup>1,2</sup>Orangutan Tropical Peatland Project, Centre for International Cooperation in Sustainable Management of Tropical Peatland (CIMTROP), University of Palangka Raya, Indonesia

<sup>1</sup>Wildlife Conservation Research Unit, Department of Zoology, Tubney House, Abingdon Road, Oxon, OX13 5QL, UK

<sup>2,3</sup>Wildlife Research Group, Anatomy School, University of Cambridge, UK

<sup>1</sup>susan.cheyne@zoo.ox.ac.uk (corresponding author), <sup>2</sup>claire\_t009@yahoo.co.uk, <sup>3</sup>djc7@cam.ac.uk

ISSN

Online 0974-7907

Print 0974-7893

OPEN ACCESS

**Abstract:** Data are presented on the locomotion of Bornean Agile Gibbons (*Hylobates albibarbis*) in a disturbed peat-swamp forest. Our results indicate that gibbons favour continuous-canopy forest, higher canopy heights and trees with a larger diameter at breast height. Gibbons select these trees despite the study site being dominated by broken-canopy forest and small trees. Gibbons also change frequently between brachiation, climbing, clambering and bipedal walking in this disturbed forest depending on the size of gap to be crossed. Gibbons are shown to be capable of adapting to some human-induced disturbances in forest continuity and canopy height, and to the presence of smaller trees, e.g., after selective logging. Despite this, gibbons are still limited to crossing gaps of  $\leq 12$ m in a single movement, and more research is needed to quantify levels of disturbance gibbons can tolerate.

**Keywords:** Brachiation, Gibbon, *Hylobates albibarbis*, locomotion, peat-swamp forest.

**Indonesian Abstract:** Data disajikan pada perilaku daya penggerak dari owa Kalimantan (*Hylobates albibarbis*) di hutan gambut sekunder. Hasil kami menunjukkan owa lebih suka kanopi hutan tertutup, ketinggian kanopi dan pohon-pohon dengan diameter yang lebih besar. Owa-owa pilih pohon-pohon besar meskipun lokasi penelitian didominasi oleh kanopi hutan terbuka dan pohon-pohon kecil. Owa-owa juga sering berubah antara 'brachiation', mendaki, memanjat dan berjalan dua kaki di hutan terganggu tergantung pada ukuran hutan buka yang harus menyeberang. Owa-owa terbukti mampu beradaptasi dengan beberapa manusia yang disebabkan gangguan dalam kontinuitas hutan dan tinggi kanopi, dan keberadaan pohon kecil, misalnya, setelah tebang pilih. Meskipun demikian, owa masih terbatas untuk menyeberangi kesenjangan dari  $\leq 12$ m dalam satu gerakan, dan penelitian lebih lanjut diperlukan untuk mengukur tingkat gangguan owa dapat mentolerir

**DOI:** <http://dx.doi.org/10.11609/JoTT.o3361.3963-8> | **ZooBank:** urn:lsid:zoobank.org:pub:D33B37B7-0E29-41DE-8662-8FAC77E71ED4

**Editor:** Mewa Singh, University of Mysore, Mysore, India

**Date of publication:** 26 March 2013 (online & print)

**Manuscript details:** Ms # o3361 | Received 23 September 2012 | Final received 11 February 2013 | Finally accepted 07 March 2013

**Citation:** Cheyne, S.M., C.J.H. Thompson & D.J. Chivers (2013). Travel adaptations of Bornean Agile Gibbons *Hylobates albibarbis* (Primates: Hylobatidae) in a degraded secondary forest, Indonesia. *Journal of Threatened Taxa* 5(5): 3963–3968; doi:10.11609/JoTT.o3361.3963-8.

**Copyright:** © Cheyne et al. 2013. Creative Commons Attribution 3.0 Unported License. JoTT allows unrestricted use of this article in any medium, reproduction and distribution by providing adequate credit to the authors and the source of publication.

**Funding:** Funding was provided to CJHT by Rufford Small Grants for Nature Conservation.

**Competing Interest:** None.

**Acknowledgements:** This work was carried out within the OuTrop-CIMTROP multi-disciplinary research project in the northern Sabangau forest, Central Kalimantan, Indonesia. We gratefully acknowledge the invaluable contribution of all the researchers and staff that assisted with the project. We gratefully thank the Centre for the International Cooperation in Management of Tropical Peatlands (CIMTROP) for sponsoring our research and providing invaluable logistical support. We thank the Indonesian Ministry of Science and Technology (RISTEK) and Director General of Nature Conservation (PHKA) for permission to carry out research in Indonesia. We are very grateful to Warren Brockelman, Mark Leighton and an anonymous reviewer for comments on earlier drafts of this manuscript.



Habitat disturbance presents a major problem for arboreal primates that travel exclusively in the canopy (Cannon & Leighton 1994; Cannon et al. 1994), where efficient travel requires the animal to take the most direct route available. Natural (e.g., tree-falls) and unnatural canopy gaps (e.g., from logging, clearing for hunting fruit bats and fire damage) may pose a problem if the canopy becomes highly uneven, producing less direct travel paths than were originally available (Estrada & Coates-Estrada 1996; Kakati 2000; Onderdonk & Chapman 2000; Estrada et al. 2002; Baranga 2004; Anderson et al. 2007; Chapman et al. 2007; Cristobal-Azkarate & Arroyo-Rodriguez 2007). Indonesia retains about 52.1%, or about 94,432,000ha, of original forest according to FAO (Food and Agriculture Organization of the United Nations <http://www.fao.org/forestry/en/>). Of this 3.8% (3,549,000ha) is classified as primary forest, the most biodiverse and carbon-dense form of forest. These alarming data on type of forest type remaining indicate that the majority of remaining forest, and thus remaining gibbon habitat, will have experienced some form of disturbance. Gibbons are obligate canopy dwellers, who require intact canopy structure for all aspects of their behavioural ecology (Carpenter 1972; Andrews & Groves 1976; Gittins 1979; Bleisch & Chen 1990; Chivers 1990; Feeroz & Islam 1992; Asquith 1995; Cannon & Leighton 1996; Campbell et al. 2008; Cheyne 2010; Hamard et al. 2010; Kakati 2000; Marshall 2010; Oka et al. 2000). Highly territorial animals such as gibbons may remain within their former ranges even following intensive forest clearance or fires which destroy a high proportion of trees (Marsh & Wilson 1981; Marsh et al. 1987).

Logging (legal and illegal) creates large patches of fragmented forest through (1) fragmentation at ground level (roads and skid trails) and (2) creating gaps in the canopy, making movement more difficult for arboreal species (Meijaard et al. 2005). Selective-logging has been seen as the long-term 'compromise' for both humans and animals, but areas that are set to be logged selectively are often over-exploited by the timber industry. In this study we provide insight into the actual level of disturbance which gibbons can tolerate by documenting gibbon preferences in a disturbed forest and the long-term implications of forest degradation on gibbon behaviour. The future of gibbon conservation and management depends on understanding how well they can adapt to these altered canopy conditions.

## Materials and Methods

The study was carried out in the Natural Laboratory for Peat-swamp Forest in the northeastern corner of the Sabangau Forest (2°19'S & 113°54'E, Fig. 1) over a period of nine months from September 2005 to June 2006. The area is operated by the Centre for International Cooperation in Management of Tropical Peatlands (CIMTROP). Comparisons between wet (flooded) and dry seasons can provide insight into felid movements in response to a potentially spatially mobile prey base. Tropical peatlands are one of the largest near-surface reserves of terrestrial organic carbon, and hence their stability has important implications for climate change (Page et al. 2002). Burning peatland in Indonesia may release 13–40 % of the mean annual global carbon emissions from fossil fuels (Page et al. 2002; Aldhous 2004; Rieley et al. 2004). It is the largest area of contiguous lowland rainforest remaining in Kalimantan and is recognised as one of the most important conservation areas in Borneo for a variety of reasons including carbon storage, regulation of water supplies and conservation of flora and fauna (Aldhous 2004). The area has been subjected to long-term legal logging, illegal logging, fire and drainage from logging canals, but is now the focus of concerted protection and restoration efforts (Morrogh-Bernard et al. 2003; Cheyne 2010).

## Study Gibbons

Gibbons in this study site are breeding on average every 2.5 years (Cheyne in prep.) and their density is estimated at 3.92 groups/km<sup>2</sup> (Cheyne et al. 2007; Hamard et al. 2010).

Data were collected on 24 individuals from six groups and a total of 1,212 data points were recorded by means of continuous, consecutive behavioural sampling on focal individuals for the duration of one follow from morning to evening sleeping trees. The sampling unit was a complete segment of locomotion when movement was initiated from a resting position and ended when the focal individual returned to a resting state, following the definitions of (Cannon & Leighton 1994). Only full locomotion sequences, where both start and end positions could be observed, were included in the analysis. All age/sex classes were included to look for differences between the effects of body size and the presence of infants ventrally. Data were collected for climbing, leaping, brachiation and bipedal walking and merged into two main locomotor modes—brachiating and leaping for comparison. It was decided to focus only on the two most recognisable and distinguishable forms of locomotion to reduce inter-observer error:

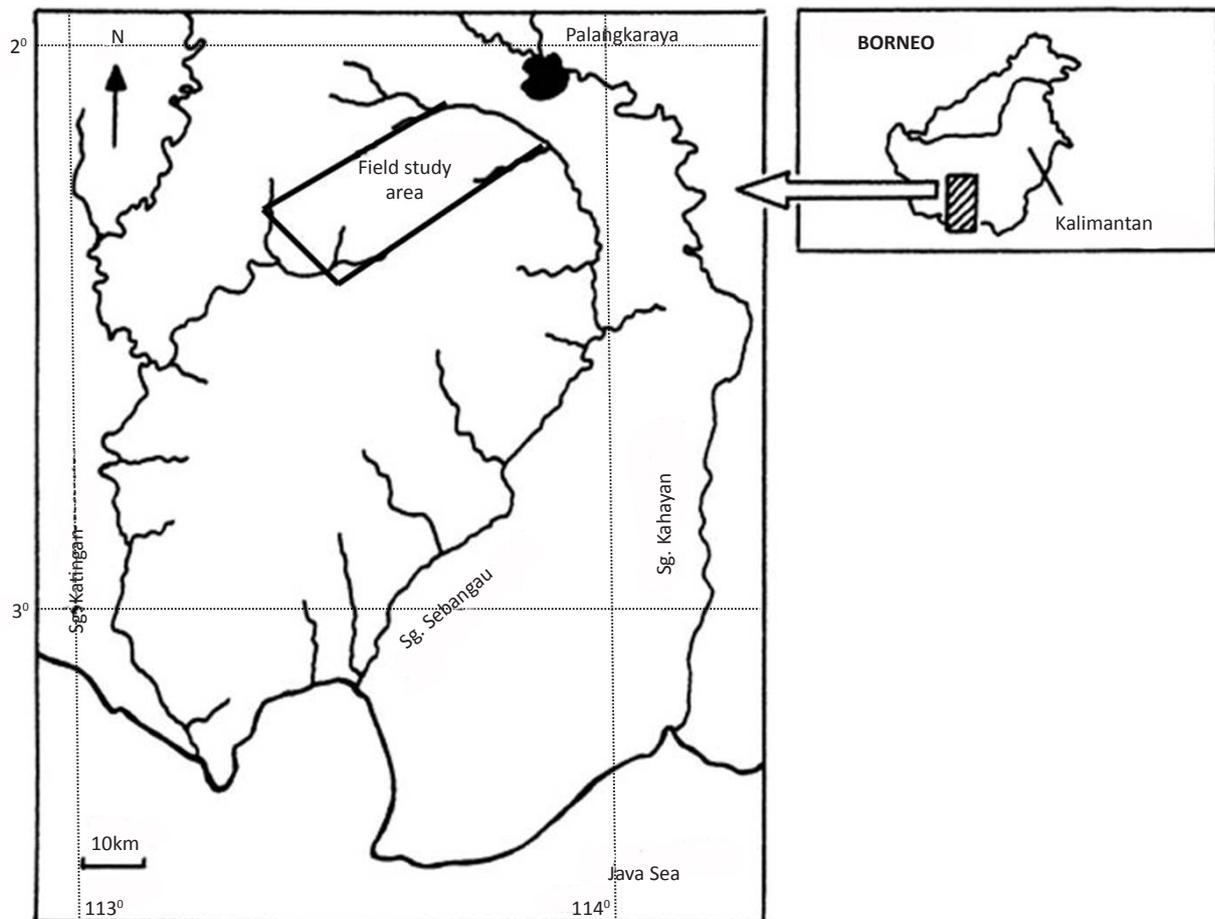


Figure 1. Map of study site with camera locations and all major villages.

leaping, defined as discontinuous progression where the hindlimbs provide all the propulsion, and brachiation (arm swinging), defined as discontinuous progression in which the forearms are used in a suspended posture (Fleagle 1976; Cant 1986; Cannon & Leighton 1994). The authors recognise the importance of studying several forms of locomotion and we recommend that in such cases data are collected by only one or two researchers to ensure that there is no confusion between locomotion types.

The majority of observations were recorded during follows typically lasting up to six hours (SD 1.3–8.4). Training consisted of independently testing individuals' ability to estimate heights tested against known standards (where tree heights were measured using clinometers and range finders). Observers were sampled by SMC to measure inter-individual variability in estimating heights, canopy condition and locomotion as part of the long-term data collection (Cheyne 2010).

Tree variables recorded were (1) height of tree in

which the gibbon started and finished the locomotion bout; (2) average surrounding canopy height measured at the location where the locomotion started; (3) distance of the travel bout in metres (between the two trees) was estimated using methods already in place for estimating the distance a gibbon moves by extrapolating from the distance on the ground. These methods are also subjected to rigorous training and regular evaluation (Cheyne 2010); (4) forest type at the start location was estimated as follows; 'continuous canopy'—trees of roughly the same heights, not much undergrowth; 'continuous with emergents'—similar to 'continuous canopy' but with more tall, emergent trees and slightly more undergrowth; 'broken canopy'—the commonest type found in the study area; uneven canopy and thick undergrowth and 'gaps'—areas that had been subjected to some disturbance following the descriptions in Fig. 2. All heights were measured using visual estimation following extensive training. Height categories used were 1–5 m, 6–10 m, 11–15 m, 16–20 m, 21–25 m, 26–

30 m, 31–35 m, 36–40 m and >40m (Cheyne 2010).

### Habitat Data Collection

Following, and adapting, methods from (Cannon & Leighton 1994), four plots were set up randomly in each of the six groups territories using random number generation based on GPS coordinates. Twenty-four 50m transects (four/group) were constructed within the territories of each of the six groups. This is half the length of transects used by (Cannon & Leighton 1994), due to the frequent changes in habitat type at the study area. Cannon & Leighton (1994) have described the small dbh size of trees to be a good indicator of poor-quality forest. Habitat data were collected in order to compare the frequency of use of habitat structure to its frequency of availability. At 25m intervals along the transect (3 points/transect, 72 points in total) the distance to the nearest tree with a diameter at breast height (dbh) larger than 6cm was measured by means of the point-centered quarter method (Mueller-Dombois & Ellenberg 1977) and tree height and average canopy height were measured using methods already described.

Additionally, a 20m line was laid at right angles to the transect on alternating sides. At 5m intervals along this line (5 points/line, 360 total) the forest type and canopy height were sampled. The transects were always moved at least 25m away from any original tracks used for walking, so as to give a fair representation of the majority of actual forest structure. The location of each transect was determined in a stratified random fashion with the proviso that transects had to remain entirely within the same habitat type and within the home ranges of the study groups. Preference for different structural features was measured using Jacob's D value (Jacobs 1974):

$$D = (r-p)/(r+p-2rp)$$

where  $r$  is the relative frequency of use and  $p$  is the relative value of availability. Jacob's D value is delimited between -1 and 1, and is symmetrical around 0 which indicates neutrality i.e. neither disproportionate avoidance nor selection. Statistical tests were performed with SPSS v16.0.

### Results

**General travel:** Brachiation was the most common form of locomotion (66% of observations,  $n=800$ ) followed by leaping (34%,  $n=412$ ;  $\chi^2=11.59$ ,  $d.f=1$ ,  $n=1269$ ,  $P<0.001$ ). Leaping was employed significantly more for travelling shorter distances (mean: 3.96m, range 1–4 m) and brachiation for longer distances (mean: 6.38m, range 5–9 m), one-way ANOVA:  $F=61.329$ ,  $d.f=1$ ,  $n=1268$ ,  $P<0.001$ , Fig. 2.

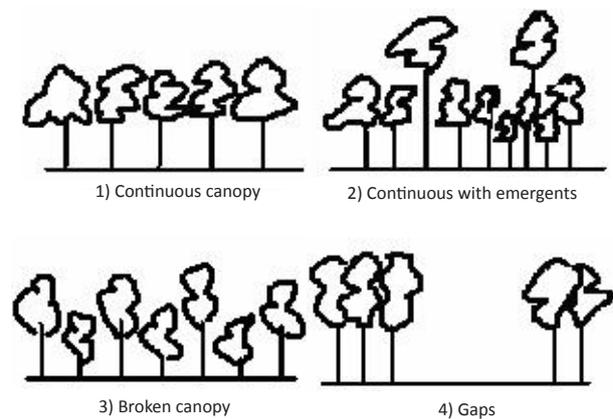


Figure 2. Diagrams of forest type were used as a visual aid in the field.

**Canopy height:** The availability of canopy height for travel is dominated by 11–15 m and 16–20 m (total 61%, Fig. 3). Jacob's D values for canopy height were 0–10 m,  $D=-0.9$ ; 11–20,  $D=0$  and 21–30 m,  $D=0.3$ . There is a significant preference for canopy height of 21–30 m or main canopy ( $\chi^2=12.19$ ,  $d.f=2$ ,  $P>0.005$ ) and a significant avoidance of trees 1–10 m tall ( $\chi^2=9.9$ ,  $d.f=2$ ,  $P>0.005$ ).

**Habitat type:** Broken canopy was by far the most available forest type in the study area (59%) with gaps representing 24%, continuous forest with emergents 14% and continuous canopy only 3%. The Jacob's D value of forest type could only be calculated if the expected values were  $\geq 1.0$ , so 'continuous canopy'

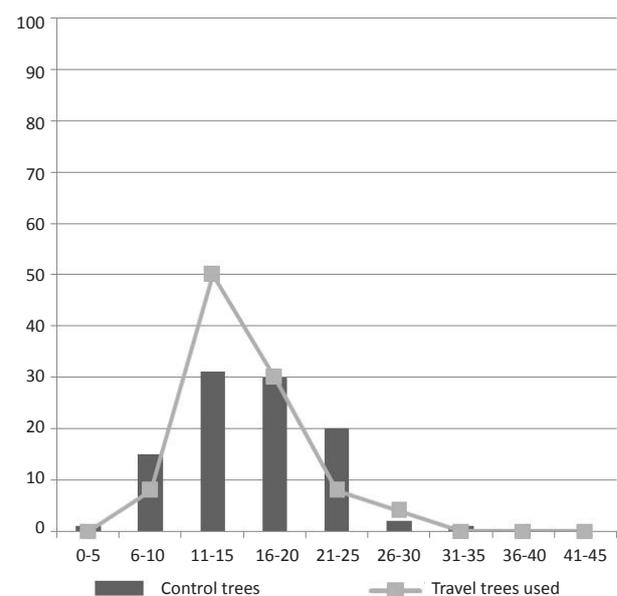


Figure 3. Percentage distribution of control tree canopy height (m) within all gibbon territories and percentage tree height use by the gibbons.

and 'continuous with emergents' were combined for analysis, as the frequency of availability for 'continuous canopy' was constantly low (hereafter known as continuous canopy). Jacob's D values for canopy type are continuous and continuous emergent combined  $D=0.4$ ; broken canopy  $D + 0$  and gap  $D=-0.5$ . There is a significant preference for continuous canopy ( $\chi^2=13.9$ ,  $d.f=1$ ,  $P>0.001$ ) and a significant avoidance of gaps and broken canopy ( $\chi^2=10.1$ ,  $d.f=2$ ,  $P>0.005$ ).

### Discussion and Conclusions

The frequency of observed brachiation exceeded that recorded by Fleagle (1976) for Siamang (*Symphalangus syndactylus* 50%) and by Cannon & Leighton (1994) for Bornean Agile Gibbons (*H. albibarbis*, 48%). Data reported in this study (66%) are closer to those reported by (Andrews & Groves 1976a) for Lar Gibbons (*Hylobates lar*, 80%). Despite this, gibbons are limited in the distances they can cross with each locomotion mode, with the maximum distance seen crossed by brachiation being 12m and 6m by leaping.

Gibbons are actively selecting bigger, taller trees with a more uniform canopy than is predominantly available. The amount of time spent in 'broken canopy' far outweighs the others. It must be noted that the selection of larger and taller trees by the gibbons in Sabangau is probably due to the extensive damage and lack of continuity in much of the canopy but could also be a behavioural adaptation to increased food availability in larger trees (Cheyne 2008) or predator avoidance (Cheyne et al. 2012). This demonstrates that selective logging has affected the gibbons' ability to move through the canopy though gibbons in highly disturbed areas have been known to travel on the ground (S.M. Cheyne pers. obs. 2003 & 2006).

Uneven canopy and canopy gaps pose a crucial problem for arboreal primates, as they either present a very large break in the canopy or a succession of smaller breaks (uneven canopy). Efficient, cost-effective travel through the canopy, in terms of reducing distance (and time) of direct travel between two points, is heavily constrained by the presence of gaps (Cannon & Leighton 1994). Gibbons may be hypothesised to select continuous forest types over discontinuous types and higher canopies over low. During travel, gibbons tend to follow established routes through the trees, referred to as 'arboreal highways' (Chivers 1974). These routes minimise their chance of encountering gaps and also provides support for the theory that they appear to be selecting actively certain structures for travel.

The key findings of this study are: (1) gibbons

can adapt in their locomotor ecology to the effects of selective logging, i.e., reduce the level of travel by brachiation and increase other modes of travel; (2) the gibbons are choosing a 'limited' resource, the continuous tall canopy, but there is evidence of a level of disturbance to which they cannot adapt. Loss of trees between 6–15 m and/or 7–17 cm dbh would be severely detrimental to this gibbon population given the limited availability of larger trees following the selective logging. The exact percentage loss of these trees which gibbons could tolerate needs more work; (3) gibbons clearly prefer continuous canopy. We did not observe crossings of gaps larger than 12m, which may be a constraint of the gibbons' physical abilities rather than a direct response to the presence of gaps, i.e., gibbons cannot cross gaps >12m in one movement. There were no parts of the forest which were completely avoided. Daily path length for Sabangau gibbons ranges from 1–5 km depending on season (Cheyne 2010), considerably more than that reported for lar gibbons in Khao Yai (Bartlett 2009), thus, because the gibbons must be more selective in their use of the habitat they may be having to travel much further though this requires more testing.

### REFERENCES

- Aldhous, P. (2004). Borneo is burning. *Nature* 432: 144–146.
- Anderson, J., G. Cowlishaw & J.M. Rowcliffe (2007). Effects of forest fragmentation on the abundance of *Colobus angolensis palliatus* in Kenya's coastal forests. *International Journal of Primatology* 28: 637–655.
- Andrews, P. & C.P. Groves (1976). Gibbons and brachiation, pp. 167–218. In: Rumbaugh, D.M. (ed.). *Gibbon and Siamang Vol 4. Suspensory Behaviour, Locomotion and Other Behaviours of Captive Gibbons*. Karger, Basel.
- Asquith, N.M. (1995). Javan gibbon conservation: why habitat protection is crucial. *Tropical Biodiversity* 3: 63–65.
- Baranga, D. (2004). Forest fragmentation and primates' survival status in non-reserved forests of the 'Kampala area', Uganda. *African Journal of Ecology* 42: 70–77.
- Bartlett, T.Q. (2009). *The Gibbons of Khao Yai: Seasonal Variation in Behavior and Ecology*. Pearson, Upper Saddle River.
- Bleisch, W. & N. Chen (1990). Conservation of the Black-crested Gibbon in China. *Oryx* 24: 147–156.
- Campbell, C., N. Andayani, S.M. Cheyne, J. Pamungkas, B. Manullang, F. Usman, M. Wedana & K. Traylor-Holzer (2008). Indonesian Gibbon Conservation and Management Workshop Final Report. Apple Valley, MN, USA: IUCN/SSC Conservation Breeding Specialist Group.
- Cannon, C.H. & M. Leighton (1994). Comparative locomotor ecology of gibbons and macaques: Selection of canopy elements for crossing gaps. *American Journal of Physical Anthropology* 93: 505–524.
- Cannon, C.H. & M. Leighton (1996). Comparative locomotor ecology of gibbons and macaques: does brachiation minimize travel costs? *Tropical Biodiversity* 3: 261–267.
- Cannon, C.H., D.R. Peart, M. Leighton & K. Kartawinata (1994). The structure of lowland rainforest after selective logging in West Kalimantan, Indonesia. *Forest Ecology and Management* 67: 49–68.

- Cant, J.G.H. (1986).** Locomotion and feeding postures of spider and howling monkeys: field study and evolutionary interpretation. *Folia primatologica* 46: 1–14.
- Carpenter, C.R. (1972).** Suspensory behaviour of gibbons *Hylobates lar*: a photoessay, pp. 1–18 In: Rumbaugh, D.M. (ed.). *Gibbon and Siamang: Suspensory behaviour, locomotion and other behaviours of captive gibbons; cognition*. S. Karger, Basel.
- Chapman, C.A., L. Naughton-Treves, M.J. Lawes, M.D. Wasserman & T.R. Gillespie (2007).** Population declines of colobus in Western Uganda and conservation value of forest fragments. *International Journal of Primatology* 28: 513–528.
- Cheyne, S.M. (2008).** Feeding ecology, food choice and diet characteristics of gibbons in a disturbed peat-swamp forest, Indonesia. In: Lee, P.C., P. Honess, H. Buchanan-Smith, A. MacLarnon & W.I. Sellers (eds.). 22nd Congress of the International Primatological Society (IPS). Top Copy, Bristol, Edinburgh, UK, 342pp.
- Cheyne, S.M. (2010).** *Behavioural ecology and socio-biology of gibbons (Hylobates albibarbis) in a degraded peat-swamp forest*. In J. Supriatna and S. L. Gursky (Eds.) *Indonesian Primates* (pp. 121–156) New York: Springer.
- Cheyne, S.M. (in prep).** Reproductive patterns and dispersal in gibbons (*Hylobates albibarbis*) in the Sabangau peat-swamp forest, Indonesia
- Cheyne, S.M., C.J.H. Thompson, A.C. Phillips, R.M.C. Hill & S.H. Limin (2007).** Density and population estimate of Gibbons (*Hylobates albibarbis*) in the Sabangau catchment, Central Kalimantan, Indonesia. *Primates* 49: 50–56.
- Cheyne, S.M., A. Höing, J. Rinear & L.K. Sheeran (2012).** Sleeping site selection by agile gibbons: The influence of tree stability, fruit availability, and predation risk. *Folia Primatologica* 83: 299–311.
- Chivers, D.J. (1974).** *The Siamang in Malaya: A Field Study of A Primate in Tropical Rainforest*. Karger, Basel.
- Chivers, D.J. (1990).** Socioecology and conservation of gibbons in south-east Asia, with special reference to Borneo, pp. 230–244. In: Ismail, G., M. Mohamed & S. Omar (eds.). *Forest Biology and Conservation*. Sabah Foundation, Kota Kinabalu.
- Cristobal-Azkarate, J. & V. Arroyo-Rodriguez (2007).** Diet and activity pattern of Howler Monkeys (*Alouatta palliata*) in Los Tuxtlas, Mexico: Effects of habitat fragmentation and implications for conservation. *American Journal of Primatology* 69: 1013–1029.
- Estrada, A. & R.C. Estrada (1996).** Tropical rain forest fragmentation and wild populations of primates at Los Tuxtlas, Mexico. *International Journal of Primatology* 17: 759–783.
- Estrada, A., L. Castellanos, Y. Garcia, B. Franco, D. Munoz, A. Ibarra, A. Rivera, E. Fuentes & C. Jimenez (2002).** Survey of the black howler monkey, *Alouatta pigra*, population at the Mayan Site of Palenque, Chiapas, Mexico. *Primates*, 43(1): 51–58.
- Feeroz, M.M. & M.A. Islam (1992).** *Ecology and Behaviour of Hoolock Gibbons in Bangladesh*. Multidisciplinary Action Research Centre Dhaka.
- Fleagle, J.G. (1976).** Locomotion and posture of the Malayan siamang and implications for hominid evolution. *Folia Primatologica* 26: 245–269.
- Gittins, S.P. (1979).** The behaviour and ecology of the agile gibbon (*Hylobates agilis*). Wildlife Research Group Cambridge, University of Cambridge.
- Hamard, M.C.L., S.M. Cheyne & V. Nijman (2010).** Vegetation correlates of gibbon density in the peat-swamp forest of the Sabangau catchment, Central Kalimantan, Indonesia. *American Journal of Primatology* 72: 607–616.
- Jacobs, J. (1974).** Quantative measurement of food selection: a modification of the forage ratio and Ivlev's electivity test. *Oecologica* 14: 413–417.
- Kakati, K. (2000).** Impact of forest fragmentation on the Hoolock gibbon (*Hylobates hoolock*) in Assam, India. University of Cambridge.
- Marsh, C.W., A.D. Johns & J.M. Ayres (1987).** Effects of habitat disturbance on rain forest primates, pp. 83–107. In: Marsh, C.W. & R.A. Mittermeier (eds.). *Primate Conservation in the Tropical Rainforest*. Alan R. Liss, Inc, New York, USA
- Marsh, C.W. & W.L. Wilson (1981).** *A Survey of Primates in Peninsular Malaysian forests*. Universiti Kebangsaan, Malaysia and University of Cambridge.
- Marshall, A.J. (2010).** Effect of habitat quality on primate populations in Kalimantan: gibbons and leaf monkeys as case studies, pp. 157–177. In: Gursky-Doyen, S. & J. Supriatna (eds.). *Indonesian Primates*. Springer, New York.
- Meijaard, E., D. Sheil, R. Nasi, D. Augeri, B. Rosanbaum, D. Iskandar, T. Setyawati, M. Lammertink, I. Rachmatika, A. Wong, T. Soehartono, S. Stanley & T. O'Brien (2005).** *Life After Logging: Reconciling Wildlife Forestry and Production Forestry in Indonesian Borneo*. CIFOR, Bogor, Indonesia.
- Morrogh-Bernard, H., S. Husson, S.E. Page & J.O. Rieley (2003).** Population status of the Bornean Orangutan (*Pongo pygmaeus*) in the Sebangau peat swamp forest, Central Kalimantan, Indonesia. *Biological Conservation* 110: 141–152.
- Mueller-Dombois, D. & H. Ellenberg (1977).** *Aims and Methods of Vegetation Ecology*. John Wiley, New York.
- Oka, T., E. Iskandar & D.I. Ghozali (2000).** *Effects of forest fragmentation on the behaviour of Bornean gibbons*, pp. 229–241. In: Guhardia, E., M. Fatawi, M. Sutisna, T. Mori & S. Ohta (eds.). *Ecological Studies: Rainforest Ecosystems of East Kalimantan: el Nino, drought, fire and human impacts*. Springer, London.
- Onderdonk, D.A. & C.A. Chapman (2000).** Coping with forest fragmentation: The primates of Kibale National Park, Uganda. *International Journal of Primatology* 21: 587–611.
- Page, S.E., F. Siegert, H.D.V. Boehm, A. Jaya & S. Limin (2002).** The amount of carbon released from peat and forest fires in Indonesia during 1997. *Nature* 420: 61–65.
- Rieley, J.O., S. Page, R. Wuest, D. Weiss & S. Limin (2004).** Tropical peatlands and climate change: past, present and future perspectives, pp. 713–719. In: Päivänen, J. (ed.) *Wise Use of Peatlands (Vol I)*. Proceedings of the 12th International Peat Congress, Tampere, Finland, 6–11 June 2004. Saarijärven Offset Oy, Saarijärvi, Finland.

