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Cover: Coromandal Sacred Langur *Semnopithecus priam* - made with acrylic paint. © P. Kritika.

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ARTICLE

Group densities of endangered small apes (Hylobatidae) in two adjacent forest reserves in Merapoh, Pahang, Malaysia

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Abstract: Small ape habitat is rapidly declining due to anthropogenic activities but the current population status of this endangered primate family in Malaysia remains unknown. Group densities of *Hylobates lar* and *Symphalangus syndactylus* in two adjacent forest reserves across the Sungai Yu Ecological Corridor (SYEC) in Merapoh, a critical connectivity area of the Central Forest Spine, were assessed. Vegetation assessment and satellite imagery were used to identify habitat characteristics and fixed-point active acoustic triangulation at six listening areas was conducted to estimate small ape group densities. Small ape habitat quality was high in the forested areas of the SYEC. The mean group density of *H. lar* across these six areas was 3.55 ± 0.9 groups km^{-2} while the mean group density of *S. syndactylus* was 2.75 ± 1.0 groups km^{-2}. The mean group densities of small apes at SYEC were moderately high, compared with densities at other sites in the region, which suggests that the forests here constitute good habitat for both species, despite some observed anthropogenic disturbances. Both species occurred in all listening areas. A nationwide population census for small apes and regular monitoring to inform conservation planning are recommended. Further improvement to connectivity across the SYEC by installing artificial canopy bridges for arboreal animals is important to support the movement of small apes across habitat fragments in Merapoh.

Keywords: Central Forest Spine, conservation, ecological corridor, endangered, gibbons, *Hylobates lar*, population density, primate, Sungai Yu Ecological Corridor, *Symphalangus syndactylus*, vegetation.

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INTRODUCTION

Wildlife populations are declining worldwide due to anthropogenic actions that cause large-scale habitat destruction, disturbance, and fragmentation (Laidlaw 2000; Phoonjampa & Brockelman 2008; Estrada et al. 2017; 2019; Hughes 2017). The survival of forest-dependent animals, especially primates, strongly depends on the quality of their habitat (Lucas & Corlett 1998; Chapman et al. 2006; Link & Di Fiore 2006) as intact forests provide essential resources including food, secure sleeping sites, protection from predators, and pathways for arboreal movement (Johns 1986; Bartlett 2010). Habitat disturbance in forested landscapes can negatively affect arboreal species due to the creation of canopy gaps from the loss of trees and the reduction of woody climbers, which hinders their movement (Phoonjampa et al. 2011).

Peninsular Malaysia has four major forest complexes, which together are known as the Central Forest Spine (CFS). The forests in Merapoh, Pahang, are a critical ecological corridor of the CFS and form the last linkage between the two largest forest complexes in Peninsular Malaysia: the Titiwangsa Range and Taman Negara Landscape (Meisery et al. 2020, Image 1). The government and several non-governmental organizations have been working together in Merapoh to realize the Sungai Yu Ecological Corridor (SYEC) Project. This corridor comprises two forest areas, which include the Tanum Forest Reserve (to the east on the Taman Negara side), separated from the Ulu Jelai and Sungai Yu Forest Reserves (to the west on the Main Range side) by the Kuala Lipis – Gua Musang Road. Along the road, three eco-viaducts have been constructed, starting in 2009, to facilitate forest connectivity and safer wildlife crossings (Meisery et al. 2020). Ecological connectivity is important for wildlife to thrive as it allows animals to move between habitat sites to find food, breed and establish new territories. Habitat connectivity can influence the distribution, genetic diversity, and health of populations (Gibbs 2001). However, management strategies formulated for large terrestrial umbrella species may not be appropriate for arboreal animals that depend on undisturbed canopy cover to effectively disperse.

Small apes (Hylobatidae) or gibbons are highly arboreal and rely on continuous and dense canopy cover for locomotion (Cannon & Leighton 1994). Even small gaps in the canopy can hinder small ape movement and dispersal (Cheyne et al. 2013; Asensio et al. 2021). Small apes occur in evergreen forests of South and Southeast Asia and southern China and are classified into four genera: *Nomascus*, *Hoolock*, *Hylobates,* and *Symphalangus* (Zihlman et al. 2011) with members of the latter two inhabiting the SYEC: Siamangs *Symphalangus syndactylus* (Raffles, 1821) and White-handed/Lar Gibbons *Hylobates lar* (Linnaeus, 1771). Siamangs live sympatrically with Lar Gibbons (or the other sympatric small ape species Agile Gibbons *H. agilis*) across almost their entire distribution range in Sumatra and Peninsular Malaysia (O'Brien 2003). The home ranges of small apes are typically around 30 ha (ranging from 5 to over 100 ha), and they usually defend all or parts of these areas as territories (Chivers 1977; Palombit 1993). However, neighbouring groups may partially share their home ranges (Cheyne et al. 2019). Small apes may intrude into the territory of neighbouring groups to feed (Gittins 1980). A study on a habituated group of *H. leuconedys* in Gaoligongshan, Yunnan, China, found that this small ape species shifted its home range according to the seasonal availability of food species (Zhang et al. 2014).

Home ranges of Siamangs are usually smaller than those of Lar or Agile Gibbons (Caldecott 1980) and although they are ecological competitors (Palombit 1997; Elder 2013), both species can thrive sympatrically due to differences in their body sizes (Lar Gibbon mean female body mass is 5.34 kg; Siamang mean female body mass is 10.5 kg; Smith & Jungers 1997) and they differ in their nutritional adaptations (Raemaekers 1978). Although they use many of the same food species and forage in similar forest strata, they exhibit slight differences in their ecological niches due to their dietary needs and preferences and their reliance on different fallback strategies (Elder 2009). All small apes are highly frugivorous (MacKinnon & MacKinnon 1980; Elder 2009, 2013) and are effective and important seed dispersers in Asian rainforests (McConkey 2009). They often rely heavily on figs (*Ficus* spp.), which function as staple or fallback foods in tropical forests (Marshall et al. 2009). Small apes are recognized for their ability to adapt and persist in certain degraded forests, even though these habitats may have fewer large food and sleeping trees and exhibit discontinuous canopies (Cheyne et al. 2013).

In their natural habitat, small apes typically form small groups consisting of an adult male-female pair (Srikosamatara 1984; Leighton 1987) and up to four offspring (Phoonjampa & Brockelman 2008). The breeding pairs frequently engage in coordinated duets (Brockelman & Ali 1987; Brockelman & Srikosamatara 1993) that can be heard up to one kilometre away if the sound is not obstructed by landscape features (Mitani 1987). Each small ape species produces different songs; thus, Lar Gibbon and Siamang calls are easily distinguishable, and pairs can be distinguished from solitary individuals because the female 'great call' is only performed by paired females (Haimoff & Gittins 1985). Relying on visual detection and identification of small apes is problematic, as unhabituated animals often hide or quickly flee when they encounter humans, and under low light conditions or while moving rapidly, the different species can appear similar in habitus. Because of the challenges involved in visually detecting small apes, coupled with the relative ease of using songs to detect and identify small ape species, acoustic surveys are the standard method for small ape population surveys (Brockelman & Ali 1987; Brockelman & Srikosamatara 1993).

Despite their ecological importance and the relative ease of acoustic detection methods, the population status of all five Malaysian small ape species remains critically understudied. All Malaysian small ape species are listed as 'Endangered' in the IUCN Red List (*S. syndactylus*, Nijman et al. 2020; *H. lar*, Brockelman & Geissmann 2020; *H. agilis*, Geissmann et al. 2020; *H. funereus*, Nijman et al. 2020; *H. abbotti*, Cheyne & Nijman 2020). Thus, information about the abundance of these threatened species will provide a crucial baseline for ongoing population monitoring, and is needed for development of data-based conservation strategies (Sutherland 2000) specifically targeted at preserving small apes in Malaysia. Thus, the specific objectives of this study were: 1) to estimate group densities of Siamangs and Lar Gibbons in two forest reserves in the SYEC landscape, i.e., the Sungai Yu Forest Reserve and Tanum Forest Reserve; 2) to compare small ape densities and habitat quality in Tanum FR, which is contiguous with the large, totally protected area of Taman Negara Pahang, with those in forests of equivalent elevation in Sungai Yu FR, which has experienced significant disturbance from mining and timber extraction and is almost a habitat island; and 3) to determine the relationship between Siamang and Lar Gibbon group densities to assess the importance of interspecific competition as a factor limiting their populations.

MATERIALS AND METHODS

Study site and period

This study was conducted in two adjacent forest reserves, which both host Siamangs and Lar Gibbons, but have different levels of disturbance. Both reserves are situated within the SYEC (also known as Merapoh Forest Complex Pahang; coordinates 101.951863–102.014998 E & 4.606160–4.543659 N) and are separated by the Kuala Lipis – Gua Musang road in the state of Pahang in Peninsular Malaysia. The Tanum Forest Reserve (FR) is considered more pristine and is contiguous with the Taman Negara National Park, which is a large, protected area with relatively intact forest. The Sungai Yu FR (Appendix 1) is connected to the Titiwangsa Range, which serves as an important ecological corridor for tigers and other threatened species in Peninsular Malaysia. While parts of the Sungai Yu FR have experienced disturbances due to the construction of logging roads and mining, the area still maintains some form of connectivity with other disturbed forests. Both forest reserves contain mostly lowland forest vegetation <400 m, although the western parts of Sungai Yu FR, which were not surveyed, contain some higher-elevation forests.

Data were collected from February to March 2018 with the help of trained field assistants. Four listening areas (LA; Sungai Yu, Kubang Rusa, Campsite, and Jelangat) in Sungai Yu FR, and two LA's (Tanum1 and Tanum2) in Tanum FR, with three distinct listening posts (LP) in each LA (Image 2) were constructed. The LPs were established ca. 500 m apart, arranged in an approximately equilateral triangle to facilitate detection of duet songs within the LA from multiple LP as often as possible, and their exact locations were recorded with a Garmin GPSMap 64s. Approximate LP locations were planned on the map ahead of the survey, but the exact LP locations were adjusted in the field as needed to avoid impassable vegetation and deep valleys where vocalizations may be missed or direction misinterpreted (Hamard et al. 2010). This resulted in slight size variation of the sampling areas at each LA (Phoonjampa et al. 2011).

Habitat vegetation characteristics

Following Hamard et al. (2010), ten 10 m x 10 m in situ vegetation 'speed plots' were established in each LA around the LPs. Three plots were placed 50 m away from each LP, with one each to the north (0°), south-east (125°), and south-west (225°) of the LP, and the tenth plot was placed near the centre of the three LPs.

In each plot, the (1) estimated canopy cover (scored visually using a GRS Densitometer™; estimated from three points within the plot; rounded to the nearest 5%), (2) diameter at breast height (DBH) of all trees >10 cm DBH, (3) height of all trees >10 cm DBH, (4) total number of trees >10 cm DBH, (5) tree species (if known), and (6) elevation (m) were recorded. Tree basal area was calculated as the sum of basal areas for all trees in

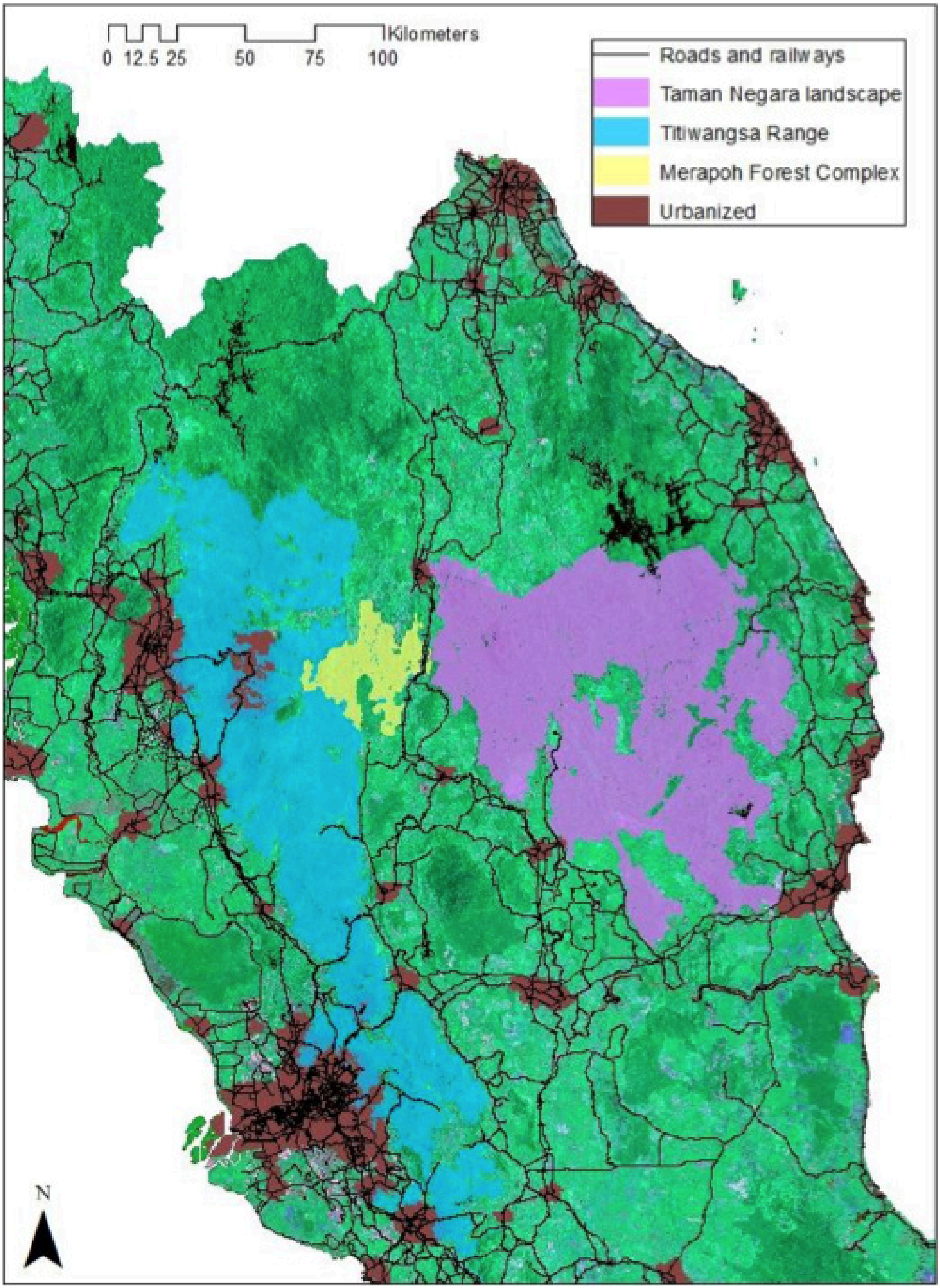

Image 1. Central Peninsular Malaysia showing the major forest complexes (blue: Titiwangsa Range; purple: Taman Negara Landscape) and the position of the Merapoh forest complex (yellow) as a crucial linkage between these landscapes. The background is a composite Landsat image (Hansen/UMD/Google/USGS/NASA) showing the 2018 forest cover (Hansen et al. 2013).

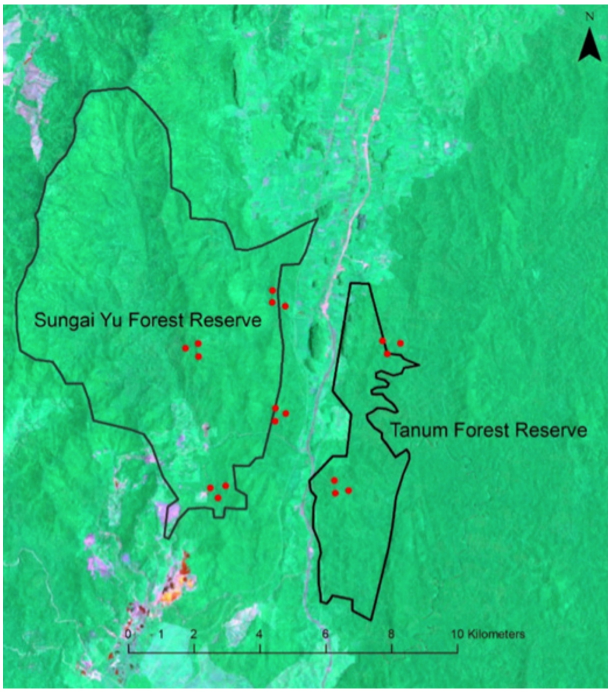

Image 2. Study sites in SYEC with the positions of the three listening posts (red dots) associated with each of the six listening areas. The background is a composite Landsat image (Hansen/UMD/Google/USGS/NASA) showing the 2018 forest cover (Hansen et al. 2013).

each plot. The basal area for each tree was estimated as (DBH/2)2 x π. Not all trees could be identified to species level by a botanist who was provided with clear photographs of leaf undersides and leaf arrangement, flowers, fruits and bark for species identification, so these data could not be used for further analysis. All vegetation characteristics were averaged for each LA. The mean DBH, tree height and canopy cover were calculated and compared among LAs using the Kruskal-Wallis Test, and between Sungai Yu and Tanum using the Mann-Whitney U test.

Remotely sensed data. Habitat quality in each LP and each FR was also assessed using remotely sensed data from open-access satellite imagery. ArcGIS (Esri, Redlands, CA) was used to match the location of each LA and each FR, with forest cover data from 2000 to 2018 from composite Landsat images (Hansen/UMD/Google/USGS/NASA) to estimate the percentage of forest cover in 2000 and forest loss from 2000 to 2018 (Hansen et al. 2013). Elevations of the study sites were measured using a Digital Elevation Model (DEM) from the National Aeronautics and Space Administration/Ministry of Economy Trade and Industry/ Advanced Industrial Science and Technology/Japan Spacesystems & U.S./Japan ASTER Science Team (2018) to estimate the mean elevation for each LA.

Small ape group density assessment

Acoustic surveys: The population density of small apes in Sungai Yu FR and Tanum FR was estimated using active acoustic survey techniques (Brockelman & Srikosamatara 1993). Only those groups that produced at least one female great call and the male's responding call (which is indicative of a pair/group) in the analyses to avoid counting solitary individuals (Cheyne et al. 2008) were included. Two observers were stationed together at each of the three LPs inside one LA for three consecutive mornings from 0700 until 1200, which are the peak calling periods for small apes in Peninsular Malaysia. When duet songs were detected, the observers recorded the compass bearing, start and stop time, and estimated distance from the LP to the duetting pair. After the assessment of one LA was completed, the six observers moved to the next LA.

Group density analysis: To determine the number of small ape groups detected at each site, the location of each duet was triangulated based on the intersection of lines originating from three adjacent LPs. The intersecting lines were mapped in ArcGIS software. Using satellite imagery and a Digital Elevation Model (DEM), the rivers, plantations, residential areas, roads and deforested areas were removed to measure the total sampling area of effective small ape habitat at the study sites.

Group density was then estimated following Brockelman and Ali (1987), as:

$$D = n / [\, p(m) \times E \,]$$

where n is the number of groups heard at each sample site, $p(m)$ is the estimated proportion of groups expected to sing during a sample period of m days, and E is the sample area. The sampling area was calculated as follows. First, the total potential LA was defined as the area within a fixed radius of 1 km from each LP, which is roughly the maximum distance at which duets can be heard in a closed forest. Then, all areas within this LA that were acoustically occluded by terrain features, such as areas that were effectively behind a hill were excluded. A one-tailed Spearman correlation was used to assess the relationship between Lar Gibbon and Siamang group densities in the LA.

RESULTS AND DISCUSSION

Habitat characteristics

Habitat characteristics in the vegetation plots are shown in Table 1. There were no significant differences among LA in tree number ($X = 5.923$, df = 5, p = 0.314), DBH ($X = 9.277$, df = 5, p = 0.099), tree height ($X = 8.445$, df = 5, p = 0.133), basal area ($X = 7.633$, df = 5, p = 0.178), or canopy cover ($X = 5.114$, df = 5, p = 0.402). Similarly, there were no significant differences in habitat characteristics between Tanum FR and Sungai Yu FR (tree number: U = 332.5, $N_1 = 4$, $N_2 = 2$, p = 0.288; DBH: U = 225, $N_1 = 4$, $N_2 = 2$, p = 0.093, tree height: U = 260.00, $N_1 = 4$, $N_2 = 2$, p = 0.309; basal area: U = 237, $N_1 = 4$, $N_2 = 2$, p = 0.146; canopy cover: U = 192.5, $N_1 = 4$, $N_2 = 2$, p = 0.914.) Mean elevation for the six LAs was 244.5 m (range 180–342 m) without significant differences between two forest reserves.

There was no difference among LAs in Sungai Yu FR and Tanum FR in the year-2000 forest cover (U = 3.000, $N_1 = 4$, $N_2 = 2$, p = 0.80) or the percentage of forest lost between 2000 to 2018 (U = 3.00, $N_1 = 4$, $N_2 = 2$, p = 0.80; Table 2). Satellite image analysis showed that ca. 4% of the Sungai Yu FR forest cover was lost between 2000 and 2018. The deforested area in Sungai Yu FR was heavily concentrated in its southern part. Tanum FR lost 2% of its forest cover between 2000 and 2018, and these losses were concentrated in a narrow band along the western edge of the forest reserve.

The results of the vegetation analysis suggest that habitat quality remained high in the forested areas of both forest reserves, despite substantial recent disturbance in the southern part of Sungai Yu FR, and encroachment on the western edge of Tanum FR The absence of detectable differences in forest cover changes in the LAs likely resulted from our methods for calculating LA area, which excluded areas that had been converted to agricultural, residential, or commercial use, or for transportation corridors, and may also reflect low statistical power. Due to the relatively small sizes of both FR and the concentration of low-elevation forest on the east side of Sungai Yu FR, our sample size was small, and several LA were placed in habitat edges.

Small ape group densities

In total, 121 distinct groups of Lar Gibbons and 101 groups of Siamangs were recorded in a total survey area of 41.9 km² across both forest reserves.

Small ape group densities did not differ between Tanum FR and Sungai Yu FR for Lar Gibbons (t = -0.395, df = 4, p = 0.713) or Siamangs (t = -0.756, df = 4, p = 0.492). The mean group density of Lar Gibbons across the six LAs was 3.55 ± 0.9 groups/km² while the mean group density of Siamangs was 2.75 ± 1.0 groups/km². The density of Lar Gibbons at Sungai Yu LA (5.28 groups/km²) was considerably higher than that of the other LAs (<4.00 groups/km²). However, the Siamang density was highest at Kubang Rusa LA (3.79 groups/km²). No significant relationship between Siamang and Lar Gibbon group densities ($\rho = -0.543$, N = 6, p = 0.133) at the study site was detected.

Habitat conditions are often predictive of animal densities (Chivers 1984; Marshall, 2010), and relatively high densities of Lar Gibbons and Siamangs were found in both forest reserves, which indicates that this habitat continues to support a substantial population of small apes. This is perhaps unsurprising, as lowland and hill forests (<750 m) generally support higher population densities of *Hylobates* spp. than higher elevation forests (Caldecott 1980; Johns 1986; Brockelman & Ali 1987; Nijman 2001; O'Brien et al. 2004). However, some populations have their highest densities at slightly higher altitudes, especially in areas of sympatry between Siamangs and *Hylobates* spp., where ecological competition between small apes may limit the population of one or both species. For example, at Gunung Benom in Krau Wildlife Reserve, Pahang, Malaysia, Siamangs occurred at a low density below 300 m, were most abundant between 700 m and 1,000 m, and their density declined with increasing altitude up to 1,500 m (Caldecott 1980), whereas Lar Gibbon density decreased with increasing elevation, and Lar Gibbons were not found in forests >1,200 m. Conversely, in Bukit Barisan Selatan National Park in Sumatra, Indonesia, where Siamangs are sympatric with *H. agilis*, Siamang densities were highest in lowland and submontane forests, and *H. agilis* density peaked in mid-elevation forests (O'Brien et al. 2004). A similar pattern is reported in Kerinci Seblat National Park, Sumatra (Yanuar 2001). Despite this apparent tendency for sympatric small apes to use different elevation ranges, our surveys indicated that both species have fairly high densities in the lowland forests of the Sungai Yu Ecological Corridor (SYEC) in Merapoh. Although no significant negative correlation between Lar Gibbon density and Siamang density in Merapoh was found, as would be expected if ecological competition was limiting their populations, this may be due to limited statistical power resulting from the small number of independent samples in our analysis. The correlation coefficient was negative, and high (>0.5), which is consistent with this explanation. Nonetheless, both species were detected in all LA, and group locations suggested considerable overlap in habitat use.

The mean density of Lar Gibbon and Siamang groups (with 3.55 groups/km² and 2.75 groups/km², respectively) in SYEC can be considered as moderate or moderately high, which suggests that the forests are of relatively

Table 1. Vegetation characteristics in the six listening areas (LAs) in Merapoh, Pahang.

Forest reserve	Listening area (LA)	Mean tree number (>10 cm DBH)	Mean DBH (cm)	Mean tree height (m)	Total tree basal area (cm²)	Mean % canopy cover
Sungai Yu	Campsite	5.6	19.7	13.0	2,176.2	53.6
	Jelangat	3.3	26.3	15.4	2,990.0	65.0
	Kubang Rusa	5.3	24.3	13.0	5,086.4	55.5
	Sungai Yu	5.8	24.7	17.2	3,456.6	65.0
Tanum	Tanum1	6.4	24.7	15.5	3,679.7	73.5
	Tanum2	4.8	29.9	15.3	4,654.2	59.6

Table 2. Remotely sensed forest cover data. Values are percentages of the area forested in 2000 (defined as having at least 30% forest cover at 5 m) and percentages of the area forested in 2000 that was lost (defined as a total stand clearance in a 30 x 30 m pixel) between 2000 and 2018.

Forest reserve	Listening area (LA)	Forest cover percentage in the year 2000	Total forest cover loss percentage from 2000 to 2018
Sungai Yu	Sungai Yu	100	0.9
	Jelangat	99.4	0.3
	Campsite	100	0
	Kubang Rusa	98.9	0
Tanum	Tanum 1	98.8	0.2
	Tanum 2	100	0

good habitat quality for both small ape species, despite the disturbances caused by logging for the conversion to rubber plantations, oil palm plantations, highways, railways, and villages, as well as selective logging and mining in the Sungai Yu site. Small apes are reported to adapt to slight disturbances by shifting their use of canopy to the lower canopy layers (Johns 1986; Nijman 2001) and changing their diets and adjusting activities to reduce energy costs (Johns 1986; O'Brien et al. 2003).

Small ape densities did not differ between Sungai Yu FR and Tanum FR. Sungai Yu FR is separated from Tanum FR by a highway and adjacent cleared areas but is contiguous with several forest reserves that have been degraded and fragmented, while Tanum FR is connected to the larger protected forests of Taman Negara Pahang. The estimated rate of forest loss in Sungai Yu FR between 2000 and 2018 was twice as high as in Tanum FR. Nonetheless, our density estimates for small apes in Tanum FR were not higher than those for Sungai Yu FR. This may be because most of our LAs in the Sungai Yu FR were in the central area or along the eastern edge of the forest reserve, whereas recent encroachment and disturbance are concentrated in the southern part of the forest reserve.

The smallest LA in our sample was Sungai Yu (3.06 km²), which included substantial areas that have been completely cleared of trees since 2010. When small ape groups experience habitat loss, the group densities may increase temporarily due to a 'compression effect', as animals are displaced from degraded or deforested areas and concentrated in the remaining forested areas (O'Brien et al. 2003; Cheyne et al. 2016, 2019; Pang et al. 2022). Thus, the relatively high density of Lar Gibbon groups recorded in the Sungai Yu LA may reasonably be interpreted as reflecting population compression due to recent habitat disturbance and loss in the area. However, continuous monitoring over at least a decade would be needed to determine the long-term fate of the small ape groups in the area.

Thus, despite our finding that small apes persist at moderately high densities in the SYEC, there is reason for concern. Small ape dispersal can be restricted in fragmented forests because gibbons rarely descend to the ground (Cannon & Leighton 1994; Cheyne et al. 2013), even to cross relatively narrow gaps in the forest canopy (Asensio et al. 2021). As a result, populations in small fragments can become isolated (Cheyne 2019), increasing the risk of small population processes such as inbreeding depression (O'Grady 2006; Geissmann 2007). Ongoing habitat degradation and fragmentation in the SYEC/Merapoh Forest Complex, especially on the periphery and interior of Sungai Yu FR, may therefore pose a threat to the long-term viability of small apes in this landscape.

The Malaysian government recognizes the importance of the SYEC as a vital linkage between the wider Taman Negara landscape and the Titiwangsa Range forests and has been working with several NGOs to develop and implement a wildlife corridor project here, whereby in 2009, an eco-viaduct in form of an underpass was built to enhance movement of terrestrial animals across the SYEC landscape to encourage safer wildlife crossings between forests (IC-CFS 2021). However, an underpass is unlikely to enhance the movement of arboreal animals across the estimated 500 m wide forest gap here.

Natural connectivity via appropriate vegetation is usually the best way to support the movement of arboreal animals, and every attempt should be made to maintain canopy connectivity and to restore it when anthropogenic disruptions occur. Where that is not possible, artificial arboreal wildlife crossing structures or canopy bridges have been built in many locations worldwide to mitigate the habitat fragmentation impacts on threatened treetop-dwelling wildlife and to re-establish habitat connectivity (e.g., Weston et al. 2011; Gregory et al. 2013; Teixeira et al. 2013; Yokochi & Bencini 2015; Balbuena et al. 2019). For example, an artificial canopy bridge installed in Hainan, China effectively facilitates the movement of a group of Hainan Black Crested Gibbons *Nomascus hainanus* across a forest gap created by a landslide (Chan et al. 2020). Malaysia's first urban canopy bridge was built in Teluk Bahang, Penang, to facilitate the safe crossing of a busy highway by endangered Dusky Langurs *Trachypithecus obscurus* and Long-tailed Macaques *Macaca fascicularis* that had previously been frequent victims of vehicle collisions. From its installation in April 2019 to May 2021, it was used in 2,028 road crossings by Dusky Langurs (21 crossings), Long-tailed Macaques (32 crossings) and Plantain Squirrels (*Callosciurus notatus*; 2,075 crossings; Yap et al. 2022). These and other examples indicate that properly designed artificial structures can facilitate the movement of arboreal animals across roads and other linear gaps in the forest.

The highway that bisects the SYEC in Merapoh creates a substantial barrier to the movement of arboreal animals, which increases the risks of local extinctions and loss of ecological services in increasingly disturbed and fragmented landscapes. To mitigate this risk, artificial canopy bridges or similar interventions for arboreal animals should be developed to complement the eco-viaduct underpass. Together with other mitigation strategies to facilitate animal movement, this could improve ecosystem health across the SYEC and the Titiwangsa and Taman Negara forest complex.

CONCLUSION

Small apes can adapt relatively well to small changes in habitat conditions and the Merapoh Forest Complex is still a good lowland forest habitat for small apes. The moderately high group densities detected in all forest sites sampled emphasize the importance of this degraded forest as a habitat for small apes. Because of the threats to small apes in Malaysia, and the uncertain status of most populations in the country, a nationwide population census and regular monitoring to inform conservation planning and implementation is strongly recommended. Importantly, the study calls for the improvement of the Sungai Yu Ecological Corridor (SYEC) Project to support the movement and persistence of populations of small apes and other arboreal wildlife across the landscape by restoring forests where possible and installing artificial canopy bridges where necessary to connect forests and habitat fragments in Merapoh.

REFERENCES

Asensio, N., J. Kachanan, C. Saralamba & J.M. José-Domínguez (2021). The impact of roads on the movement of arboreal fauna in protected areas: the case of lar and pileated gibbons in Khao Yai National Park, Thailand. *Journal of Tropical Ecology* 37(6): 276–285. https://doi.org/10.1017/S0266467421000390

Balbuena, D., A. Alonso, M. Panta, A. Garcia & T. Gregory (2019). Mitigating tropical forest fragmentation with natural and semi-artificial canopy bridges. *Diversity* 11(4): 66. https://doi.org/10.3390/d11040066https://doi.org/10.3390/d11040066

Bartlett, T.Q. (2010). The Hylobatidae: Small apes of Asia, pp. 274–289. In: Campbell, C., A. Fuentes, K. MacKinnon, S. Bearder & R. Stumpf (eds.). *Primates in Perspective, 2nd Edition*. Oxford University Press, UK, 864 pp.

Brockelman, W.Y. & R. Ali (1987). Methods of surveying and sampling forest primate populations, pp. 23–63. In: Marsh, C.W. & R.A. Mittermeier (eds). *Primate Conservation in Tropical Rainforests.* Alan R. Liss, USA, 365 pp.

Brockelman, W.Y. & S. Srikosamatara (1993). Estimation of density of gibbon groups by use of loud songs. *American Journal of Primatology* 29(2): 93–108. https://doi.org/10.1002/ajp.1350290203

Brockelman, W.Y. & T. Geissmann (2020). *Hylobates lar*. The IUCN Red List of Threatened Species 2020: e.T10548A17967253. Downloaded on 23 May 2023. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T10548A17967253.en

Caldecott, J.O. (1980). Habitat quality and populations of two sympatric gibbons (Hylobatidae) on a mountain in Malaya. *Folia Primatologica* 33(4): 291–309. https://doi.org/10.1159/000155943

Cannon, C., & M. Leighton (1994). Comparative locomotor ecology of gibbons and macaques: Selection of canopy elements for crossing gaps. *American Journal of Physical Anthropology* 93(4): 505–524. https://doi.org/10.1002/ajpa.1330930409

Chan, B.P.L., Y.F.P. Lo, X.J. Hong, C.F. Mak & Z. Ma (2020). First use of artificial canopy bridge by the world's most critically endangered primate the Hainan gibbon *Nomascus hainanus*. *Scientific Reports* 10(1): 15176. https://doi.org/10.1038/s41598-020-72641-z

Cheyne, S.M., C.J. Thompson, A.C. Phillips, R.M. Hill & S.H. Limin (2008). Density and population estimate of gibbons (*Hylobates albibarbis*) in the Sabangau catchment, Central Kalimantan, Indonesia. *Primates* 49: 50–56. https://doi.org/10.1007/s10329-007-0063-0

Cheyne, S., C. 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. https://doi.org/10.11609/JoTT.o3361.3963-8

Cheyne, S.M., L.J. Gilhooly, M.C. Hamard, A. Höing & P.R. Houlihan (2016). Population mapping of gibbons in Kalimantan, Indonesia:

correlates of gibbon density and vegetation across the species' range. *Endangered Species Research* 30: 133–143.
Cheyne, S., B. Capilla, K. Abdulaziz, Supiansyah, Adul, E. Cahyaningrum & D. Smith (2019). Home range variation and site fidelity of Bornean southern gibbons (*Hylobates albibarbis*) from 2010–2018. *PLoS ONE* 14(7): 1–13.
Cheyne, S.M. & V. Nijman (2020). *Hylobates abbotti*. The IUCN Red List of Threatened Species 2020: e.T39889A17990882. Downloaded on 23 May 2023. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T39889A17990882.en
Chapman, C.A., M.J. Lawes & H.A. Eeley (2006). What hope for African primate diversity? *African Journal of Ecology* 44(2): 116–133. https://doi.org/10.1111/j.1365-2028.2006.00636.x
Chivers, D.J. (1977). Socio-ecology and Conservation of Malayan Forest Primates. *Environmental Conservation* 4(2): 102.
Chivers, D.J. (1984). Feeding and ranging in gibbons: a summary, pp. 267–281. In: Preuschoft, H., D.J. Chivers, W.Y. Brockelman & N. Creel (eds.). *The Lesser Apes: Evolutionary and Behavioural Biology*. Edinburgh University Press, U.K., 709 pp.
Elder, A.A. (2009). Hylobatid diets revisited: the importance of body mass, fruit availability, and interspecific competition, pp. 133–159. In: Lappan, S. & D.J. Whittaker (eds.). *The Gibbons: New Perspectives on Small Ape Socioecology and Population Biology*. Springer, USA, 526 pp. https://doi.org/10.1007/978-0-387-88604-6_8
Elder, A.A. (2013). Competition among three primate species at Way Canguk, Sumatra, Indonesia. PhD Thesis. Department of Anthropology, State University of New York at Stony Brook, xxii+272 pp. https://www.proquest.com/openview/988854f8758f8d5d54ec2942e7e1614c/1?pq-origsite=gscholar&cbl=18750
Estrada, A., P.A. Garber, A.B. Rylands, C. Roos, E. Fernandez-Duque & A. Di Fiore (2017). Impending extinction crisis of the world's primates: Why primates matter. *Science Advances* 3(1): e1600946. https://doi.org/10.1126/sciadv.1600946
Estrada, A., P.A. Garber & A. Chaudhary (2019). Expanding global commodities trade and consumption place the world's primates at risk of extinction. *PeerJ* 7: e7068. https://doi.org/10.7717/peerj.7068
Geissmann, T., V. Nijman, R. Boonratana, W.Y. Brockelman, C. Roos & M.G. Nowak (2020). *Hylobates agilis*. The IUCN Red List of Threatened Species 2020: e.T10543A17967655. Downloaded on 23 May 2023. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T10543A17967655.en
Geissmann, T. (2007). Status reassessment of the gibbons: results of the Asian primate red list workshop 2006. *Gibbon Journal* 7(3): 5–15.
Gibbs, J.P. (2001). Demography versus habitat fragmentation as determinants of genetic variation in wild populations. *Biological Conservation* 100(1): 15–20. https://doi.org/10.1016/S0006-3207(00)00203-2
Gittins, S.P. (1980). Territorial behavior in the Agile Gibbon. *International Journal of Primatology* 1(4): 381–399. https://doi.org/10.1007/BF02692281
Gregory, T., F.C. Rueda, J. Deichmann, J. Kolowski, M.C. Faura, F. Dallmeier & A. Alonso (2013). Methods to establish canopy bridges to increase natural connectivity in linear infrastructure development. In: *SPE Latin-American and Caribbean Health, Safety, Environment and Social Responsibility Conference*, 26-27 June 2013; OnePetro, Peru. https://doi.org/10.2118/165598-MS
Haimoff, E.H. & S.P. Gittins (1985). Individuality in the songs of wild agile gibbons (*Hylobates agilis*) of Peninsular Malaysia. *American Journal of Primatology* 8(3): 239–247. https://doi.org/10.1002/ajp.1350080306
Hamard, M., 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. https://doi.org/10.1002/ajp.20815
Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S. Stehman, S. Goetz, T. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. Justice & J.R. Townshend (2013). High-resolution global maps of 21st century forest cover change. *Science* 342: 850–853. https://doi.org/10.1126/science.1244693
Hughes, A.C. (2017). Understanding the drivers of Southeast Asian biodiversity loss. *Ecosphere* 8(1): e01624. https://doi.org/10.1002/ecs2.1624
IC-CFS (2021). https://www.ic-centralforestspine.com.my/. Accessed on 23 May 2023.
Johns, A.D. (1986). Effects of selective logging on the behavioral ecology of West Malaysian primates. *Ecology* 67(3): 684–694. https://doi.org/10.2307/1937692
Laidlaw, R.K. (2000). Effects of habitat disturbance and protected areas on mammals of Peninsular Malaysia. *Conservation Biology* 14(6): 1639–1648. https://doi.org/10.1111/j.1523-1739.2000.99073.x
Leighton, D.R. (1987). Gibbons: Territoriality and Monogamy, pp. 135–145. In: Smuts, B.B., D.L. Cheney, R.M. Seyfarth, R.W. Wrangham & T.T. Struhsaker (eds.). *Primate Societies.* University of Chicago Press, USA, 585 pp. https://doi.org/10.7208/9780226220468-014
Link, A., & A. Di Fiore (2006). Seed dispersal by spider monkeys and its importance in the maintenance of neotropical rain-forest diversity. *Journal of Tropical Ecology* 22(3): 235. https://doi.org/10.1017/S0266467405003081
Lucas, P.W. & R.T. Corlett (1998). Seed dispersal by long-tailed macaques. *American Journal of Primatology* 45(1): 29–44. https://doi.org/10.1002/(SICI)1098-2345(1998)45:1<29::AID-AJP4>3.0.CO;2-Y
MacKinnon, J. & K. MacKinnon (1980). The behavior of wild spectral tarsiers. *International Journal of Primatology* 1(4): 361–379. https://doi.org/10.1007/BF02692280
Marshall, A.J., C.M. Boyko, K.L. Feilen, R.H. Boyko & M. Leighton (2009). Defining fallback foods and assessing their importance in primate ecology and evolution. *American Journal of Physical Anthropology* 140(4): 603–614. http://doi.org/10.1002/ajpa.21082
Marshall, A.J. (2010). Effect of habitat quality on primate populations in Kalimantan: gibbons and leaf monkeys as case studies, pp. 157–177. In: J. Supriatna & S.L. Gursky (eds.). *Indonesian Primates*. Springer, USA. Xvi+410 pp.
McConkey, K.R. (2009). The seed dispersal niche of gibbons in Bornean dipterocarp forests, pp. 189–207. In: Lappan, S. & D.J. Whittaker (Eds). *The Gibbons: New Perspectives on Small Ape Socioecology and Population Biology*. Springer, USA, 526 pp. https://doi.org/10.1007/978-0-387-88604-6_10
Meisery, A.A.H.A., L. Adam, A.N. Ghazali, M.H.H. Shah, M.F. Yazi, C.C. Tan, P.A. Patah, M. Azhari & S. Fairi (2020). Diversity of mammals in Sungai Yu Ecological Corridor, Pahang. *Journal of Wildlife and Parks* 35: 1–15. https://jwp.wildlife.gov.my/index.php/jwp/article/view/14
Mitani, J.C. (1987). Territoriality and monogamy among agile gibbons (*Hylobates agilis*). *Behavioral Ecology and Sociobiology* 20(4): 265–269. https://doi.org/10.1007/BF00292179
Nijman, V. (2001). Effects of behavioural changes due to habitat disturbance on density estimation of rain forest vertebrates, as illustrated by gibbons (Primates: Hylobatidae), pp. 33–42. In: Hillegers, P. & H. H. di Iongh (eds.). *Forest and primates: conservation and ecology of the endemic primates of Java and Borneo*. Tropenbos Foundation, Netherlands, 278 pp.
Nijman, V., T. Geissmann, C. Traeholt, C. Roos & M.G. Nowak (2020). *Symphalangus syndactylus*. The IUCN Red List of Threatened Species 2020: e.T39779A17967873. Downloaded on 23 May 2023. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T39779A17967873.en
Nijman, V., S. Cheyne & C. Traeholt (2020). *Hylobates funereus*. The IUCN Red List of Threatened Species 2020: e.T39890A17990856. Downloaded on 23 May 2023. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T39890A17990856.en
'Brien, T.G., M.F. Kinnaird, A. Nurcahyo, M. Prasetyaningrum & M. Iqbal (2003). Fire, demography, and the persistence of siamang (Symphalangus syndactylus: Hylobatidae) in a Sumatran rainforest. *Animal Conservation* 6: 115–121. https://doi.org/10.1017/

S1367943003003159

O'Brien, T.G., M.F. Kinnaird, A. Nurcahyo, M. Iqbal & A. Rusmanto (2004). Abundance and distribution of sympatric gibbons in a threatened Sumatran rain forest. *International Journal of Primatology* 25(2): 267–284. https://doi.org/10.1023/B:IJOP.0000019152.83883.1c

O'Grady, J.J., B.W. Brook, D.H. Reed, J.D. Ballou, D.W. Tonkyn & R. Frankham (2006). Realistic levels of inbreeding depression strongly affect extinction risk in wild populations. *Biological Conservation* 133(1): 42–51. https://doi.org/10.1016/j.biocon.2006.05.016

Ong, L., K.R. McConkey & A. Campos-Arceiz (2022). The ability to disperse large seeds, rather than body mass alone, defines the importance of animals in a hyper-diverse seed dispersal network. *Journal of Ecology* 110(2): 313–326. https://doi.org/10.1111/1365-2745.13809

Palombit, R. (1993). Lethal territorial aggression in a White-Handed Gibbon. *American Journal of Primatology* 31: 311–318.

Palombit, R.A. (1997). Inter-and intraspecific variation in the diets of sympatric Siamang (*Hylobates syndactylus*) and Lar Gibbons (*Hylobates lar*). *Folia Primatologica* 68(6): 321–337. https://doi.org/10.1159/000157260

Pang, Y.H., S. Lappan, T.Q. Bartlett, S.A.M. Sah, N.F.N. Rosely & N. Ruppert (2022). Population densities of *Hylobates agilis* in forests with different disturbance histories in Ulu Muda Forest Reserve, Malaysia. *American Journal of Primatology* 84(7): e23388. https://doi.org/10.1002/ajp.23388

Phoonjampa, R. & W.Y. Brockelman (2008). Survey of pileated gibbon *Hylobates pileatus* in Thailand: populations threatened by hunting and habitat degradation. *Oryx* 42(4): 600–606. https://doi.org/10.1017/S0030605308000306

Phoonjampa, R., A. Koenig, W.Y. Brockelman, C. Borries, G.A. Gale, J.P. Carroll & T. Savini (2011). Pileated gibbon density in relation to habitat characteristics and post-logging forest recovery. *Biotropica* 43(5): 619–627. https://doi.org/10.1111/j.1744-7429.2010.00743.x

Raemaekers, J. (1978). Changes through the day in food choice of wild gibbons. *Folia Primatologica* 30: 194–205.

Smith, R.J. & W.L. Jungers (1997). Body mass in comparative primatology. *Journal of Human Evolution* 32(6): 523–559. https://doi.org/10.1006/jhev.1996.0122

Srikosamatara, S. (1984). Ecology of pileated gibbons in southeast Thailand, pp. 242–257. In: H. Preuschoft, D.J. Chivers, W.Y. Brockelman & N. Creel (eds.). *The Lesser Apes: Evolutionary and Behavioural Biology*. Edinburgh University Press, UK, 709 pp.

Sutherland, W.J. (2000). Mammals, pp. 57–59. In: Sutherland, W.J. (ed.). *The Conservation Handbook: Research, Management and Policy.* Oxford: Blackwell Science Ltd, UK, 294 pp.

Teixeira, F.Z., R.C. Printes, J.C.G. Fagundes, A.C. Alonso & A. Kindel (2013). Canopy bridges as road overpasses for wildlife in urban fragmented landscapes. *Biota Neotropica* 13: 117–123. https://doi.org/10.1590/S1676-06032013000100013

Weston, N., M. Goosem, H. Marsh, M. Cohen & R. Wilson (2011). Using canopy bridges to link habitat for arboreal mammals: successful trials in the wet tropics of Queensland. *Australian Mammalogy* 33(1): 93–105. https://doi.org/10.1071/AM11003

Yap, J.L., N.F.N. Rosely, M. Mahadzir, M.L. Benedict, V. Muniandy & N. Ruppert (2022). "Ah Lai's Crossing"–Malaysia's first artificial road canopy bridge to facilitate safer arboreal wildlife crossings. *Folia Primatologica* 93(3–6): 255–269. https://doi.org/10.1163/14219980-20211105

Yanuar, A. (2001). The Population Distribution and Abundance of Primates in Kerinci-Seblat National Park, Sumatra, Unpublished MSc Thesis, University of Cambridge, Cambridge, UK.

Yokochi, K. & R. Bencini (2015). A remarkably quick habituation and high use of a rope bridge by an endangered marsupial, the western ringtail possum, pp. 79–94. In: Seiler, A. & J.-O. Helldin (eds.). Proceedings of IENE 2014 International Conference on Ecology and Transportation, Malmö, Sweden. Nature Conservation 11: 74–94. https://doi.org/10.3897/natureconservation.11.4385

Zhang, D., H. Fei, S. Yuan, W. Sun, Q. Ni, L. Cui & P. Fan (2014). Ranging behavior of Eastern Hoolock Gibbon (*Hoolock leuconedys*) in a northern montane forest in Gaoligongshan, Yunnan, China. *Primates* 55(2): 239–247.

Zihlman, A.L., A.R. Mootnick & C.E. Underwood (2011). Anatomical contributions to hylobatid taxonomy and adaptation. *International Journal of Primatology* 32(4): 865–877.

Abstrak Bahasa Malaysia: Aktiviti manusia telah mengancam habitat mawas kecil dengan pantas, namun status populasi semasa keluarga primata ini di Malaysia masih tidak diketahui walaupun ia telah terancam diseluruh dunia. Ketumpatan kumpulan *Hylobates lar* dan *Symphalangus syndactylus* telah dinilai di dua hutan rizab sepanjang Koridor Hidupan Liar Sungai Yu (KHLSY) di Merapoh, dimana ia merupakan kawasan ketersambungan kritikal gugusan kompleks hutan, iaitu 'Central Forest Spine'. Penilaian tumbuh-tumbuhan dan pengimejan satelit telah digunakan untuk mengenal pasti ciri habitat dan triangulasi akustik aktif yang mempunyai titik tetap di enam kawasan mendengar telah dijalankan untuk menganggarkan kepadatan kumpulan mawas kecil. Kualiti habitat mawas kecil lebih tinggi di kawasan berhutan KHLSY. Purata ketumpatan kumpulan *H. lar* merentasi enam kawasan ini ialah 3.55 ± 0.9 kumpulan km^{-2} manakala purata ketumpatan kumpulan *S. syndactylus* ialah 2.75 ± 1.0 kumpulan km^{-2}. Purata kepadatan kumpulan mawas kecil di KHLSY adalah sederhana tinggi, berbanding dengan ketumpatan di tapak kawasan lain. Ini menunjukkan bahawa hutan di sini merupakan habitat yang masih baik untuk kedua-dua spesis, walaupun telah terganggu oleh aktiviti manusia. Kedua-dua spesis ada di semua kawasan kajian yang telah dijalankan. Maklumat banci kepadatan mawas kecil dan pemantauan berkala di seluruh negara untuk perancangan pemuliharaan adalah amat digalakkan. Penambahbaikan lanjut kepada ketersambungan merentasi KHLSY dengan memasang jambatan kanopi tiruan untuk haiwan arboreal adalah penting untuk menyokong pergerakan mawas kecil merentasi habitat yang telah terpisah di Merapoh.

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Author contributions: ASK designed the research, carried out the fieldwork and data analysis, and wrote and revised the article. NIAMR carried out the fieldwork and approved the submission. SL conceptualised the central research idea, designed the research, provided the theoretical framework for the research, provided comprehensive training in data analysis, supervised research progress, revised all article drafts, and approved the submission. TQB conceptualised the central research idea and designed the research, revised the article drafts, and approved the submission. NFNR supervised the research progress, revised the final article, and approved the submission. SAMS facilitated research logistics and supervised research progress, revised the final article draft, and approved the submission. NR conceptualised the central research idea, designed the research, provided the theoretical framework for the research, facilitated logistics, supervised research progress, revised all article drafts and handled the submission.

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