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Research Article

Effects of river width on the selection of sleeping-site by Proboscis monkeys (*Nasalis larvatus*) in Sabah, Malaysia

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ABSTRACT. Previous studies have suggested that Proboscis monkeys sleep in trees located by riverbanks and cross rivers at their narrower points to effectively avoid land-based and aquatic-based predators. In this study, we provide some evidence in support of the low predation pressure theory from land-based predators of Proboscis monkeys at the Padas Damit Forest Reserve in the west of Sabah, Malaysia. We compared the mean width of the Garama River adjacent to where Proboscis monkey sleeping trees were located (mean=31.0m; SD: ± 11.3; Range: 10-50m; n = 88) with the mean width of the entire length of this river surveyed for Proboscis monkey sleeping trees (mean=33.3m; SD: ± 13.4; Range:13-68m; n = 31) , i.e. approximately 8.4 km long . We found that Proboscis monkeys' choice of sleeping trees was not dependent on where the narrowest sections of the river are (two-sample independent t-test: t = -0.912; d.f. = 117; P = 0.36). We suggest that this may be an indication of low land-based predation pressure. We also argue that the reluctance of Proboscis monkeys to cross large rivers may indicate a high aquatic-based predation pressure.

Keywords: Predation pressure, Sleeping site selection, *Nasalis larvatus*.

INTRODUCTION

In non-human primate species, predation pressure has been indicated to play an important role in their behavioural evolution (Cheney & Wrangham, 1987; Miller & Treves, 2007), though directly observed cases of attempted or successful predation are rarely reported. Patterns of habitat use, especially sleeping-site selection, have been shown to reflect the predation avoidance strategy in various non-human primate species including the Proboscis monkey (e.g. van Schaik *et al.*, 1996; Matsuda *et al.*, 2008; Rayadin & Saito, 2009; Phoonjampa, 2010; Bernard *et al.* 2011).

The Proboscis monkey (*Nasalis larvatus*), a member of the subfamily Colobinae, is endemic to Borneo Island and primarily inhabits mangroves, peat swamps, and riverine forests. The monkeys are adept at swimming because of morphological features such as webbing between fingers and toes and sufficient body fat (Napier, 1985; Yeager, 1991). Proboscis monkeys typically roost on riverside trees in the late afternoon (Kern, 1964; Jeffrey, 1979; Bismark, 1981; Bernard & Zulhazman 2006). Matsuda *et al.* (2011) suggest that this riverine refuging by Proboscis

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monkeys is part of a strategy to avoid land-based predators, particularly the Sunda clouded leopard (*Neofelis diardi*). The long range visibility from trees located by the riverside may allow these monkeys to easily detect incoming terrestrial predators. Moreover, selecting sleeping trees by the riverbank may permit an effective escape route across rivers which terrestrial predators cannot access. River crossings of Proboscis monkeys may take place in two ways: by leaping from one side of the riverbank to the other riverbank using tree branches as springboards, or by swimming (Matsuda *et al.*, 2008; Yeager, 1991). Although Proboscis monkeys are proficient swimmers and have been known to swim across rivers frequently (Boonratana, 2000), studies have shown that they prefer to cross rivers at narrower points to effectively avoid aquatic predators, such as the estuarine crocodile, *Crocodylus porosus* (Matsuda *et al.*, 2008) and the False ghavial, *Tomistoma schlegeli* (Gladikas, 1985; Yeager, 1991).

Previously, we described the characteristics of night sleeping-trees of Proboscis monkeys inhabiting riverine, mangrove and mixed mangrove-riverine forests along 8.4 km of the Garama River, a tributary of the Klias River, located at the Padas Damit Forest Reserve (PDFR) in the Klias peninsula in western Sabah, Malaysia (Bernard *et al.*, 2011). We found that although the sleeping trees of Proboscis monkeys were significantly located closer to riverbanks (5-35m), the sleeping trees also included trees further inland (max. 46 m from river). We explained that these inland roosting sites may be due to low predation pressure from terrestrial predators inside the study area. We proposed that since terrestrial predation pressure is low, Proboscis monkeys may choose trees for sleeping more freely and are not forced to return to river side trees every night. In this study, we provide further evidence in support of the low predation pressure theory at the same study area. Specifically, we sought to test the hypothesis that if the predation pressure from land-based predators on the Proboscis monkeys is high, then it would be expected that Proboscis monkeys would choose to sleep at locations by riverbanks where the width of the river is narrowest. We suggest that this behavior allows for a quick and efficient river crossing by Proboscis monkeys when attacked by terrestrial predators.

METHODS

We measured the width of the Garama River at points located nearest to night sleeping trees of Proboscis monkeys. These sleeping trees were exactly the same trees that have been identified as night sleeping trees of the Proboscis monkeys from our previous study conducted from June to September 2008 (Bernard *et al.*, 2011). The width of the river was taken as the shortest perpendicular distance (m) measured from one side of the riverbank, where the sleeping trees occurred, to the other riverbank or the "bank-to-bank" river distance. In cases where the sleeping tree branches overhanged the river, the width of the river was taken as the nearest branch to the opposite riverbank distance. This value is the shortest perpendicular distance (m) measured from the tip of the longest tree branch that extended beyond the river to the opposite riverbank, or the "branch-to-bank" river distance. In addition, to test whether the locations of the Proboscis monkey sleeping trees are independent from the width of the river, we measured the width of the Garama River at every 200 – 300 m intervals along the entire stretch of this river, approximately 8.4 km long, which was surveyed for Proboscis monkey sleeping trees. These measurements included both bank-to-bank and branch-to-bank river distances and included the narrowest and the widest width of the river. All measurements were taken exactly using a 100m measuring tape. We used two-sample independent t-test to examine whether on average the widths at sleeping sites were different than the widths across the river. We checked for the conformity to the homogeneity of variance assumption of the data using Levene's test before performing the statistical analysis. Significance level was set at $P=0.05$.

RESULTS AND DISCUSSION

The mean width of the Garama River measured at the points nearest to the Proboscis monkey sleeping trees was 31.0 m (SD: ± 11.3; Range: 10-50 m; n = 88), whereas the mean width of the Garama River measured at regular intervals along the entire stretch of the river surveyed for Proboscis monkey sleeping trees was 33.3 m (SD: ± 13.4; Range:13-68 m; n = 31). Comparison between the two mean values of the Garama River width showed no significant difference (two-sample independent t-test: t = -0.912; d.f. = 117; P = 0.36; equal variances assumed, Levene's test: F = 0.41, P = 0.52). This analysis indicates that the Proboscis monkey groups were not selecting the locations of their sleeping trees based on river width.

In a previous study in Sukau, where predation pressure from land-based predators was suspected to be high, the sleeping-site selections of Proboscis monkeys suggested that the monkeys prefer to sleep at river side trees with narrower branch-to-bank river locations, because those sites may provide good escape routes from both terrestrial and aquatic predators (Matsuda *et al.*, 2008). Nonetheless, no apparent relationship between the river width and sleeping site locations was detected in the present study. The reason for this finding could be lower terrestrial predation pressure at our study site compared to that in Sukau. It was not known if the clouded leopard, a well known predator of Proboscis monkeys are present at the study area, but the reticulated python (*python reticulatus*) is a potential land-based predator and has been observed in the study area.

While the predation pressure from land-based predators in the present study site may be low, the same may not be true for aquatic-based predation pressure. We may need to consider the width of the rivers at different study sites before making direct comparisons on the effect of aquatic-based predation pressure on sleeping site selections between different study areas. The mean bank-to-bank river width of the Menanggul River in Sukau studied by Matsuda *et al.* (2008), was 19.9m (n=78) and the mean river width of the Sekonyer Kiri River at Tanjung Puting National Park in Kalimantan studied by Yeager (1991) was 17.5 m (n=99). In both studies, Proboscis monkeys were frequently observed to cross the river at its narrower sections, i.e. 10.8 – 16.2m (Matsuda *et al.*, 2008) and 13.5m (Yeager, 1991), respectively. In the present study, the Garama River had a mean width of 33.3m, i.e. approximately two-third to twice wider than the width of the Menanggul and Sekonyer Kiri rivers. Moreover, we never observed monkeys crossing the surveyed stretch of the Garama River during the survey period. It is possible that the reason why the monkeys do not cross this river is due to the wider river width in Klias compared to other study sites. It may be difficult and even dangerous to cross an extremely wide river especially for females (often with infants) or juveniles as the monkeys will take longer time to traverse the distance, increasing the likelihood of predation. However, Proboscis monkeys have been observed to cross wide rivers such as the Padas River (> 60 m) in the west of Sabah and the Kinabatangan River (> 80 m) in the east of Sabah and even at sea in coastal waters (Boonratana, 1993; Payne, 2010; pers. observ. HB). These crossings of large rivers, nevertheless, occurred only very rarely and normally involved one or two adult males, although a harem group may also cross such rivers (Boonratana, 1993). The reluctance of Proboscis monkeys to cross rivers may be inferred to be due to high predation pressure of aquatic-based predators. No estimates of estuarine crocodiles in the Garama River are available, but the density of estuarine crocodiles in the main Klias River was estimated to be between 0.9 km^{-1} to 1.8 km^{-1} in 1993 (Shahrul & Stuebing, 1996). No attempt was made to estimate the density of estuarine crocodiles in the preset study, but juveniles and subadults of the estuarine crocodiles have been observed frequently at the sandy beaches along some parts the Garama riverbanks surveyed for Proboscis monkey sleeping trees indicating that Garama River is a suitable breeding habitat for estuarine crocodiles. In conclusion, while

there is some evidence in the present study to suggest that the terrestrial predation pressure at our study area in Klias may likely to be low, the predation pressure of aquatic-based predators may be high.

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