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Research Article

Nest density of the Black-and-Red Broadbill (*Cymbirhynchus macrorhyncos*) along the Kinabatangan River, in Relation to Riverine Habitat Reduction

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Abstract

In Borneo, the forest type that supports the largest number of species, the tropical lowland rainforest, is decreasing rapidly. To estimate what is the general effect of this habitat degradation and loss on birds, this study looks at the easily visible Black-and-Red Broadbill nests that were surveyed along the Kinabatangan river in eastern Sabah, Malaysian Borneo, and answers the following questions: (i) what is the current density of the population of the Black-and-Red Broadbill between Batu Putih and Bilit, along the Kinabatangan river, (ii) is the abundance of nests correlated with the surrounding habitat type (forest or disturbed area), and (iii) do Black-and-Red Broadbills need and/or use the riparian zone at the riverbank for nesting sites. During this study, a 55.6 kilometre river transect was surveyed for 3 days, and nests that were found were recorded. This study found that Black-and-Red Broadbills nests were significantly more often located in areas with a higher proportion of forest habitat type (compared to disturbed habitat type). Furthermore, this study shows that Black-and-Red Broadbills need branches and sticks at the river's edge to build their nest on, so they are profiting from the riparian zones along the river. Therefore we recommend enhancement of nesting opportunity by artificially providing above-water nesting sites along the river edge.

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Introduction

Every year, the amount of rainforest in the world is reduced by approximately 21 million hectares, as the combined consequence of logging for timber and clearing land for agriculture (Laurance, 1999). For organisms more or less restricted to the rainforest habitat, this forest cover reduction means a great loss and fragmentation of distribution area (Estes et al., 2012; Pahl et al., 1988; Wich et al., 2008). One of the main forest types that has been cleared is the Southeast-Asian lowland forest. In Sabah, the northern state in the Malaysian part of Borneo, approximately 40 % of the forest was lost during the 20th century (Estes et al., 2012). In Sabah, in the tropical floodplain of the lower Kinabatangan, the oil palm plantation land coverage has dramatically increased from 9,735 ha in 1975 to 156,848 ha in 1994 (Azmi, 1998). Today, 250,617 ha (of a total area of 520,269 ha) is cultivated with oil palm (Abram et al., 2014).

In Borneo, some species are strongly influenced by such habitat reduction, and it has had disastrous consequences for certain large-bodied vertebrates, such as the Bornean elephant (*Elephas maximus borneensis*), of which there are approximately 300 individuals left in the Lower Kinabatangan Managed Elephant Range (Estes et al., 2012). Other affected species are the Bornean orangutan (*Pongo pygmaeus*), which cannot live in the monoculture landscape of oil palm plantations (Ancrenaz et al., 2015; Wich et al., 2015), and certain bird species like hornbills, terrestrial insectivores, and bark-gleaning insectivores, which depend on unlogged forests for foraging (Cleary et al., 2007). Other species, on the other hand (e.g., tailorbirds (*Orthotomus*), munias (*Lonchura*) and certain sunbirds (Nectariniidae), are adapted to naturally occurring forest edges and they may thrive in the more disturbed areas that are created by clearing the lowland forests (Myers, 2016; Cleary et al., 2007).

It may be very hard to properly assess the impact of disturbance on bird populations that live in the lowland forest. This is due to the difficulty of accurately estimating numbers of breeding pairs in densely vegetated habitats with a high canopy, especially since this may need to be done by ear, and it may be hard to distinguish one species among many competing calls and songs. Selecting a bird species that has unique nesting locations and that can be nearly exhaustively sampled, such as the Black-and-Red Broadbill (*Cymbirhynchus macrorhyncos*), can circumvent these difficulties. This bird almost exclusively builds its nest on a stick or branch along the waterside and the bird is brightly coloured and easily visible when at or near the nest

(Smythies, 1999; Phillipps & Phillipps, 2009). Building a nest on a stick in the water could be a strategy to avoid egg predation by vertebrates, which is one of the major limitations for forest bird populations (Cooper & Francis, 1998).

During this study, we therefore investigated the nest density of the Black-and-Red Broadbill along the Kinabatangan in Sabah. With this information we could determine the effect of habitat fragmentation for this species. When we know more about the needs of the bird, conservation measures can be taken to prevent a decrease in this and other bird species that have similar ecological requirements.

Specifically, in this study we try to find out (i) what is the current density of the population of the Black-and-Red Broadbill along the 55.6-km-long river transect between Batu Putih and Bilit, (ii) whether the abundance of nests is correlated with the surrounding habitat type (forest or disturbed area), and (iii) whether Black-and-Red Broadbills need and/or use the riparian zone at the riverbank as nesting sites.

Materials and Methods

Study species

Black-and-Red Broadbills belong to the family Eurylaimidae, which is a small family distributed in tropical Africa and Asia, reaching South-East Asia in Central Myanmar, Thailand, Southern Indochina, Sumatra, and Borneo (Smythies, 1999). There are 15 species in the world and they are very well represented in Borneo, which is a hot spot of broadbill diversity with eight species including two endemics, namely Whitehead's Broadbill and Hose's Broadbill (Phillipps & Phillipps, 2009; Myers, 2016). The adult Black-and-Red Broadbills are 20-24 cm in length and have a distinctive plumage consisting of black, white and maroon-red, and a turquoise/yellow bill (Smythies, 1999; Robson, 2008; Phillipps & Phillipps, 2009). Black-and-Red Broadbills are found throughout the lowlands of Borneo up to 750 m elevation (Myers, 2016). They can be found in primary and secondary lowland dipterocarp forests, near water in riverine and peat swamp forest, mangroves, and overgrown plantations (Myers, 2016). Generally, Black-and-Red Broadbills are not very vocal (Phillipps & Phillipps, 2009). They are well known for river-haunting habits (Smythies, 1999). Black–and-Red Broadbills are substrate-gleaning insectivores, and their diet includes beetles, crickets, grasshoppers, snails and hemipterans (Smythies, 1999). They also have frugivorous habits, feeding on large-stoned berries, small white seeds, and leaves (Lambert & Woodcock, 1996; Myers,

2016) and in addition, small riverine animals such as small fishes, small crustaceans (Sheldon et al., 1992), and small crabs (Smythies, 1999). Their breeding season spans from January to September (Smythies, 1999). The birds particularly build their nests at the banks of rivers or streams, where the gigantic, pear-shaped nests can be found suspended from branches over water. The nests appear to mimic the bunches of flood-debris that are commonly found hanging from the ends of the branches of trees or sticks along rivers (Smythies, 1999). All other broadbill species build differently shaped or differently situated nests. The nests are highly characteristic and, in our opinion, cannot be confused with the nests of other species. The (two or rarely three) eggs of the Black-and-Red Broadbill are densely flecked chestnut on a pinkish-buff ground (Smythies, 1999). The conservational status of the Black-and-Red Broadbill in Sabah, as categorized by the IUCN (International Union for Conservation of Nature) Red List (www.redlist.org) is 'least concern'. This is mainly because of the extremely large range of the bird; the current population trend is, however, decreasing (BirdLife International, 2012).

Study Site

The Kinabatangan River is at 560 kilometres, the second longest river in Malaysia. It has a total catchment area of 16,800 km^2 (Azmi, 1996). Along the river, a large area of forest has been cleared for oil palm since 1975 (Azmi, 1998. The Lower Kinabatangan Wildlife Sanctuary contains riparian forest, seasonally flooded forest, swamp forest, dry dipterocarp forest, estuary nipa palm (*Nypa fruticans*) and mangrove (Estes et al., 2012). During this study, we recorded all the nests along the Kinabatangan River between Batu Putih (5°24'25"N, 117°57'4"E) and Bilit (5°29'49"N, 118°12'25"E), a distance of about 55.6 km. We chose this length based on a rough estimate for the number of nests per km along the Menanggul tributary as given in Smythies (1999), namely four per 2.6 km.

Survey Procedure

From the 29th of February until 2nd of March 2016, three to five persons identified nests by cruising along the river and scanning potential nesting sites along the banks with binoculars or with the naked eye. We surveyed on the first day from 7:00 am until 4:00 pm with 3 persons, the second day from 8:00 am until 1:00 pm with 5 persons, and the third day from 7:00 am until 11:00 am with 3 persons. Each day, a different part of the transect was covered. Per potential nest found, we recorded the coordinates, left or right side of the river (defined by the direction of the current), the height above the water (estimated) and we roughly estimated the nest size in centimetres. Once a

nest was found, we started a 15-minute survey of the nest to determine the occupancy status (yes/no) of the nest. The 15 minutes survey time was determined based on the time available for the entire project. As soon as a Black-and-Red Broadbill was seen emerging from the nest or entering into it, or perching within 5 m from the nest, we considered the nest occupied and stopped the 15-minute watch. In addition, we recorded the types of vegetation along the entire riverbank; we distinguished (i) reedland and/or grassland and (ii) forest.

Coordinates

For the coordinates we used two different devices: the iPhone compass application for nest numbers 16-28, 26, 35 and 38-42, and a Garmin Oregon 600 GPS device for nest numbers 1-15, 29-33, 37, and 43-69. For the coordinates from the GPS device we applied Timbalai as map datum, which required us to correct the coordinates by shifting all 3.65" east and 9.54" south. In addition we needed to correct numbers 5, 6, 15, 25, 33, and 66 slightly to place them in the correct place, according to our notes. The coordinates derived from the iPhone compass application proved less precise than the ones from the GPS device but they were accurate enough to show in which habitat type the nests were situated.

Nest Categories

We categorized the nests in three categories (see figure 1). Category 1 nests did not (yet) have the right size or structure to function as a nest. These nests could be old nests or nests that are still under construction or even non-nest debris. Category 2 nests had the right size and structure and could be nests that were in use at the time of the survey, but no bird was seen during the 15-minute watch. Category 3 nests were nests at which we observed one or two birds during the 15 minutes of observation. For each nest, we recorded the type of riverbank vegetation in which it was present.

Data Analysis

We plotted all nest locations (of all three categories) in Google Earth (see figure 2 and figure 3). We projected a pattern of 100 m x 100 m plots on an area ranging 500 m from the river, on both sides and determined if the plot was composed of (more than 50 %) (1) river, (2) forest or (3) disturbed area, namely oilpalm plantations, roads, and villages. We did the same for circles of 1 kilometre diameter around the nests. Then, we counted the different blocks and compared the habitat types around the nests with a baseline habitat type distribution around the entire river transect, using a Pearson's Chi-squared test with Yates' continuity correction. For the statistics we have used RStudio (Rstudio 0.99.484).

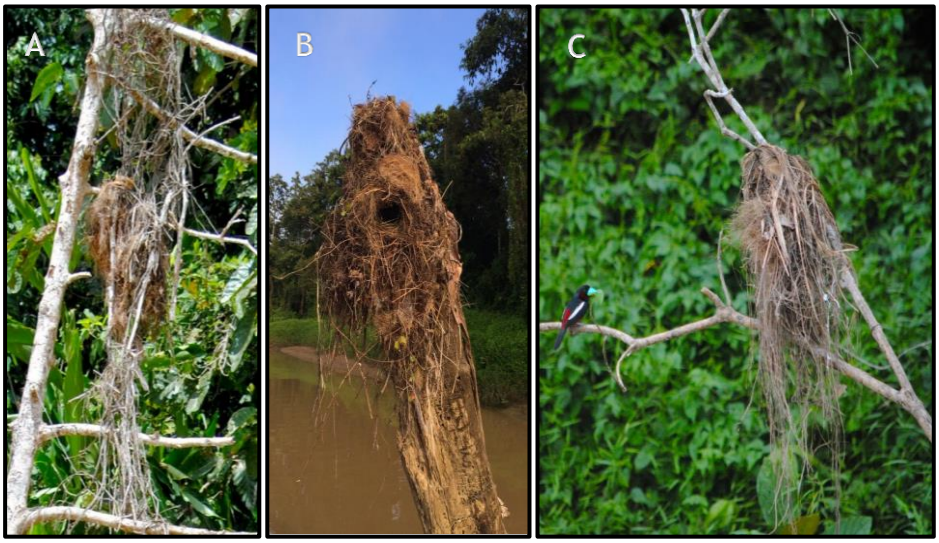

Figure 1. Examples of the different nest categories used in this study. **A** Category 1 nest **B** Category 2 nest **C** Category 3 nest

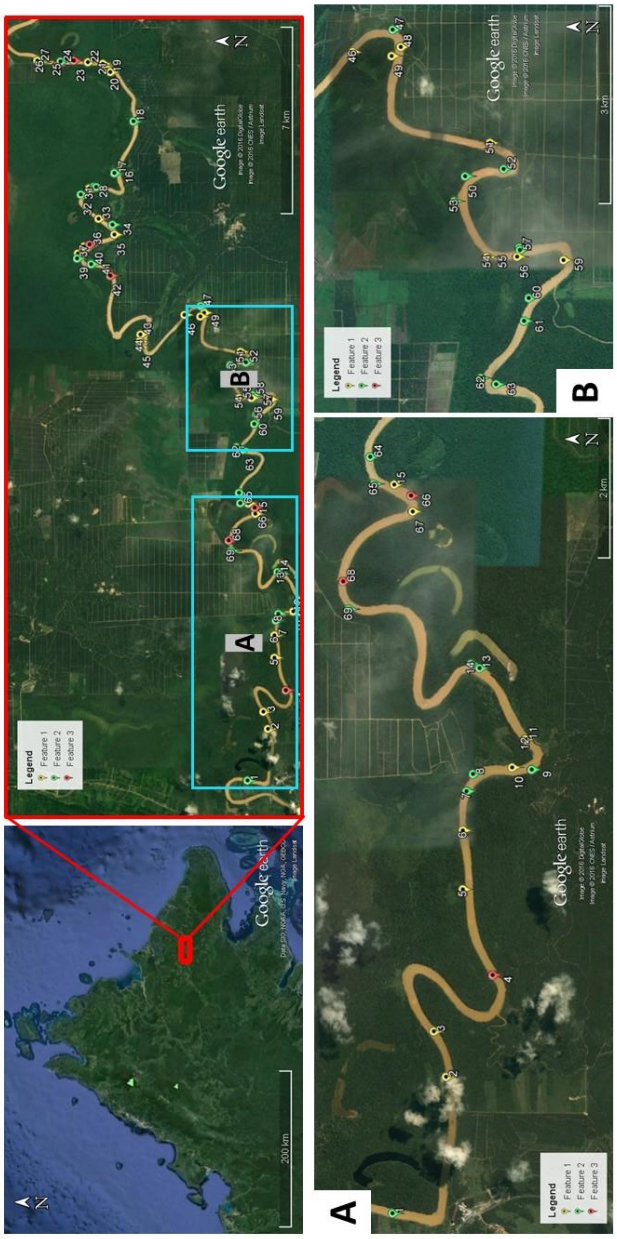

Figure 2. Nest location plotted on Google Earth image of the area

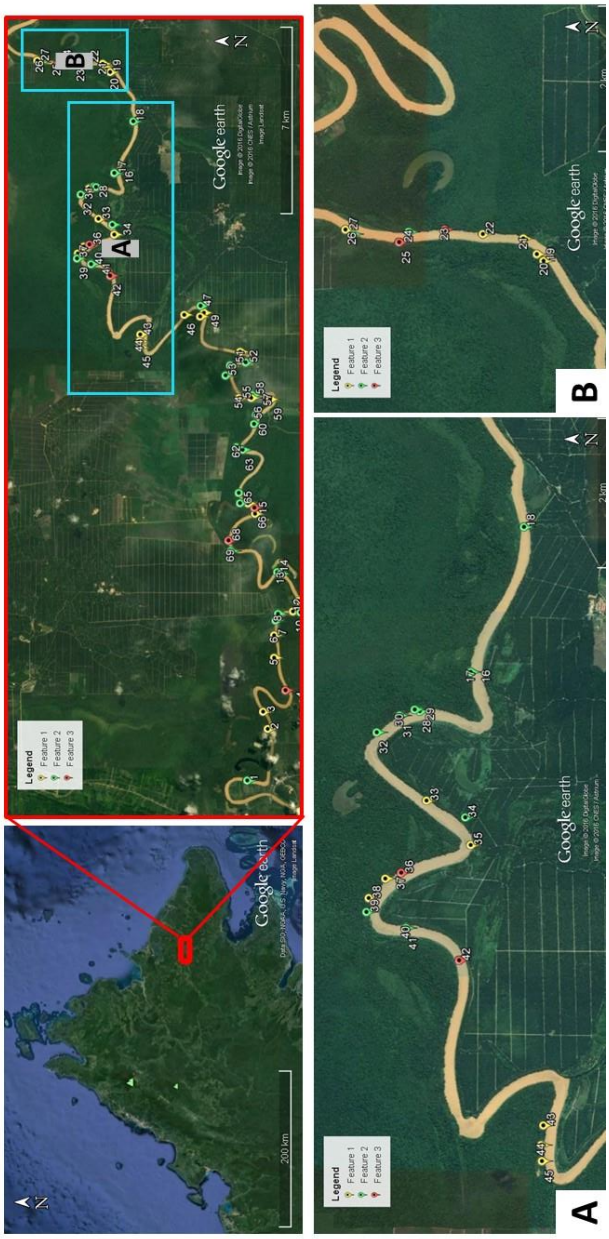

Figure 3. Nest location plotted on Google Earth image of the area

Results

Nest abundance

During the three days of survey, we registered 69 potential nests of the Black-and-Red Broadbill of which eight were in category 1; 30 in category 2; and 31 in category 3. For this area, we found 2 occupied nests per 3.6 kilometres of river, which is a lower abundance than along the Menanggul tributary as given in Smythies (1999).

Association with surrounding habitat type

Our study found that the nests are not randomly distributed among habitat types (see table 1). With the chi-square test, we found that these results are significant ($p<0.001$), which suggests that the Black-and-Red Broadbill prefers building its nest in areas with a lot of forest.

Table 1. The numbers in the cells are the numbers of 100m x 100m plots counted in a map. The first row represents the null hypothesis as it shows the overall area around the river[1], the second row shows the deviations from the null hypothesis for the areas around all nests[2].

	River[(i)]	Forest[(ii)]	Disturbed[(iii)]	**Total**
Habitat type along the river[1]	656	2672	1971	**4643**
Habitat type around the nests[2]	906	3022	1385	**5313**

Riparian zone

We found that all the nests were situated at the waterside where there is some form of tree coverage or dead wood. There were no nests in riverside sections where the banks were covered by reed or grass. At these sides, there was a lack of strong branches for attaching nests to.

Discussion

Nest abundance

It is not possible to say much about the population density of the Black-and-Red Broadbill based only on this study because we only surveyed a very short part of their nine-months breeding season (Smythies, 1999). Moreover, our surveying method did not allow us to cover oxbow lakes and tributaries, which also are likely to contain nesting sites. To tell if the population is increasing or decreasing with habitat degradation of the forest, one requires data over many years. So, with this study we can only give an indication of the population at the time of the survey. We recommend a multi-year monitoring of the

population to document the population trends. It could be tempting to advocate the monitoring of Black-and-Red Broadbill nests as a quick method to assess habitat quality. However, if population density for this bird species depends strongly on the availability of nesting sites (Cooper & Francis, 1998), its use as a habitat quality indicator may be limited.

Correlation with surrounding habitat type

During this study we found a clear preference in habitat type for the nesting location of the Black-and-Red Broadbills. Whether this is due to the need for nesting material, food or other resources has not been looked at in this study, but is definitely interesting to investigate in the future.

Riparian zone

When land in low-lying floodplains is cleared and converted to agricultural lands, such as oil palm plantations, a riparian zone at the riverbank can be a conservation measure taken to reduce river siltation and to function as a corridor for migrating animals (Goossens et al., 2005), or as a refuge (Sieving et al., 2000) for others. For the Black-and-Red Broadbill, the riparian zone can be useful when it comes to finding a suitable place to build a nest. It might be possible that the Black-and-Red Broadbill does not rely on the actual tree zone, and that just some dead trees in the water or artificial sticks close to the waterside would be sufficient. Therefore, we recommend enhancement of nesting opportunity by artificially providing above-water nesting sites along the river edge. It might also be that the birds are relying on the forest for foraging, as they consume different food types (Myers, 2016) but this was not taken into account during this study.

General Conclusion

Black-and-Red Broadbills build their nests along the river on branches and sticks that are standing in the water or hanging above the water. They prefer to build their nests in an area with more forest as a habitat type compared to the alternative: disturbed habitat type. They might profit from the riparian zones when it comes to finding a branch or stick to build their nests on but it also might work to just provide these branches or sticks artificially. The preference shows that the Black-and-Red Broadbills might rely on forest habitat and riparian zone for other resources than just the nest location but further research is necessary to provide this information.

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