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S10-1 Effects of rainforest fragmentation and disturbance on the demographics of Southeast Asian birds

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Abstract Southeast Asia is currently subject to one of the highest rates of deforestation in the world. The consequences are poorly understood. Accordingly, I review my recent work on the effects of forest fragmentation and disturbance on the demography of Southeast Asian birds. Studies using indirect demographic measures (age structure, sex ratio, recapture rates, presence of ectoparasites and fault bars) found that such variables did not differ among monitored populations in intact and fragmented/secondary forests. However, more individuals had fault bars in forest fragments and more recaptures were recorded in intact continuous forest. Artificial nest predation experiments showed that bird populations in primary forests generally suffered less from depredation than those in secondary forests. Overall, information available on the demographics of Southeast Asian forest birds remains poor; yet it is vital for enhancing knowledge of regional avian ecology and effective regional conservation.

Key words Body condition, Conservation, Habitat fragmentation, Mist-netting, Parasitism, Reproductive success

1 Introduction

Deforestation of Southeast Asian rainforests has reached unprecedented levels with an estimated 1% of forests cleared annually (Achard et al., 2002). Because of it, most tropical rainforests now survive in small patches (remnants or fragments) or as disturbed forest (e.g., secondary forest). As a result, a considerable number of endemic bird species are threatened with extinction (Casteletta et al., 2000). Now more than ever, monitoring of birds in the remaining rainforests is urgently needed so that plans can be devised to preserve them. Additionally, documentation of reduced avian diversity and abundance in remnant and disturbed forests is crucial for arguing for the protection of large undisturbed tracts of forest. Towards providing this information, I review here my current work on the effects of forest fragmentation and disturbance on the demography of the Southeast Asian avifauna.

2 Materials and methods

2.1 Mist-netting

Because tropical birds are generally long-lived, relatively precise demographic data can be obtained by monitoring marked individuals over several years. In Southeast Asia, however, such data are often difficult to collect because study sites can be logged before the completion of a study. For breeding data, moreover, nests are particularly difficult to find in rainforests because of the ease of concealment; and birds may breed throughout the year, making statistically interpretable data difficult to collect.

Due to such constraints, I resorted to collecting data on body condition, age structure, sex ratio and recapture frequency from mist-netting instead, based on the assumption that these parameters would be indicative of avian reproductive success and survival. I also collected data on various surrogates for body condition (e.g., parasite load). Two forest fragments in Singapore were sampled and the data compared with those from two intact primary forests in Sarawak on Borneo. The two fragments in Singapore, Nee Soon and MacRitchie forests, are located in the central water catchment area (1°22'N, 103°48'E; Fig. 1), and cover 937 and 483 ha, respectively. The two continuous forests in Sarawak, the Matang Wildlife Sanctuary (hereafter Matang; 1°48'N, 110°00'E) and Gunung Gading National Park (hereafter Gading; 1°48'N, 109°52'E) cover 2 230 and 4 196 ha, respectively (Fig. 1). Because they are in the same biogeographic region (Greater Sundas), both Singapore and Sarawak harbor similar forest types and bird communities.

In all four sites, I conducted mist-netting between March and November 1998. The total net-hours were 1 442, 1 413, 1 566 and 1 661 in Nee Soon, MacRitchie, Matang and Gading, respectively. All captured individuals were identified, measured, banded and released. Captured individuals were sexed by plumage coloration where possible, aged at < 1 or > 1 year based on skull pneumatization, and weighed. A bird was considered recaptured if it was caught again during any of the subsequent mist-netting sessions excluding those within the same month. I determined the presence of ectoparasites (chewing lice, suborder Mallophaga) by carefully examining the right wing against

sunlight. Parasitic prevalence is predicted to be high in lower quality habitats (Sodhi, 1995). The presence of fault bars was determined by carefully examining the tail against sunlight. Fault bars are thought to result from nutritional stress during feather growth, and are considered reliable indicators of body condition (Steeger and Ydenberg, 1993). Only resident bird species were recorded and compared. Comparisons were usually made at the community/population level (e.g., for sex ratio), but when sample sizes permitted, variables were compared across three particular species: little spiderhunter (*Arachnothera longirostra*), short-tailed babbler (*Malacocincla malaccensis*) and chestnut-winged babbler (*Stachyris erythroptera*). Further details of the study sites and methods are given in Sodhi (2002a).

In Java, I gathered further data in Linggoasri (109°30'E, 7°00'S), which is located in the Dieng mountains (Fig. 1). The total area of continuous forest in the Dieng Mountains covers 25 500 ha, and is one of the last remaining lowland rainforests in Java. The four monitoring sites comprised (1) a selectively-logged tract of primary lowland/submontane forest at least 80 years old, 30% of which had been logged illegally, (2) two young secondary lowland forests clear cut in 1998, and (3) a pine (*Pinus merkusii*) plantation planted in 1952. Mist-netting was carried out at all sites between April and July 2001. Total net-hours were 825, 900, 941 and 770 in the primary, two secondary and pine forest sites, respectively. The same variables were recorded as in the Singapore and Sarawak programs.

2.2 Artificial nest predation experiments

Because actual predation events are difficult to observe, I used artificial nest experiments to compare predation pressure among sites. Artificial nest predation experiments were conducted in August 1996 in five forest fragments in Singapore state. Two sites were in primary forest, two in secondary forest, and the fifth was located in an abandoned rubber (*Hevea brasiliensis*) plantation. In an experiment to screen ground-nest predation, one chicken (*Gallus gallus*) egg and one plasticine egg were placed together at each station. The eggs were simply placed on the open ground without any attempt to create an artificial nest. Experimental nest stations were checked on day 8. Nests were considered attacked on if an egg was missing, or if the chicken egg was cracked, pecked or smashed, or if the plasticine egg showed bite-marks. More details of this procedure can be found in Wong et al. (1998).

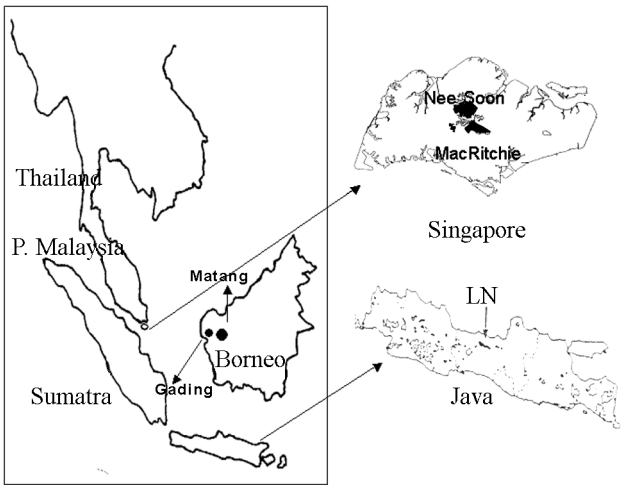

Fig. 1 Map of Southeast Asia showing the study sites
LN = Linggoasri.

Because nest placement can affect predation (Yahner and Scott, 1988), I conducted additional experiments in Singapore in May and June 2000. These were carried out in two tracts of primary forest, two of secondary forest and two of woodland (abandoned rubber plantations). The egg of one Japanese Quail (*Coturnix japonicus*) and one plasticine egg were placed together in an artificial cup nest (15 cm in diameter × 5 cm high) secured by wire fasteners in shrubs or trees at a height of 1 m. In June 2001, I conducted similar experiments in Linggoasri, Java. There artificial arboreal nests were placed in a primary forest, a young secondary forest and a pine plantation. All artificial nests were checked after eight and four days in Singapore and Java, respectively.

Previously, Cooper and Francis (1998) performed artificial nest predation experiments in Pasoh, Peninsular Malaysia (2°58'N, 102°17'E). They placed experimental ground nests containing two quail eggs in the interior of unlogged and logged forest and on the edges. Their stations were checked on days 2 and 5.

3 Results

3.1 Fragments (Singapore) versus continuous forest (Sarawak)

For all species combined, bird recaptures were at least 18% higher in Gading than in other sites ($\chi^2 = 8.35$, $df = 3$, $P = 0.04$). However, for the little spiderhunter ($\chi^2 = 9.7$, $df = 2$, $P = 0.008$) and short-tailed babbler ($\chi^2 = 6.75$, $df = 2$, $P = 0.03$), recaptures were still higher by 24% and 34% respectively in MacRitchie and Gading. Neither the proportion of adults nor sex ratios differed among sites ($P > 0.11$), either for all species combined or individual species. Similarly, body mass of the little spiderhunter and short-tailed babbler did not differ among the sites ($P > 0.06$). However, chestnut-winged babblers were 1 g heavier, on average, in Nee Soon than MacRitchie (Mann-Whitney $U = 21$, $df = 8, 14$, $P = 0.02$). For all species combined, the load of ectoparasites did not differ among sites. At least 39% more short-tailed babblers carried parasites in Nee Soon than in other forests ($\chi^2 = 7.73$, $df = 2$, $P = 0.02$). However, 55% more chestnut-winged babblers were parasitized in MacRitchie than in Nee Soon ($\chi^2 = 7.49$, $df = 1$, $P = 0.006$). Overall, at least 15% more individuals had fault bars in MacRitchie than other forests. Similarly, at least 40% and 52% more little spiderhunters and short-tailed babblers, respectively, had fault bars in MacRitchie than in other forests ($P < 0.01$). For sample sizes and further comparative details, see Sodhi

(2002a).

3.2 Forests of central Java (disturbed versus undisturbed)

Because very few individuals were captured in the pine plantation, only the results for the primary and two secondary forest sites are compared here. Little spiderhunters were recaptured at least 12% more times in primary than the secondary forests ($n \geq 6$); and at least 17% more adult little spiderhunters were recorded in primary forest ($n \geq 6$). However, these and other differences were not statistically significant ($P > 0.05$).

3.3 Artificial nest predation

In Singapore, 80% of 328 set ground nests were predated, but one primary forest site suffered at least 12% less predation than other fragments ($P = 0.01$). Sixty-two percent of the arboreal nests ($n = 110$) were depredated. However, there was no difference in predation among forest types ($\chi^2 = 3.12$, $df = 5$, $P = 0.68$). In Java, only 10% of 105 set arboreal nests were predated. Predation was 20% less in primary forest than secondary forest sites. However, the same proportion (3%) of nests was predated in primary and pine forests. After five days in Pasoh, Cooper and Francis (1998) recorded that at least one more nest had survived within unlogged forest than in logged forest interior and forest edge.

4 Discussion

For all the species combined, as well as the short-tailed babbler, Gading produced the highest recapture rates. It is possible that higher recaptures in the larger forest tract imply low mortality or greater site fidelity, but they can also be affected by resource distribution. Chestnut-winged babblers were heavier in Nee Soon and carried a low parasitic load there. Body mass has been shown to be negatively correlated with parasitism in birds (Paperna and Smallridge, 2002). However, such a relationship was not apparent for the other species. This suggests that species may differ in how body mass affects their susceptibility to parasitism. The highest occurrence of fault bars in MacRitchie may indicate that the bird community there was more resource-limited than elsewhere; it is possible that habitat quality was poorer, at least for some bird species. One possible factor depressing habitat quality for birds in MacRitchie could have been high anthropogenic disturbance from army and other exercises.

As for Singapore and Sarawak sites, more recaptures were recorded in the primary forest tract on Java, and this forest contained more adult little spiderhunters too. These differences, however, were not statistically significant, probably due to small sample sizes. They do suggest, nevertheless, that habitat quality in primary forest is higher, a likelihood supported by lower predation of artificial nests there than in at least one of the secondary forests.

Artificial nests, both ground and arboreal, experienced heavy predation pressure in Singapore. Singapore has been severely deforested, with less than 5% of the native forest cover remaining. In this heavily developed island, forest birds suffer because of infiltration of nonnative generalized predators (e.g., feral cats, *Felis catis*) from surrounding suburbia. Other small predatory mammals, e.g., squirrels, are also often in high numbers in forest fragments due to the loss of mesopredators. It is not surprising then that at least one of the primary forest sites suffered less ground nest predation than those in secondary and plantation forests. Similarly in Pasoh and Java, nest predation in more pristine forest was lower. Although the artificial nest experiments may not realistically reflect natural nest predation rates (Haskell, 1995), they nonetheless indicate here that less disturbed sites suffer less nest loss than more disturbed sites.

I conclude by repeating that information on the ecology of Southeast Asian forest birds is poor (Sodhi, 2002b). More data on their demographics are needed to enhance ecological understanding and to understand and predict the effects of heavy deforestation.

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References

Achard F, Eva HD, Eva H-J, Stibig P, Mayaux J, Gallego T, Richards, Malingreau J-P, 2002. Determination of deforestation rates of the world's humid tropical forests. Science 297: 999–1002.

Castelletta M, Sodhi NS, Subaraj R, 2000. Heavy extinctions of forest avifauna in Singapore: lessons for biodiversity conservation in Southeast Asia. Conserv. Biol. 14: 1 870–1 880.

Cooper DS, Francis CM, 1998. Nest predation in a Malaysian lowland rain forest. Biol. Conserv. 85: 199–202.

Haskell DG, 1995. A reevaluation of the effects of forest fragmentation on rates of bird-nest predation. Conserv. Biol. 9: 1 316–1 318.

Paperna I, Smallridge C, 2002. *Haemoproteus columbae* infection of feral pigeons. Raff. Bull. Zool. 50: 281–286.

Sodhi NS, 1995. Parasitic infection of migratory bird species. Trends Ecol. Evol. 10: 417–418.

Sodhi NS, 2002a. A comparison of bird communities of two fragmented and two continuous southeast Asian rainforests. Biodiver. Conserv. 11: 1 105–1 119.

Sodhi NS, 2002b. The effects of food-supply on Southeast Asian forest birds. Ornithol. Sci. 1: 89–93.

Steeger C, Ydenberg RC, 1993. Clutch size and initiation date of osprey — natural patterns and effect of a natural delay. Can. J. Zool. 71: 2 141–2 146.

Wong TCM, Sodhi NS, Turner IM, 1998. Artificial nest and seed predation experiments in tropical lowland rain forest remnants in Singapore. Biol. Conserv. 85: 97–104.

Yahner RH, Scott DP, 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Manag. 52: 158–161.