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SHORT COMMUNICATION

Recovery of termite (Isoptera) assemblage structure from shifting cultivation in Barito Ulu, Kalimantan, Indonesia

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The lowland rain-forest ecosystem in Sundaland (Borneo, Sumatra, Java, the Malay Peninsula south of 10°N, and associated islands) has been recognized as a biodiversity hotspot (Myers *et al.* 2000). However, it is suffering from huge amounts of disturbance, and it is predicted that South-East Asia will lose three-quarters of its rain forest by the turn of next century (Sodhi *et al.* 2004).

Shifting cultivation (otherwise known as swidden or slash-and-burn agriculture, or *ladang* in Indonesia and Malaysia) has been blamed as the primary agent of worldwide rain-forest loss (Myers 1993) and clearance of forest for agriculture certainly has a far greater impact on forest structure and communities than selective logging (Whitmore 1984). However, relatively little is known about the recovery of abandoned fields, and the duration of the effects of this type of cultivation. In this study, we investigated the rate of recovery of the termite assemblage structure from the effects of shifting cultivation in central Borneo.

Termites are providers of many important ecosystem services. They are the most important arthropod decomposers in the lowland rain-forest ecosystem (Collins 1989). They are thought to have an essential role in the recovery of soil fertility after habitat disturbance, and therefore the recovery of the forest ecosystem (Davies *et al.* 1999). They are known to be sensitive to disturbance, especially to forest canopy loss (Gathorne-Hardy *et al.* 2001), and forest conversion to oil palm or rubber plantations (Gathorne-Hardy *et al.* 2002a, Jones *et al.* 2003).

The Barito Ulu study site (113°56′E, 0°6′S) is at an altitude of about 150 m asl, on the banks of the Busang River in Central Kalimantan, Indonesian Borneo (Figure 1). The vegetation is mainly lowland mixed dipterocarp rain forest, with a mean annual rainfall of 3600 mm (Mirmanto *et al.* 1999). The study site is a Quaternary rain-forest refugium (Gathorne-Hardy *et al.* 2002b). Much of the forest is secondary, having been used for *ladang*. The age of these secondary forest sites is known, from communication with local Dyaks (J. Proctor, R. Ridgeway, pers. comm.).

We sampled termites in primary forest and secondary forest of different ages (*c.* 60, 30, 20 and 2 y old). All secondary forest sites are within 300 m of primary forest. The primary forest site is known to be primary (John Proctor, pers. comm.), and has been shown to have a very similar termite composition to other ancient primary rain-forest sites in the region (Gathorne-Hardy *et al.* 2002b). We assumed that, before they were disturbed, the secondary forest sites had termite communities similar to the primary site. The sampling sites were chosen to give us a disturbance gradient similar to that studied by Jones *et al.* (2003), except with a variable of time since disturbance, rather than different disturbance types.

We used a standardised transect method (Jones & Eggleton 2000), which has been demonstrated to give a representative sample of the composition of the local termite assemblage.

The specimens collected were identified at The Natural History Museum (BMNH), London. They will be lodged at the Bogor Zoology Museum, Indonesia, with duplicates at the BMNH. Specimens were identified to species or, where this proved impossible, to numbered morphospecies. Specimens were classified as wood or soil feeders following

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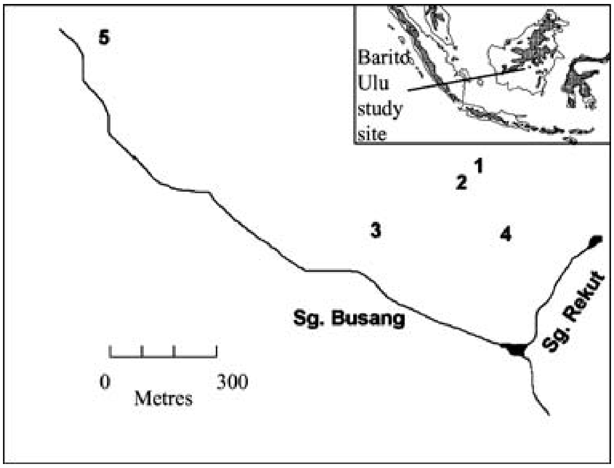

Figure 1. Map of study site. Indented is a map of Sundaland, showing the position of the Barito Ulu study site. Sites where transects run shown: 1, Primary forest; 2, 60-y-old secondary; 3, 30-y-old secondary; 4, 20-y-old secondary; 5, 2-y-old secondary.

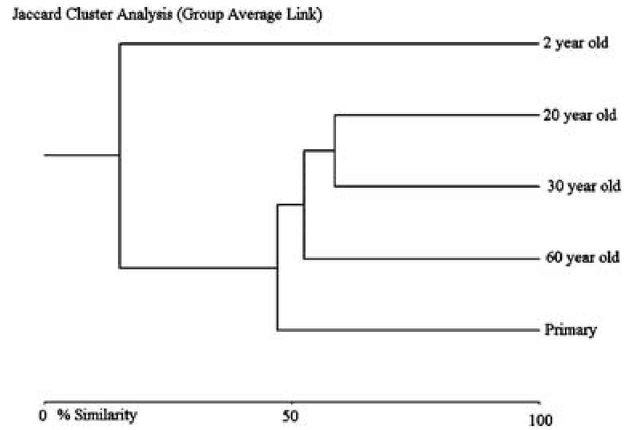

Figure 2. Jaccard's coefficient cluster analysis diagram showing difference of 2-y-old site from others.

the feeding group classification of Donovan *et al.* (2001), with species in Donovan feeding groups i and ii being classified as wood feeders, and species in groups iii and iv classified as soil feeders.

All data are expressed as numbers of encounters (hits) per taxonomic unit per transect. The number of hits acts as a surrogate for relative abundance (Gathorne-Hardy *et al.* 2001). We used Jaccard's coefficient cluster analysis (Krebs 1999), to examine the similarity of the five sites to each other, using the Biodiversity Professional computer program (McAleece, N. © 1997 The Natural History Museum and The Scottish Association for Marine Science, all rights reserved.) to carry out the analysis.

A total of 41 species of termite were found in the five transects run in the Barito Ulu study area (Table 1). Only six species of termite were found in the 2-y-old site, while in all the others a similar species richness (between 23 and 26 spp.) was found. No soil-feeding species was found in the 2-y-old site, though they made up 40–50% of the species (and 40–70% of the relative abundance) in the other sites. Cluster analysis shows that the assemblage of the 2-y-old site was very different from the other sites (only 17% similarity – see Figure 2), while the other four sites had a very similar (at least 45% similarity) species assemblage (Figure 2).

The assemblage of the 2-y-old site is very similar to other recently cleared *ladang* sites sampled in the region (Syaukani, unpubl. data). It is known that termite assemblages are severely affected by removing the rain-forest canopy (Gathorne-Hardy *et al.* 2002a) and it appears that the 2-y-old site has not yet recovered.

The termite species composition of the secondary forest sites older than 2 y was extremely similar to that of primary forest, especially as only about 30% of the total species assemblage is actually collected in one transect (Jones & Eggleton 2000), as are species richness and abundance (Table 1). The secondary forest has an almost complete termite assemblage, which is probably able to provide important ecosystem services, thereby conserving soil fertility (Lavelle *et al.* 1997). In a pilot study of the dung beetles of the area, it has been found that they too have an almost complete assemblage in the 20-y-old secondary forest (D. J. G. Inward, unpubl. data). An area containing this assemblage is therefore important, both for conservation of insect species, and of their vital ecosystem services (Collins 1989, Davis *et al.* 2001). It can also act as a source area from where termites (and other insects) can recolonize nearby younger secondary forest. If the younger secondary forest is far away however, recolonization is likely to take longer. For termites, it is thought that it takes more than 10 000 y for the assemblage to fully recolonize over distances of 150 km (or more) after a disturbance event (Gathorne-Hardy *et al.* 2002b).

It is possible that traditional *ladang* methods, with long fallow periods, a mosaic of fields of different ages, and with many old fields planted with rubber or fruit trees (Gönner 2000), therefore may be able to support functionally viable termite populations (though the effects of repeated disturbance on termites has not yet been tested), even if almost all of the primary forest in an area has gone. This emphasises the conservation value of even disturbed, regenerating forests, and indicates that a measure of protection for these should be introduced.

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Table 1. Table showing termite species found in transects at Barito Ulu. The data are expressed as number of hits per species per transect.

Species	Food type: W = wood. S = soil	Primary forest	60-y-old secondary	30-y-old secondary	20-y-old secondary	2-y-old secondary
Rhinotermitidae						
Schedorhinotermes medioobscurus (Holmgren) 1914	W	9	11	3	0	5
Schedorhinotermes brevialatus (Haviland) 1898	W	1	3	4	5	0
Schedorhinotermes malaccensis (Holmgren) 1913	W	1	0	0	0	0
Parrhinotermes aequalis (Haviland) 1898	W	1	0	0	2	0
Parrhinotermes minor Thapa 1981	W	0	1	0	0	0
Parrhinotermes buttelreepeni Holmgren 1913	W	2	0	0	0	0
Heterotermes tenuior (Haviland) 1898	W	14	5	6	17	0
Coptotermes kalshoveni Kemner 1934	W	0	0	0	0	2
Macrotermitinae						
Macrotermes malaccensis (Haviland) 1898	W	3	0	3	3	0
Odontotermes minutus Amir 1975	W	7	16	2	2	0
Odontotermes billitoni Holmgren 1913	W	0	0	0	1	0
Amitermes group						
Prohamitermes mirabilis (Haviland) 1898	W	4	4	2	1	0
Microcerotermes serrula (Desneux) 1904	W	2	0	0	3	0
Globitermes globosus (Haviland) 1898	W	0	5	3	8	0
Foraminitermes group						
Labritermes buttelreepeni Holmgren 1913	S	0	3	4	5	0
Labritermes kistneri Krishna & Adams 1982	S	0	2	0	2	0
Labritermes emersoni Krishna & Adams 1982	S	0	0	4	0	0
Group III *Termes/Capritermes* group						
Termes rostratus Haviland 1898	S	2	0	0	0	0
Pericapritermes nitobei (Shiraki) 1909	S	16	1	22	23	0
Pericapritermes dolichocephalus (John) 1925	S	6	0	8	2	0
Dicuspiditermes nemorosus (Haviland) 1898	S	11	1	2	4	0
Pseudocapritermes sp. 1	S	3	14	11	13	0
Pseudocapritermes orientalis (Ahmad & Akhtar) 1981	S	0	0	1	0	0
Procapritermes prosetiger Ahmad 1965	S	0	1	0	0	0
Procapritermes minutus (Haviland) 1898	S	1	0	0	0	0
Procapritermes neosetiger Thanpa 1981	S	0	0	1	2	0
Mirocapritermes connectens Holmgren 1914	S	1	5	13	9	0
Homallotermes exiguus Krishna 1968	S	0	2	3	0	0
Homallotermes foraminifer (Haviland) 1898	S	0	1	0	0	0
Group IV *Termes/Capritermes* group						
Oriencapritermes kluangensis Ahmad & Akhtar 1981	S	4	1	1	0	0
Kemneritermes sarawakensis Ahmad & Akhtar 1981	S	1	0	0	0	0
Group II Nasutitermitinae						
Longipeditermes longipes (Haviland) 1898	W	2	5	0	0	0
Hospitalitermes hospitalis (Haviland) 1898	W	0	1	0	0	0
Nasutitermes longinasus (Holmgren) 1913	W	3	0	0	3	9
Nasutitermes neoparvus Thapa 1981	W	0	0	1	0	0
Bulbitermes flavicans (Holmgren) 1913	W	0	8	1	2	8
Bulbitermes singaporiensis (Haviland) 1898	W	4	3	4	8	2
Bulbitermes constrictus (Haviland) 1898	W	11	5	8	7	11
Hirtitermes brabazoni Gathorne-Hardy 2001	W	1	3	0	3	0
Group III Nasutitermitinae						
Malaysiotermes spinocephalus Ahmad 1968	S	9	17	11	4	0
Malaysiotermes holmgreni (Ahmad) 1968	S	7	2	0	0	0
Total No. hits		126	120	118	129	37
Total No. spp.		26	25	23	23	6

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