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Short communication

Utilization of *Macaranga* trees by the Asian elephants (*Elephas maximus*) in Borneo

Hisashi Matsubayashi[1,*], Peter Lagan[2] and Jum Rafiah Abd. Sukor[3]

[1] *Tokyo University of Agriculture, 1737 Funako, Atsugi, Kanagawa 243-0034, Japan*
[2] *Forestry Department of Sabah, Sandakan, Sabah, Malaysia*
[3] *Wildlife Department of Sabah, Kota Kinabalu, Sabah, Malaysia*

Study on the interaction between elephants and plants had been conducted in Africa (Laws 1970; Wing and Buss 1970) and South Asia (Mueller-Dombois 1972; Sukumar 1989). *Loxodonta africana*, caused serious damage to trees, particularly to the *Acacia* spp., Baobab (*Adansonia digitata*), and Marula (*Sclerocarya birrea*) (Buechner and Dawkins 1961; Weyerhaeuser 1985; Ruess and Halter 1990; Barnes et al. 1994; Tchamba 1995; Gadd 2002), while *Loxodonta cyclotis* has been assumed to contribute to the complexity of the forest by spreading seed and maintaining open areas (Short 1981). However other studies in South Asia have shown that *Elephas maximus* did not cause serious damage to trees. Only a few literatures have been published in Southeast Asia (Khan 1977). *Macaranga* (Euphorbiaceae) is a genus of approximately 280 species, distributed from West Africa to the south Pacific islands, with the center of diversity in New Guinea and Borneo (Whitmore 1969). Although *Macaranga* was listed as one of the foods of the Asian elephant (*Elephas maximus*) in the Malay Peninsula (Khan 1977), little is known about the damage they cause on the trees. The Elephas maximus is one of the largest populations of Asian elephants in Borneo (Payne and Andau 1991). To understand utilization of *Macaranga* trees by the Asian elephant, we investigated their foraging behavior in Deramakot Forest Reserve, Sabah, Borneo.

Materials and methods

The study was conducted in the Deramakot Forest Reserve (55083 ha; 05°22'N, 117°26'E) (Fig. 1), Sabah, Malaysia, which is mostly covered by the lowland mixed dipterocarp forests dominated by the family Dipterocarpaceae (*Dipterocarpus* spp., *Shorea* spp., and *Parashorea* spp.), and has a breeding population of Bornean elephant. The climate is humid equatorial with a mean annual temperature of about 26°C, and is greatly influenced by the northeast monsoon (November–February) and the southwest monsoon (May–August), the average annual precipitation ranges from 1700 to 5100 mm (Kleine and Heuveldop 1993; Huth and Ditzer 2004).

We established a survey-transect: 300 m long and 5 m wide along the road (05°24'N, 117°25'E), and conducted the tree survey in 28 January 2004. Two species of *Macaranga* trees, *M. hypoleuca* and *M. gigantea* were counted, the size of Girth at Breath Height (GBH) was measured, and the number of foraged *Macaranga* trees and the number of fatally damaged trees were recorded. We defined trees with broken trunks and fallen down from the root through foraging as fatally damaged, and the trees with only foraged shoots as having survived damage.

GBH size of the damaged and undamaged trees, and that of the fatally damaged and surviving damaged trees were statistically examined throgh Mann-Whitney *U*-tests. Data are presented as mean ± standard deviation (*SD*).

Results and Discussion

Fig. 2-1 shows huge foot prints of *Macaranga* trees foraged by elephants along a forest road on 28th January, 2004. Such *Macaranga* trees foraged by elephants in other parts of Deramakot were observed 4 times over 4 months from June 2004 through March 2005 (n = 48, 22.8 cm ± 8.1 *SD*).

The elephant foraged only shoots of the trees (Fig. 2-2). Fig. 3 shows GBH-size distribution of damaged trees, *M. hypoleuca* and *M. gigantea*. Of 223 trees (7.7

*To whom correspondence should be addressed. E-mail: matsubayashi_hisashi@yahoo.co.jp

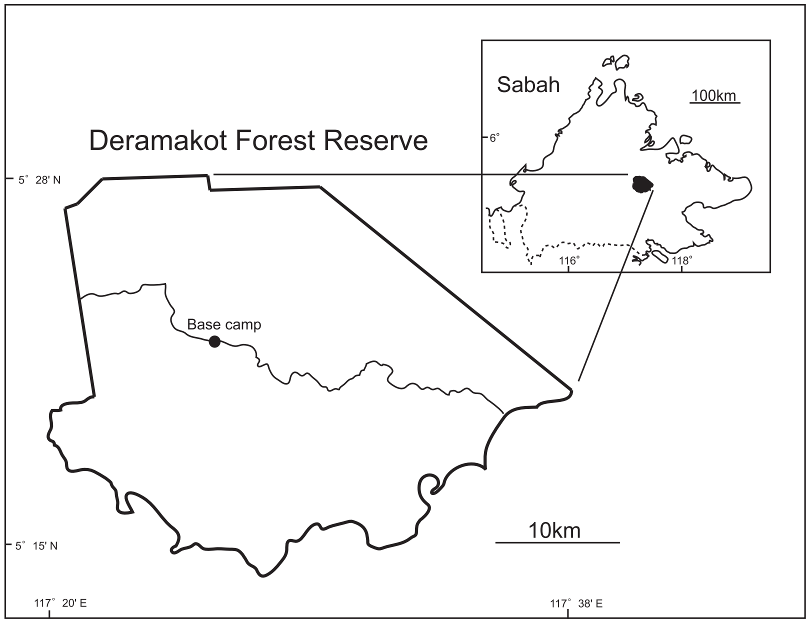

Fig. 1. Location of Deramakot Forest Reserve, Sabah, Malaysia. Closed circle, Base camp of Forestry Department of Sabah; ~, Main road.

Fig. 2. 2-1: Prints of *Macaranga* trees foraged by the elephants along a forest road. 2-2: Foraged shoot (left open circle) and non-foraged shoot (right open circle).

cm ± 5.1 *SD*), 125 trees (56.1%, 9.0 cm ± 5.8 *SD*; *M. hypoleuca*: $n = 85$, 8.3 cm ± 5.8 *SD*; *M. gigantea*: $n = 40$, 10.5 cm ± 5.6 *SD*) were foraged. The percentage of damaged trees increased in proportion to their GBH. GBH of damaged trees was significantly larger than that of undamaged trees (*M. hypoleuca*: $P = 0.007$, and *M. gigantea*: $P = 0.002$). This suggests that the elephant prefers the larger *Macaranga* trees because they have many shoots. Fig. 4 shows GBH-size distribution of the fatally damaged trees, *M. hypoleuca* and *M. gigantea*. Sixty-two (49.6%, 12.4 cm ± 6.0 *SD*; *M. hypoleuca*: $n = 39$, 12.2 cm ± 6.0 *SD*; *M. gigantea*: $n = 23$, 12.7 cm ± 6.2 *SD*) of 125 trees were fatally damaged. The percentage of fatally damaged trees increased in proportion to their GBH, and that of fatally damaged trees was significantly larger than that of surviving damaged trees (*M. hypoleuca*: $P = 0.0003$, and *M. gigantea*: $P = 0.0001$). As the elephant tries to gain access to the shoots, the larger trees are more likely to become twisted and broken from the root while the smaller trees are more flexible.

This study revealed that elephants in the Deramakot Forest Reserve foraged shoots of the *Macaranga* and damaged forest vegetation. As to the former, further research on the chemical contents of the shoot would clarify why elephants eat only the shoot rather than other parts. As to the latter, considering that elephant troops almost always use the same routes in their home range, their foraging behaviors may contribute to maintaining gaps in the forest. Many pioneer plants in gap areas are

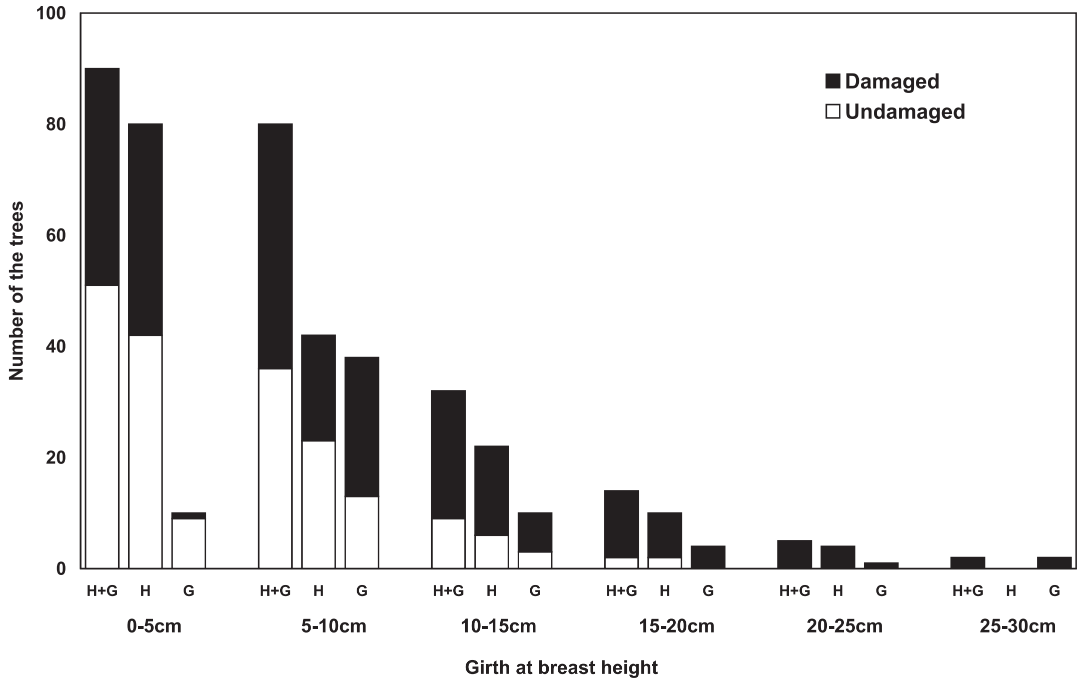

Fig. 3. GBH-size distribution of the trees damaged by the elephants. H, *Macaranga hypoleuca*; G, *Macaranga gigantea.*

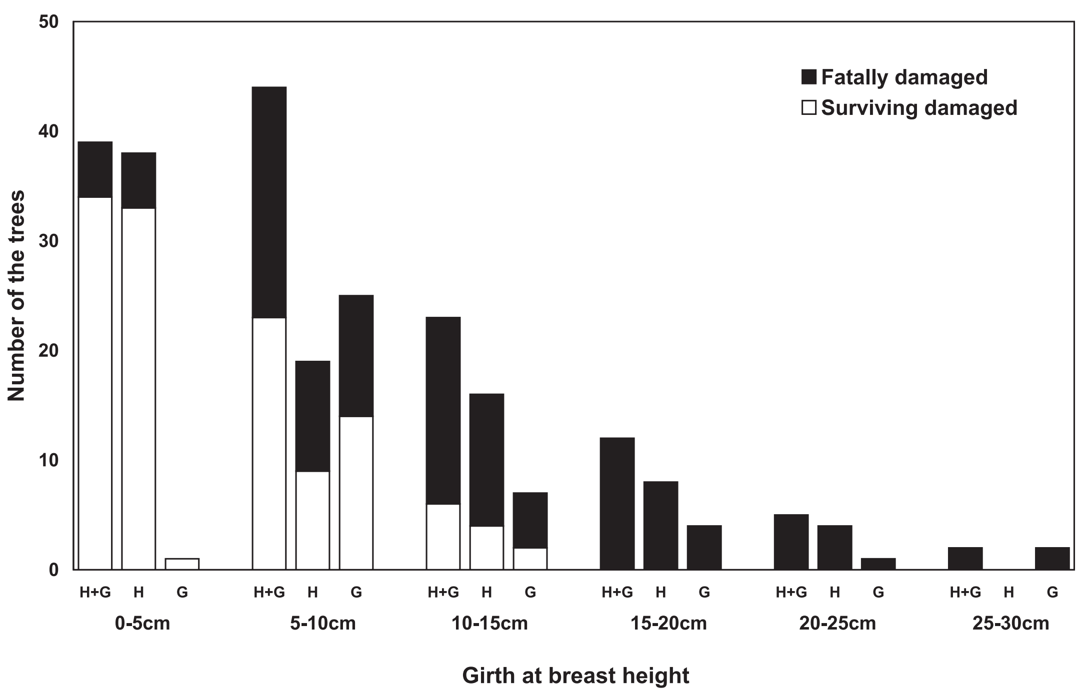

Fig. 4. GBH-size distribution of the trees fatally damaged by the elephants. H, *Macaranga hypoleuca*; G, *Macaranga gigantea*.

known to save the products of photosynthesis: secondary metabolite production and/or provide mechanical protection against foraging by herbivores to achieve a higher growth rate (Coley 1983; Coley et al. 1985; Whitmore 1998). Therefore, leaves in the gaps are assumed to be an important food source for many terrestrial herbivorous mammals (McCullough et al. 2000; Matsubayashi et al. 2003). Moreover, fruits in the gaps are also assumed to be an important food source because of their abundance and continuous production (Whitmore 1998).

These results suggest that the Bornean elephant may act as an ecosystem engineer that supports the biodiversity of the tropical rain forests by maintaining gaps. This function is important for primary forests where there is less gap area. However, nowadays, considering primary forests have severely decreased in the elephant's habitat, their role as ecosystem engineers might decline. Furthermore, habitat loss would increase the elephant's population density beyond the capacity of its habitat. In African savanna, some vegetation destruction, such as *Acacia* and *Adansonia* by increased elephant population were reported (Barnes et al. 1994). Thus, population density-food resource imbalance may make the elephant a forest destroyer. Further research on foraging behavior of Asian elephant would clarify interaction of elephant and its habitat.

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