

Wasp-mediated seed dispersal in agarwood plant (*Aquilaria malaccensis*), a critically endangered and overexploited species of North East India

Aquilaria malaccensis Lamk. (Malvales: Thymelaeaceae), popularly known as ‘agarwood plant’ is an economically important, critically endangered and highly exploited species of North East (NE) India. It is the major source of agarwood (resinous heart wood) used extensively in perfume and incense industry^{1,2}. The resin, the source of perfume, is produced in the heart wood in response to infection by a parasitic ascomycetous fungus, *Phaeoacremonium parasiticum* (formerly *Phialophora parasitica*)³. The agarwood or ‘gaharu’ has been traded internationally for centuries. As a result of overexploitation throughout its range, its natural populations have reached their critical minimum level⁴, and now the trees are found only in few protected pockets in the NE India. It is considered to be globally threatened in the wild and included in The World List of Threatened Trees^{5,6}. In India, it is considered to be critically endangered and has been included in the Red Listed Species (IUCN Red List, Version 2009.2, Vulnerable A1cd, Year Assessed: 1998) and is also included in Appendix II of CITES, and all export of its products has been prohibited⁷.

Despite its immense economic value, knowledge on the reproductive biology of *Aquilaria* species is meagre^{8,9}. Dispersal of seeds is one of the most critical aspects of reproductive ecology; it enables the plants to escape from specialist predators and pathogens concentrated around the parent, prevents competition between parent and offspring and results in location of at least some seeds in safe sites where they can successfully germinate and establish seedlings^{10,11}. Vertebrates are the main animal seed-dispersers, particularly in tropical rainforests^{12,13}. Here I report seed dispersal by a wasp in *A. malaccensis*.

The studies were carried out during 2011 and 2012 season on natural populations located at Itangkam (Nagaland), and on plants growing in plantations located in the Rain Forest Research Institute, Jorhat. Studies were also carried out on plants growing in homestead gardens at Amguri (Sivsagar district) and Salbari (Naogaon district) in Assam, and Tha-

hekhu village in Nagaland. Phenology of flowering and fruiting was studied through regular field visits. To study seed dispersal, 5–10 freshly dehisced fruits on each selected tree ($N = 25$) were kept under observation from 06.00 to 18.00 h each day for 3–5 days at each study site during the peak of the fruiting season. In order to study the possible distance of dispersal, the flight of each wasp carrying a seed was followed with the help of 3 or 4 persons, one running behind each wasp until it landed and discarded the seed.

A. malaccensis trees start flowering and fruiting at the age of 4–5 years. The flowers are yellowish-green, produced in umbels; the fruit is a woody capsule (Figure 1). Flowering and fruiting occur in the dry season – flowering in April–May and the fruiting in June–July. Flowers open (anthesis) during the night between 22.00 and 04.00 h. Flowering and fruiting are profuse; in 6–8-year-old trees 4500–6000 flowers and 900–1200 fruits were recorded. Nearly 20–25% of the fruits were found to be infested by larvae of thrips and other insects. The fruit is a bilocular leathery dehiscent capsule, with each locule harbouring a single seed. Mature fruits split longitudinally while they are still on the tree; the seeds

remain hanging through thread-like structures (Figure 1c) for a few days after dehiscence. Each seed bears a conspicuous crimson red, fleshy caruncle at the tip.

Detailed observations on dehisced fruits indicated that a yellow banded wasp, *Vespa affinis* L. (Hymenoptera: Vespidae)^{14,15} is the only insect involved in seed dispersal. The brightly coloured caruncle seems to attract the wasp. As soon as the wasp perches on the seed, the thread-like structure connecting the seed to the fruit breaks; the wasp carries the seed over varying distances before it lands on the leaves or branches of the same or any other tree. It feeds on the caruncle after it lands, leaving behind an undamaged seed that falls to the ground. The flight of the seed-carrying wasp could be followed up to 500 m away from the parent tree. The wasps feed only on caruncle of fresh seeds and those 1–2 days after dehiscence, in which the caruncle remains fresh. Seeds that are more than three days old by which time the caruncle becomes dry and naturally fallen seeds, and those experimentally kept on the ground remained untouched by wasps. On a bright sunny day, 3–4 wasps were found visiting each tree.

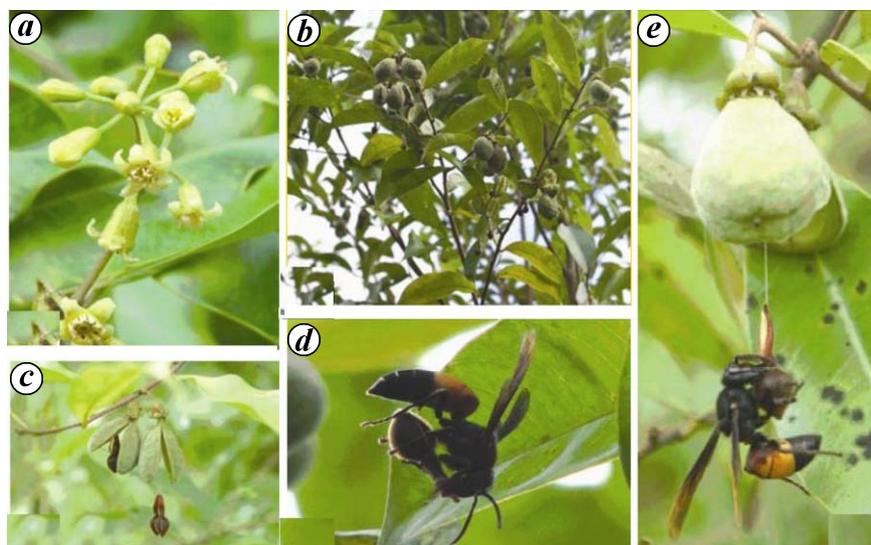


Figure 1 a–e. *Aquilaria malaccensis*. **a**, Flowering branch. **b**, Fruiting branch. **c**, Dehisced fruits, the seed is still hanging in one of them. **d**, Wasp feeding on the caruncle. **e**, Wasp landing on the seed.

Wasp visitation was maximum during 07.00–11.00 h and again at 15.00–17.00 h. Although there were 2 or 3 types of wasps observed in the vicinity of the plantations, only *V. affinis* was found to feed on the caruncle and bring about seed dispersal.

The wasp-dispersed seeds (after consuming the caruncle) and fresh seeds harvested from the trees germinated in 14 days when sown in a petri plate lined with moist filter paper. During the peak of the fruiting season, 10–15 fruits dehisce per plant on each day and 20–30 fresh seeds are available on any given day. About one-third of the seeds were found to be dispersed by wasps. The remaining seeds fall on the ground below the canopy by the action of wind and gravity.

Studies on seed dispersal have so far been vertebrate-centric^{10,11}. Amongst insects, ants are well recognized as secondary seed dispersers. Wasps are known to be effective pollinators and also seed predators, but generally not seed dispersers¹⁶. Earlier records of seed dispersal by wasps are confined to *Vancouveria hexandra*¹⁷ and species of *Trillium*^{18,19}, all herbaceous species. Jules¹⁸ has coined the term ‘vespicochory’ to describe seed dispersal by vespid wasps. The present study reports wasp dispersal of seeds not only in a tropical forest species, but also in a tree species. More studies are needed to understand the extent of mutualism

between wasps and plants in seed dispersal.

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