Ant Plant Interactions – Phylogeny, Ecology, and Evolution

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- Ecology and evolution of myrmecophytic interactions and the role of phylogenetic approaches in understanding these interactions.

  - Heil, M. and McKey, D. 2003. Protective ant-plant interactions as model systems in ecological and evolutionary research. *Annu. Rev. Ecol. Syst*. **34**, 425-53.

- Case study – *Macaranga*

Macaranga (Euphorbiaceae)

- Ca 280 species
- Tropical and subtropical trees
- Western Africa to Pacific Islands
- Greatest species diversity – Borneo, New Guinea
- Important member of secondary forests in western Malesia
- Davies, S.J., Lum, S.K.Y., Chan, R., and Wang, L.K. 2001. Evolution of myrmecophytism in western Malesian *Macaranga* (Euphorbiaceae). *Evolution* **55**, 1542-1559**.**

Macaranga

- Range of ant plant associations/mutualisms
- Species with extrafloral nectaries attracting opportunistic ants
- Myrmecophytes providing food and nest sites for ants
- In Western Malesia ca. 30 species – myrmecophytes, associated primarily with *Crematogaster* ants
  - Malay Peninsula, Borneo, Sumatra
- Fiala, B., Jakob, A., Maschwitz, U., and Linsenmair, K.E. 1999. Diversity, evolutionary specialization and geographic distribution of a mutualistic ant-plant complex: *Macaranga* and *Crematogaster* in South East Asia. *Biol. J. Linn. Soc*. **66**, 305-331.

http://cms.jcu.edu.au/discovernature/plantcairns/JCUDEV_006200

http://www.nationaalherbarium.nl/macmalborneo/Indonesian/gigantea-fiala1.jpg

M.tanarius, M. gigantea

Myrmecophytes

- Long term ecological studies of *Macaranga*
- Plants – food bodies, nest sites
- Ants - protection from herbivores and plant competitors (vines)
- *Crematogaster* (*Decacrema*)
- Fiala, Maschwitz, Hiel, Federle, Feldhaar and co-workers

Food Bodies and Domatia

- Extrafloral nectaries and food bodies common in *Macaranga* with food body production reported for myrmecophytic and non-myrmecophytic species in Malaysia (Fiala and Maschwitz 1992)
- Myrmecophytes – domatia, food body production
- Provision of protected nest sites on host plant - important factor in evolution of myrmecophytism (Fiala and Maschwitz 1992)

- Ref. - Fiala, B. and Maschwitz, U. 1992. Food bodies and their significance for obligate ant-association in the tree genus *Macaranga* (Euphorbiaceae). *Bot. J. Linn. Soc.* **110**, 61-75.
- Fiala, B. and Maschwitz, U. 1992. Domatia as most important adaptations in the evolution of myrmecophytes in the paleotropical tree genus *Macaranga* (Euphorbiaceae). *Pl. Syst. Evol*. **180**, 53-64.

http://www.nparks.gov.sg/blogs/garden_voices/wp-content/2007/08/ants.jpg

http://science.shinshu-u.ac.jp/~bios/Evo/itino/english/image/top_e.jpg

Davies et al. 2001. Evolution of myrmecophytism in western Malesian *Macaranga* (Euphorbiaceae). *Evolution* **55**, 1542-1559.

- *Macaranga* species from sections *Pachystemon*, *Pruinosae* and W*inklerianae*
- Ant species of the genera *Crematogaster* and *Camponotus*
- Phylogenetic relationships - cladistic analyses of morphological and molecular characters

Davies et al. 2001. Evolution of myrmecophytism in western Malesian *Macaranga* (Euphorbiaceae). *Evolution* **55**, 1542-1559.

- Fig. 1. Distribution map – myrmecophytic *Macaranga*
- Fig. 3. Strict consensus (ITS)
- Fig. 4. Strict consensus (combined ITS and morphology)
- Fig. 5. Reconstructions of myrmecophytism

http://www.nationaalherbarium.nl/macmalborneo/Indonesian/angulata3.JPG

M.winkleri

http://farm3.static.flickr.com/2332/2267932279_e1fd3f1337.jpg?v=0

Davies et al. 2001. Evolution of myrmecophytism in western Malesian *Macaranga* (Euphorbiaceae). *Evolution* **55**, 1542-1559.

- Fig. 6. Evolution of domatia and location of food bodies in *Macaranga*
- Table 3. Characteristics of myrmecophytic *Macaranga* lineages
- Fig. 7. Variation in stipular morphology in *Macaranga* species

Ant Associations

- *Crematogaster* (*Decacrema*)(Fiala et al. 1999)
- *Camponotus* (*Colobopsis*) *and Macaranga puncticulata* (Federle et al. 1998)
- *Macaranga caladiifolia* – opportunistic ant species (Fiala et al. 1996.)

- Refs. – Federle, W., Maschwitz, U. and Fiala, B. 1998. The two-partner ant-plant system of *Camponotus* (*Colobopsis*) sp. 1 and *Macaranga puncticulata* (Euphorbiaceae): natural history of the exceptional ant partner. *Insectes Soc.* **45**, 1-16.
- -Fiala, B., Maschwitz, U. and Linsenmair, K. 1996. *Macaranga caladifolia,* a new type of ant-plant among Southeast Asian myrmecophytic *Macaranga* species. *Biotropica* **28**, 408-412.
- Fiala, B., Jakob, A., Maschwitz, U., and Linsenmair, K.E. 1999. Diversity, evolutionary specialization and geographic distribution of a mutualistic ant-plant complex: *Macaranga* and *Crematogaster* in South East Asia. *Biol. J. Linn. Soc*. **66**, 305-331.

•Federle, W., Maschwitz, U., Fiala, B., Riderer, M., and Holldobler, B. 1997. Slippery ant-plants and skilful climbers: selection and protection of specific ant partners by epicuticular wax blooms in *Macaranga* (Euphorbiaceae). *Oecologia* **112**, 217-224.

•Federle, W., Maschwitz, U. and Holldobler, B. 2002. Pruning of host plant neighbors as defence against enemy ant invasions: *Crematogaster* ant partners of *Macaranga* protected by “wax barriers” prune less than their congeners. *Oecologia* **132**, 264-270.

http://www.biozentrum.uni-wuerzburg.de/fileadmin/REPORT/ZOO2/pic/zoo2000_img_0.jpg

Banfer, G., Fiala, B., and Weising, K. 2004. AFLP analysis of phylogenetic relationships among myrmecophytic species of *Macaranga* (Euphorbiaceae) and their allies. *Plant Systematics And Evolution* **249**, 213-231.

Fig. 2. Majority rule consensus (AFLP) with myrmecophytic plants and presence/absence of wax indicated.

Quek, S. P., Davies, S. J., Itino, T., and Pierce, N. E. 2004. Codiversification in an ant-plant mutualism: Stem texture and the evolution of host use in *Crematogaster* (Formicidae : Myrmicinae) inhabitants of *Macaranga* (Euphorbiaceae). *Evolution* **58**, 554-570**.**

Additional References

Feldhaar, H., Fiala, B., Gadau, J., Mohamed, M., Maschwitz, U. 2003. Molecular phylogeny of *Crematogaster* subgenus *Decacrema* ants (Hymenoptera : Formicidae) and the colonization of *Macaranga* (Euphorbiaceae) trees. *Molecular Phylogenetics And Evolution* **27**, 441-452.

Banfer, G., Moog, U., Fiala, B., Mohamed, M., Weising, K. and Blattner, F.R. 2007. A chloroplast genealogy of myrmecophytic *Macaranga* species (Euphorbiaceae) in Southeast Asia reveals hybridization, vicariance and long-distance dispersals. *Molecular Ecology* **15**, 4409-4424.

Quek, S.-P., Davies, S. J., Ashton, P. S., Itino, T., and Pierce, N. E. 2007. The geography of diversification in mutualistic ants: a gene's-eye view into the Neogene history of Sundaland rain forests. *Molecular Ecology* **16**, 2045-2062.