Exploring Japan ecologically

In just five years, the Centre for Ecological Research at Kyoto University in Japan has attained exemplary status and is doing pioneering work in ecological research

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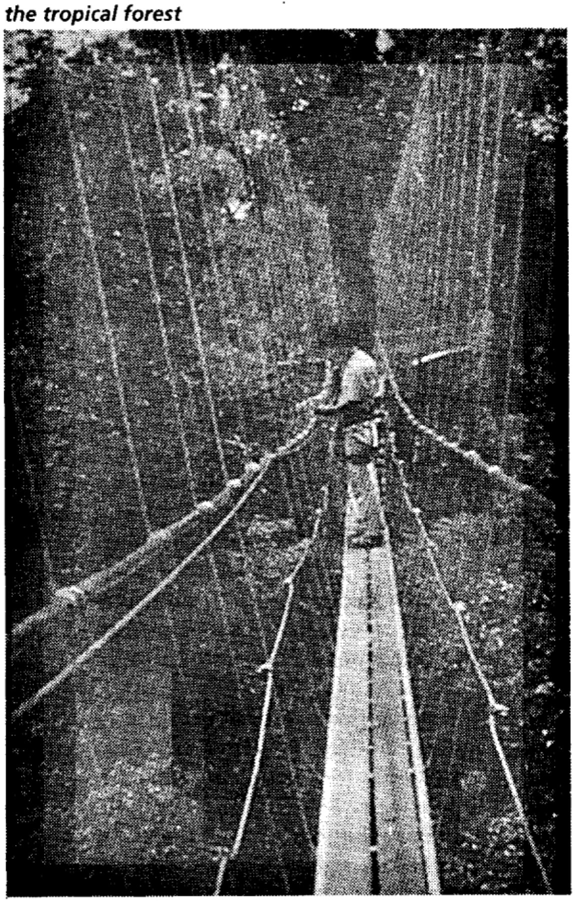
THE Centre for Ecological Research (CER) was set up at Kyoto University in April, 1991, to "promote fundamental research in various ecological topics, and provide facilities for the collaborative utilisation by ecologists throughout Japan and the rest of the world." In December 1991, the Indian Academy of Sciences brought out a special issue of the *Journal of Biosciences* on the occasion of an International Geosphere-Biosphere Project (IGBP) symposium held at the CER. The title of the symposium, "Diversity and Flexibility of Biotic Communities in Fluctuating Environments", reflects a major preoccupation of the scientists at CER. Organised into seven divisions — structural ecology, evolutionary ecology, freshwater ecology, tropical ecology, temperate ecology, boreal ecology and ecological complexity — CER has about 15 senior scientists who combine teaching and research at their main campus at Kyoto University, as well as several field facilities in and outside Japan. Because of it's limited geographical area and even more limited wilderness area, Japan has a rather restricted range of habitats and, therefore, only a modest flora and fauna. Japanese ecologists are worthy of praise and admiration at the way in which they have turned these apparent shortcomings to their advantage.

The local flora and fauna are rather well studied and there are innumerable field guides for different groups of plants and animals, so that students and the public can intelligently participate in discussions about their local ecological and environmental problems. At the same time, Japanese ecologists have a conspicuous presence in other parts of the world such as Africa, South America and Southeast Asia, where there is a much richer flora and fauna and, therefore, there are also abundant opportunities for generating new ecological knowledge.

The Canopy Biology Programme in the dipterocarp forests of Sarawak in Malaysia is an excellent example of the work of the CER outside Japan. For a variety of reasons, the dipterocarp forests in Sarawak are an excellent choice for initiating a long-term ecological study. These are amongst the richest tropical forests anywhere in the world and have a canopy that goes up to 70 m in height.

The Canopy Biology Programme: walking on the roof of the tropical forest



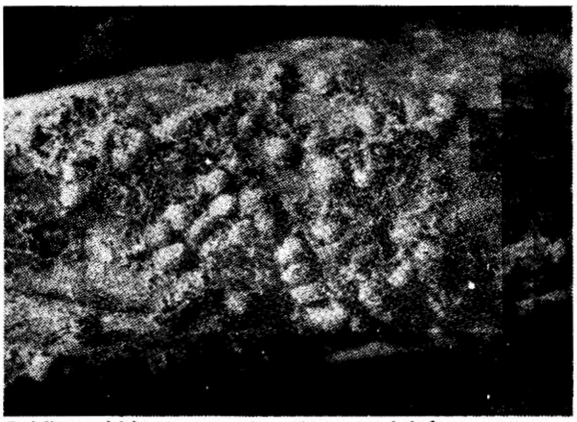
Recent research shows that contrary to what was believed earlier, these forests are under considerable flux due to global environmental changes such as the El Niño Southern Oscillation. In the early '80s, Terry Erwin of the Smithsonian Institution in Washington D C termed the rain forest canopy as the "last biotic frontier" and initiated studies to sample the arthropod fauna of tropical forest canopies in Panama.

Erwin fogged the canopies of a few trees with a rapidly degrading insecticide and sampled the rain of dead arthropods that came down. The result was spectacular. He found such a tremendous uniqueness and diversity of canopy arthropods that the estimate of the number of species of living organisms on earth went up overnight from about 10 million to over 30 million! It took a while for people to recover from the shock of the tripling of the estimate of the number of species of living organisms, to realise that the network of interactions and hence the opportunities and challenges of canopy ecology increase even more dramatically, by several orders of magnitude. But one hardly studies ecology by fogging the canopy and collecting dead insects! Ecologists owe it to Erwin for focusing their attention on the canopy but they do need a way of walking on the roof of the forest with binoculars around their shoulders and a butterfly net in their hands and do field work! This is no fantasy — it is just the kind of facility that CER's canopy biology programme has built at Sarawak. Their canopy observation system consists of two tree towers and nine spans of aerial walkway with a total length of 300 m at a height of 50 m above the ground. Although there are similar systems elsewhere, this is now the most expansive canopy observation system anywhere in the world.

Perhaps the most interesting finding from the canopy biology programme is the discovery of the pollination mechanism of the gymnosperm Gnetum by nocturnal moths, by M Kato and T Inoue, and T Nagamitsu, in 1994 and 1995. The Gnetales are an order of gymnosperm that are thought to be a sister group of angiosperms. The tremendous success of angiosperms can be largely attributed to their co-opting insects for pollination and seed dispersal, a "decision" that appears to have set both angiosperms and insects on an evolutionary course of expanding biodiversity. Hence the great interest in the pollination mechanisms of the Gnetales.

While wind pollination is known to occur in the Gnetales, some species were suspected to use generalised insect pollination. The present study provides direct observational evidence of fairly specialised moth pollination in the genus Gnetum, accompanied by the secretion of droplets of nectar as a reward and with a strong pungent odour to serve as an attractant.

While these are advanced characters compared to other gymnosperms, the "inferiority" of Gnetum compared to angiosperms is evident in its lack of showy petals and failure to have coevolved with more effective pollen carriers compared to the Pyralid moths that now visit its strobili. Given the large number of ecologists associated with the canopy biology programme, there seems little doubt that increasingly significant findings will continue to emerge from this pioneering ecological study.



Soldier aphids: supreme breed care and defence strategy

All about insect castes

Eusocial insects are those which live in colonies consisting of individuals belonging to two or more generations; they cooperate in brood care and organise themselves in such a way that only one or a small number of individuals constitute the fertile reproductive caste while the remaining constitute a sterile worker caste. Until about 20 years ago, only termites, ants and some species of bees and wasps were thought to have attained this pinnacle of social evolution. The Japanese scientist Shigeyuki Aoki made a discovery in 1977, that has considerably altered our understanding of insect social evolution. Aoki found out that many aphid species live in colonies where some of the individuals, appropriately called soldiers, sacrifice their lives in defence of their colony against predators.

This and other features of the aphid life cycle and behaviour qualify them for the label eusocial. Eusociality has since been discovered in a number of aphid species and in many species, the soldiers have enlarged four legs and armoured heads, reminiscent of the helmets of ancient Japanese Samurai warriors, prompting Mark Moffett to call them Samurai aphids (*National Geographic*, September, 1989).

Although Japanese scientists are in serious danger of loosing out to British and American researchers who have seized the unique opportunity created by Aoki's discovery of aphid soldiers, pensive soldier production. This is where the flexibility in soldier production discovered by Yosiaki Ito, a scientist at CER, and his co-workers, comes in handy. The eusocial aphids promise to enrich studies on the evolution of social life in insects.

In the Hinokuma National Park, a natural secondary forest in Kanzaki forest, Saga perfecture, in Kyushu, the Southern-most mainland of the Japanese archipelago, you can enjoy the breathtaking sight of a large number of aggregations of the brightly coloured red and black shield bug *Parastrachia japonenis*. Aggregations of these bugs can have anywhere from 15 to 10,000 individuals. A large number of such aggregations are usually found close to each other, making the phenomenon even more spectacular.

Lisa Filippi-Tsukamoto and her professor, Sumio Tojo, have spent an enormous amount of time and effort investigating this question, with Lisa Filippi-Tsukamoto earning her Masters and Doctorate degrees along the way. In a fascinating lecture, she provided details of a number of interesting ways in which they have tried to solve the riddle of the aggregations; but after many years of work, they seem to be no wiser than when they began their research.

Usually the males fly from aggregation to aggregation repeatedly mating with several females. Most of these are short-term matings lasting about 15 seconds and very few are long-term matings lasting over 20 minutes. The long-term matings involve guarding a female after insemination and ensuring that no other male sperm gains entry. The female bugs expend little energy and effort in mating, apparently resisting most of the males' attempt, but end up mating with several males found L Tsukamoto, K Kuki and S Tojo in 1994.

After mating, females make nests in the leaf litter, lay eggs and forage to provide their young ones food. They repeatedly run back and forth from their nests, bringing back fruits of the host tree, which they will accept only at an extremely specific stage of development. Parental care involves more than merely supplying food. A carabid beetle can destroy eggs and nymphs in the absence of the mother who guards her eggs or young ones by using her body as a shield, or she may simply run away from the predator carrying the egg mass, said L Filipi-Tsukamoto, S Nomakuchi, K Kuki and S Tojo, in their 1995 research findings. Such extreme specialisation, leading to the dependence on fruits of a single host tree which are scarce and ephemeral, may make *Parastrachia japonensis* a highly evolved species, albeit a very fragile one. ■