Editorial

Project IBISCA – Investigating the Biodiversity of Soil and Canopy Arthropods

Raphael K. Didham[1]
Laura L. Fagan[2]
[1]School of Biological Sciences, University of Canterbury, Private Bag 4800, Christchurch (raphael.didham@canterbury.ac.nz)
[2]Landcare Research, PO Box 40, Lincoln 8152, Canterbury (FaganL@landcareresearch.co.nz)

One of the fundamental questions in biology is "How many species are there?" In 1982, Smithsonian tropical biologist Terry Erwin made a series of simple extrapolations from the bewildering diversity of new beetle species he discovered on just one species of tropical tree (*Luehea seemannii* Triana and Planch, Tiliaceae), and calculated that there may be as many as 30 million species of arthropods in the world! Unwittingly, Erwin had opened a Pandora's box of speculation and conjecture on the exact magnitude of global biodiversity (Erwin 1982, 1991, Stork 1988, 1993, May 1988, 1990, 1992, Hammond 1995, Odegaard 2000, Novotny *et al.* 2002). In the last 20 years, Erwin's estimates have been the subject of intense scrutiny and re-evaluation (Odegaard 2000), with current global arthropod diversity estimates stabilizing at around 3 – 5 million species (Novotny *et al.* 2002). However, despite this heated debate only the first two of the three central assumptions in Erwin's calculations have ever been rigorously tested (see also Stork, Didham & Adis 1997): (1) beetles represent 40% of all arthropods (now recognized to be only ca. 23%) (Odegaard 2000); (2) host specificity in the tropics is high, with up to 136 species of beetle unique to each tree species (now recognized to be less than 10 species per tree) (Novotny *et al.* 2002); and (3) the canopy fauna represents 66% of all forest arthropods (never tested). Although no-one seriously doubts that tropical forest canopies harbour a large number of undescribed arthropod species (e.g. Stork, Adis & Didham 1997, Didham 2002, Basset *et al.* 2003, Didham & Fagan, *in press*), the degree of vertical stratification of arthropod biodiversity between the soil and the canopy, and the level of canopy specialisation of tropical arthropods are unknown.

In many respects, assessing *where* the greater proportion of arthropod biodiversity is distributed is just as vital as knowing *how many* species there are. Erwin (1982) clearly contended that the canopy fauna was the most species-rich, but subsequent evidence supports a greater role for tropical soil communities in global totals (e.g., Hammond 1990, 1995, André *et al.* 1992, 2002, Hammond *et al.* 1997, Walter *et al.*

1998). For example, a major study of beetles at one location in Sulawesi, S.E. Asia (Hammond 1990, Hammond *et al.* 1997), suggested that the greatest abundance and biomass of insects occurs in the soil and as many as 70-80% of the species are restricted to ground habitats. In order to test the assumption that tropical forest canopies harbour a substantial portion of global arthropod biodiversity, the Canopy Raft Consortium (CRC) and the Smithsonian Tropical Research Institute (STRI) in Panama have launched a major new initiative to investigate the spatial distribution of arthropod diversity between soil and canopy habitats in lowland tropical forests.

Project IBISCA – Investigating the Biodiversity of Soil and Canopy Arthropods - is a massive collaborative undertaking, involving 23 entomologists, 22 field support personnel and a large number of collaborating taxonomists from at least 15 countries, under the coordinated guidance of Yves Basset, Bruno Corbara and Héctor Barrios at STRI, Panama. The objective of the project is to explicitly test the hypothesis that tropical forest canopies are more diverse in species than other vertical strata within the forest by sampling across a range of all insect taxa (not just beetles), at eight sites within a tropical forest (to increase spatial replication) and at up to nine different heights from the forest floor to the forest canopy, using massive sampling effort and replication. This project would be logistically impossible without the large-scale international collaboration organised by the CRC, with major funding provided by the company Solvin-Solvay, by STRI and by the Global Canopy Programme.

During September and October 2003 the IBISCA team sampled soil and canopy arthropods using all major sampling methods (including pitfall trapping, Winkler and Berlese extraction of soil and litter, canopy fogging, flight interception trapping, foliage beating, light trapping, sticky trapping, chemical and colour attractants, and hand collecting) and utilising all major state-of-the-art access technologies – single rope techniques, canopy crane, canopy raft (a platform of plastic beams and netting), treetop bubble (a manned helium balloon) and IKOS tree-house (Figure 1). Pairs of researchers were responsible for overseeing and managing one complete aspect of sampling using a chosen sampling methodology.

Arthropod samples from the *ca.* 10,000 individual samples were sorted to arthropod Class and Order, to extract the *ca.* 40 focal taxa selected for species-level taxonomic identification (including Coleoptera: all families; Diptera: Dolichopodidae, Mycetophilidae, Syrphidae, Ceratopogonidae, Phoridae, and other selected families; Homoptera: Membracidae and other selected families; Lepidoptera: Geometridae, Pyralidae and Arctiidae; Orthoptera; Isoptera; Dermaptera; Mantodea; Thysanoptera: Phlaeothripidae; Hymenoptera: Formicidae, Apidae, Vespidae, Braconidae, Ichneumonidae and other selected families; Myriapoda; Isopoda; Tardigrada; Opiliones; Araneae: Salticidae; and Acari: Oribatida). The coordination of sorting and identification, and the analysis of the resulting ecological data will be a massive undertaking that is not expected to be completed until 2005.

Figure 1. Canopy sampling and access technology employed on Project IBISCA, Panama 2003. All sites were located in the San Lorenzo Protected Area (Caribbean coast, 9º17’N 79º58’W; 130m a.s.l.). This tropical wet evergreen forest averages 3152 mm of annual rainfall and an annual air temperature of 25.8ºC. Clockwise from top left: (1) the canopy bubble (photo: Y. Basset); (2) the IKOS tree-house (photo: J. Orivel); (3) canopy fogging (photo: S. Ribeiro); (4) the canopy crane (photo: R. Le Guen); (5) N. Baiben beating for insects (photo: R. Le Guen); (6) the canopy raft (photo: Y. Basset).

In addition, Project IBISCA plans to conduct seasonal sampling at a range of the same study sites during February, May and October 2004, in order to assess the degree of temporal variation in the vertical stratification of arthropods between the soil and canopy (there can be a remarkably high degree of temporal variation in tropical arthropod abundance and diversity; see Didham & Springate 2003). For example, it is widely believed that the larval stages of many arthropods develop in the soil and subsequently move up to the canopy to feed and breed as adults (Hammond 1990, Basset & Samuelson 1996). As most arthropod taxonomy is based on the identification of adult insects, some bias in the assessment of habitat specificity is likely without the combined use of seasonal sampling and emergence trapping.

Significance of the project and expected outputs

The key components of the study are the large-scale spatial and temporal sampling and the international, cross-discipline approach that should greatly extend the degree of inference drawn about the distribution of biodiversity in tropical rainforests. The major scientific outputs of the project are expected to be: (i) the first attempt to compare arthropod species richness in the soil versus canopy habitats of a tropical rainforest, including a wide range of taxa and sufficient spatial and temporal replication, as well as samples obtained *in situ* from the canopy; (ii) one of the first studies of beta-diversity at a fine scale (a few kilometres) in a lowland tropical forest, encompassing a sample size accounting for spatial and seasonal variation in arthropod diversity; and (iii) one of the first studies of airborne arthropod fine stratification (a few metres) within the canopy. The amount of data generated on the vertical stratification and beta-diversity of *ca.* 40 phylogenetically distant, focal arthropod taxa is incomparable. Results from analyses of this dataset will have far-reaching implications for the conservation of biodiversity in tropical rainforests.

The end products of the project are envisioned as being: (i) a multi-authored paper in a high-profile journal; (ii) a series of summary papers published in a special issue of a journal; and (iii) a series of more detailed papers authored by the participants. An analytical workshop for dissemination of the first results of Project IBISCA is planned towards the end of 2005.

Acknowledgements

We thank Landcare Research, the University of Canterbury, the Royal Society of New Zealand International Science and Technology Linkages Fund (04-CBRP-USA-15-DIDH), the Canopy Raft Consortium, the Smithsonian Tropical Research Institute, the Global Canopy Programme and Solvin-Solvay for funding to support IBISCA 2003.

References

André HM, Ducarme X, Lebrun P. 2002. Soil biodiversity: myth, reality or conning? *Oikos* 96:3-24.

André HM, Lebrun P, Noti M-I. 1992. Biodiversity in Africa: a plea for more data. *Journal of African Zoology* 106:3-15.

Basset Y, Novotny V, Miller SE, Kitching RL. 2003. *Arthropods of Tropical Forests. Spatio-temporal Dynamics and Resource Use in the Canopy*. Cambridge University Press, Cambridge.

Basset Y, Samuelson GA. 1996. Ecological characteristics of an arboreal community of Chrysomelidae in Papua New Guinea. In: *Chrysomelidae Biology. Volume 2 Ecological Studies* (eds PHA Jolivet & ML Cox), pp. 243-262. SPB Academic Publishing, Amsterdam.

Didham RK. 2002. Editorial – Living the high life. *The Weta* 24:1-4.

Didham RK, Fagan LL. 2004. Forest canopies. In: *Encyclopaedia of Forest Sciences* (eds J Burley, J Evans & J Youngquist). Academic Press, London (*in press*).

Didham RK, Springate ND. 2003. Determinants of temporal variation in canopy arthropod community structure. In: *Arthropods of Tropical Forests: Spatio-Temporal Dynamics and Resource Use in the Canopy* (eds Y Basset, V Novotny, SE Miller & RL Kitching), pp. 28-39. Cambridge University Press, Cambridge, UK.

Erwin TL. 1982. Tropical forests: their richness in Coleoptera and other arthropod species. *The Coleopterist's Bulletin*, 36:74-75.

Erwin TL. 1991. How many species are there?: Revisited. *Conservation Biology* 5:330-333.

Hammond PM. 1990. Insect abundance and diversity in the Dumoga-Bone National Park, N. Sulawesi, with special reference to the beetle fauna of lowland rain forest in the Toraut region. In: *Insects and the Rain Forests of South East Asia (Wallacea)* (eds WJ Knight & JD Holloway), pp. 197-254. The Royal Entomological Society of London, UK.

Hammond PM. 1995. Magnitude and distribution of biodiversity. In: *Global Biodiversity Assessment* (eds VT Heywood & RT Watson), pp.113-138. Cambridge University Press, Cambridge, UK.

Hammond PM, Stork NE, Brendell MJD. 1997. Tree-crown beetles in context: a comparison of canopy and other ecotone assemblages in a lowland tropical forest in Sulawesi. In: *Canopy Arthropods* (eds NE Stork, J Adis & RK Didham), pp.184-223. Chapman & Hall, London, UK.

May RM. 1988. How many species are there on earth? *Science* 241:1441-1449.

May RM. 1990. How many species? *Philosophical Transactions of the Royal Society of London, Series B* 330:293-304.

May RM. 1992. Past efforts and future prospects towards understanding how many species there are. In: *Biodiversity and Global Change* (eds OT Solbrig, HM van Emden & PGWJ van Oordt), pp. 71-81. IUBS Press, Paris.

Novotny V, Basset Y, Miller SE, Weiblen GD, Bremer B, Cizek L, Drozd P. 2002. Low host specificity of herbivorous insects in a tropical forest. *Nature* 416:841-844.

Odegaard F. 2000. How many species of arthropods? Erwin's estimate revised. *Biological Journal of the Linnean Society* 71:583-597.

Stork NE. 1988. Insect diversity: facts, fiction and speculation. *Biological Journal of the Linnean Society* 35:321-337.

Stork NE. 1993. How many species are there? *Biodiversity and Conservation* 2:215-232.

Stork NE, Adis J, Didham RK. 1997. *Canopy Arthropods*. Chapman & Hall, London.

Stork NE, Didham RK, Adis J. 1997. Canopy arthropod studies for the future. In: *Canopy Arthropods* (eds NE Stork, J Adis & RK Didham), pp.551-561. Chapman & Hall, London.

Walter DE, Seeman O, Rodgers D, Kitching RL. 1998. Mites in the mist: how unique is a rainforest canopy-knockdown fauna? *Australian Journal of Ecology* 23:501-508.