VOL. 12 NO. 1 AUTUMN, 2005

WHAT'S UP?

THE NEWSLETTER OF THE INTERNATIONAL CANOPY NETWORK

NALINI NADKARNI, EXECUTIVE EDITOR HANNAH ANDERSON, EDITOR

IBISCA: Towards a Census of Canopy Life

Yves Basset
Smithsonian Tropical Research Institute
bassety@si.edu

Maurice Leponce
Royal Belgian Insitute of Natural Sciences
maurice.leponce@naturalsciences.be

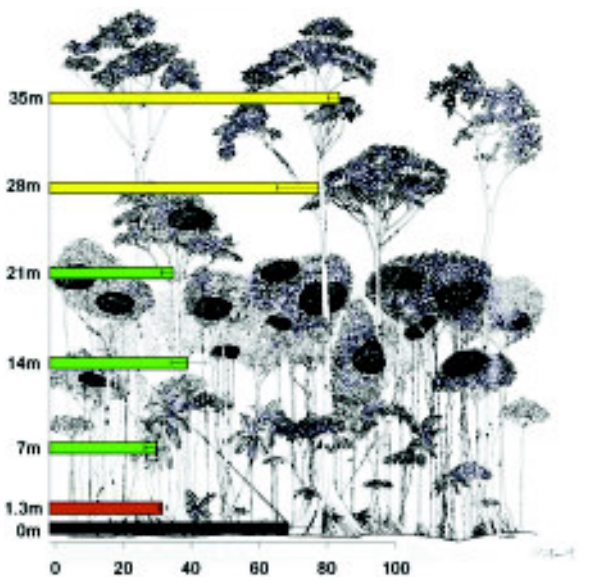
A three-day workshop was organized at the Royal Belgian Institute of Natural Sciences, Brussels, Belguim, 6-8 July 2005, with financial support from the European Science Foundation, United Nations Environment Programme and Global Canopy Programme ‹‹www.sciencesnaturelles.be/cb/ants/meetings/esf_exploratory_workshop.htm››. The workshop focused on the international project IBISCA (Investigating the Biodiversity of Soil and Canopy Arthopods; ‹‹www.naturalsciences.be/cb/ants/projects/ibisca_main.htm››, an initiative of the Smithsonian Tropical Research Institute and of Pro-Natura International with the technical support of Océan Vert. This project studies the vertical stratification and beta diversity of arthropods in the San Lorenzo rainforest in Panama, using state-of-the art methods of canopy access and sampling, namely canopy fogging, canopy cranes, single rope techniques, and canopy raft and peripherals. The aims of the workshop, which was attended by 37 scientists from 16 countries, were (a) to summarize what has been learned from the IBISCA project overall; (b) to plan meta-data analyses and the dissemination of this novel and important information; and (c) to use this material as a springboard to initiate new collaborative programs of research about the distribution of mega-biodiversity in tropical rainforests and to plan a 'census of tropical rainforest life'. The workshop consisted of 30 presentations and plenary and group discussions.

View of the canopy of the San Lorenzo forest, home of the IBISCA project.

Preliminary results of the IBISCA project

Currently the IBISCA database, which summarizes horizontal (beta diversity), vertical (vertical stratification) and seasonal distribution of arthropods in the San Lorenzo forest, includes 85 contributors (ecologists and taxonomists), 14 sampling programmes, 7,233 samples, 422,217 specimens and 1,960 species. We estimate that the final product should shed light on the spatial and seasonal distribution of about half a million specimens and several

thousand species, distributed among ca. 60 focal groups of different phylogeny and ecology. This database currently has no equivalent. The main job of sorting the material to higher taxa and extracting focal taxa has been done for all sampling programmes. The morphotyping of most focal groups will probably be completed by December 2005. Identifications, when possible, will be much slower. We expect that databasing of most IBISCA-related information could be completed by June 2006, and that participants will be able to analyze collectively their major findings and report them in a leading scientific journal. Problems identified during the IBISCA project could be eased by working with local parataxonomists trained beforehand to sort and process focal groups, as well as additional funding to speed up different tasks.



Mean number of arthropods collected per sticky trap at different heights in the San Lorenzo forest during IBISCA. These preliminary results are based on one of the 14 sampling programmes used in IBISCA.

Analyses and Dissemination of IBISCA Results

The following steps are needed to complete the IBISCA-Panama project: additional field work, further taxonomical analyses and specimen databasing, processing of ecological variables, improvement of the IBISCA database, and development of a web site. The keys questions targeted by IBISCA are: (1) What is the relative contribution of vertical stratification, seasonality and degree of beta diversity to the distribution of arthropod biodiversity in a closed-canopy tropical rainforest? (2) How do life history traits of species, such as host specificity or feeding guild, influence the spatial and temporal partitioning of arthropod biodiversity in a closed-canopy tropical rainforest? To this end, one leading concept will be to consider diversity partitioning: total diversity consists of alpha diversity (within sample units), horizontal beta diversity, and vertical beta diversity. So far, the IBISCA project has been presented in six scientific articles and 13 magazine articles. We expect that most IBISCA results should be disseminated during 2006-2008 (multi-authored research papers, high-profile collective article in a leading journal, collective book, etc.).

The Future

The 'IBISCA' brand will be retained in further projects. The IBISCA research group (ca. 100 scientists) will also get organized into an official network of biodiversity experts. The most pressing priority of the research group will be raising funding as to quickly complete the IBISCA-Panama project. Future priorities will be, among others, to persist with the IBISCA approach beyond the Panama project and to join new biodiversity-related projects. Improvement of future research needs: (a) considering parataxonomist help to facilitate future IBISCA-type projects; (b) focusing on the relations between biodiversity and ecosystem functions, disturbance, and climate change; and (c) designing better IBISCA-style projects to help answer ecological and evolutionary questions. The IBISCA research group also plans to organize several scientific meetings to discuss how to organize an ambitious Census of Tropical Rainforest Life (IBISCA-CTRL programme).

Big Canopy Database
Website Re-Launch

Kathryn Madson & Kris Dale
SciDB Lab, The Evergreen State College

On November 15th, 2005, the Canopy Database Project, housed at The Evergreen State College, launched version 2 of The Big Canopy Database (BCD2). The BCD2 is a database-driven ecological reference site, funded by the National Science Foundation. It acts as a central resource for canopy related citations, images, events, and general canopy information. BCD2 has been re-engineered as a cleaner application with increased functionality and an improved user interface. The site has the same external architecture and feel of the previous version but with the much needed face-lift and internal overhaul. Future releases of the BCD will include a map-driven research site locator tool, a restructuring of the image gallery that will provide more information with improved navigation, and continued structural improvements. Look for improved usability and functionality in later releases of the BCD.

‹‹http://canopy.evergreen.edu/bcd››

An Evaluation of Canopy Tourism in Costa Rica

Markus Seibel
markus-seibel@web.de

From March to August 2005 Markus Seibel, student of Geography at Humboldt-University of Berlin carried out his State-Exam Thesis. This thesis was written with the support of the Global Canopy Programme (GCP), which considers it a pilot study to evaluate the global value of canopy tourism.

Objectives

Rainforest canopy tourism takes place at the "last biotic frontier" of this planet.[1] Presumably the ecosystem with the highest biodiversity on earth, the rainforest canopy is seriously threatened by deforestation. Canopy tourism can be seen as an approach to provide a sustainable economic alternative to resource depletion and thus contribute to the conservation of endangered forest areas. It was the goal of this study to verify this basic assumption and evaluate whether canopy tourism fulfils the general criteria of ecotourism.

The author spent five weeks in Costa Rica to describe the development, current situation and future perspectives of canopy tourism, verify the basic assumption of this study, and develop recommendations for best practice guidelines for sustainable canopy tourism. Those recommendations will be made available to the GCP.[2]

Methodology

Because canopy tourism is a new field of research, this study contained a considerable amount of exploration and so a qualitative approach was chosen. Research methods included participant observation and the expert interview.[3] Both methods were used for all three objectives of this study. The guiding questions of the expert interviews and the observation protocol were developed from the *Québec Declaration on Ecotourism* and the Australian *National Ecotourism Accreditation Program*.[4]

During May and June 2005 nine privately run canopy tourism facilities (fig. 1) were visited and evaluated in Costa Rica. In addition, fourteen expert interviews were conducted with representatives from non-governmental organizations (NGO), governmental organizations (GO), and those from the tourism industry. The interviewee groups included: The

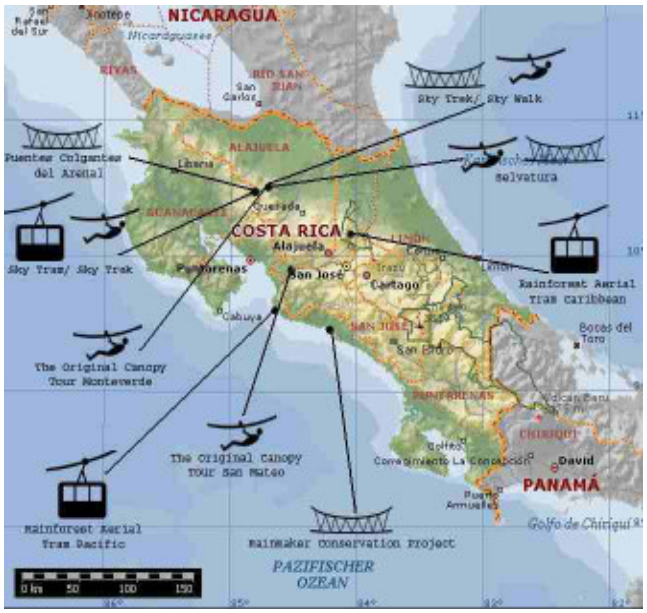


Figure 1. Map of evaluated facilities and their features.

International Ecotourism Society, Rainforest Alliance, Tropical Science Center , Ministry of Tourism, National Park Service and the authority to grant permission for constructions in ecologically sensitive areas, the management and a designing engineer of canopy tourism facilities, and the National Chamber of Tourism.

Outcomes

Costa Rica can be considered one of the pioneering countries of canopy tourism. Canopy tourism facilities have been developed since the early 1980s. In the late 1990s a veritable boom in canopy tourism began. Today, 90 – 110 canopy tourism facilities exist in Costa Rica. Most of them are so-called Canopy Tours where tourists ride attached to steel cables through the canopy. Besides these, canopy walkways and aerial trams exist. Nearly all canopy tourism facilities in Costa Rica are privately run. No canopy activity exists in any of Costa Rica's public protected areas.

According to the ministry of tourism, about 25% of Costa Rica's foreign visitors take part in a canopy activity. More than 90% of the people who take part in canopy activities are foreigners. Canopy tourism is a highly lucrative market, at the time of evaluation a two- to three-hour tour costs between US$40-70. Given that a quarter of all visitors to Costa Rica take part in it, canopy tourism can be considered a significant contribution to the country's tourism economy. At the same time, canopy tourism is a highly unregulated market. Little requirements for security are made by the governmental authorities. Hardly any regulations and no eco-certificates exist for environmental matters. Even though various authorities plan to regulate and certify the market, no knowledge of the exact number and location of the various canopy facilities yet exists.

Canopy walkway constructed with platforms from tree to tree.

Concerning the basic assumption of this study, it can be said that in Costa Rica canopy activities are one way of increasing the economic benefits from standing forest and thus change the economic equation towards conservation. In all nine evaluated cases, canopy tourism took place in forest areas, which otherwise would have most likely been transformed into pasture land by now.

Looking at the compatibility of canopy tourism with general ecotourism criteria, it can be said that all nine evaluated facilities were called ecotourism facilities by the management. Nevertheless, no facility fulfilled all the general ecotourism requirements. It must be taken into consideration however, that no criteria specifically for canopy tourism exist yet.

Concerning environmental aspects, there were impacts from construction including erosion, cutting of corridors into the forest, massive steel platforms and towers. Noise impacts exist from big group sizes, unguided tours and chainsaw-like sounds produced by the rolls on the steel cables. Deficits in carrying capacity studies and monitoring make measurement of these impacts difficult at best.

No negative socio-economic or socio-cultural impacts for the local communities could be discovered. As all evaluated facilities are privately run, no models of participation existed. The local communities benefited from canopy tourism through employment, special entry fees and secondary economic effects, such as an overall higher tourism activity. About 90% of the employees of the evaluated facilities were from the area.

Concerning the raising of awareness towards rainforests, some canopy tourism facilities carried out school projects with the aim to educate future generations about the importance of rainforests, as well as giving them the opportunity of future employment in the facility. Large differences were discovered in the quality of interpretation and eco-education. In the case of canopy tours (steel cables) and unguided walks, literally no interpretation took place at all. Often no real interpretation of the ecosystem took place but rather single plants and animals were being pointed out. In almost all of the evaluated cases there were deficits in the interpretation of the ecosystem of the rainforest as a whole and its global importance. In almost all cases the forest canopy wasn't pointed out especially. Furthermore, tourists were not informed of how much they contribute to its protection by taking part in the canopy tourism activity.

Recommendations

The development of ecotourism criteria for canopy tourism seems indispensable. Best practice guidelines, as envisioned by the GCP can be a basis for such criteria. Sustainable canopy tourism should not only provide an economic alternative to logging, it should also raise awareness towards rainforests as

a whole. Sustainable canopy tourism should be conducted in primary forest, consequently helping to sustain those areas. Buffer zones of protected areas provide ideal ground for a canopy tourism facility.

Rules and techniques established to reduce negative environmental impact during construction and operation of a canopy tourism facility are suggested. Carrying capacity studies and regular independent monitoring should ensure that no negative environmental impact takes place. Noise impact should be avoided.

Canopy tourism should provide employment for the local communities. Furthermore, participatory mechanisms should be established in order to integrate local communities in the process of planning and carrying out of the canopy tourism project. Most ideally a canopy tourism project should be entirely in the hands of the local communities, e.g. as a cooperative.

School projects should be carried out to raise awareness of future generations. The quality of eco-education and interpretation must be emphasized, focusing on representing the ecosystem as a whole and taking the forest canopy into account.

Every tour should be guided and guides should be specially trained. In every canopy activity eco-educational elements should be included. This applies especially to canopy tours on cables, where a lack of such elements was obvious. Cooperation between NGOs, GOs, academic institutions and canopy tourism projects should ensure the feasibility and quality of measures and guidelines for sustainable canopy tourism.

Conclusions

The results of this study illustrate that canopy tourism can function as an approach to sustain endangered forest areas. Costa Rica serves as an example that, in this case, is reached by emphasizing the economic value of ecotourism relative to the value of cutting down the forest. The rainforest thereby very much becomes a scenic backdrop for a kind of tourism, which focuses more on thrill and adventure than on nature experience.[5] In order to use canopy tourism as a tool for conservation in an ecotouristic sense, the rainforest has to be the main focus. The ecosystem and its canopy must be emphasized as a whole, canopy tourism merely being the vehicle, which makes this experience possible.

Sources

1 Erwin , T. 1983: "Tropical forest canopies: the last biotic frontier" in: *Bulletin of the Entomological Society of America.* 29, 14 – 19.

2 See GCP: Core Project Areas: <<www.globalcanopy.org/core/, 01.04.2005>> and GCP press release: <<www.globalcanopy.org/news/press-releases/GCPPressRelease7Mar05.pdf, 01.04.2005>>.

3 Girtler, R. 1984: *Methoden der qualitativen Sozialforschung*. Graz. Lamnek, S. 2005: *Qualitative Sozialforschung. Weinheim.*

4 See WTO 2002: Québec Declaration on Ecotourism: <<www.world-tourism.org/sustainable/IYE/quebec/anglais/declaration.html, 01.05.2005>>; Ecotourism Australia: NEAP III:<<www.ecotourism.org.au/eco_certification.asp, 19.06.2005>>.

5 See also Stecker, Bernd 1996: *Ecotourism: Potential for Conservation and Sustainable Use of Tropical Forests.* Eschborn.

Diversity Patterns of Vascular Epiphytes Along an Elevational Gradient in the Andes

Thornsten Krömer, Michael Kessler, S. Robbert Gradstein
Institute of Plant Sciences, University of Göttingen, Germany
and Amparo Acebey
Herbario Nacional de Bolivia, La Paz, Bolivia
Contact: tkroemer@ibiologia.unam.mx

Vascular epiphytes, including orchids, bromeliads, aroids, and ferns, among others, are an important component of the vegetation of tropical montane forests. Due to the difficulty of quantitatively sampling and of identifying tropical epiphytes, the number of epiphyte inventories is still rather small, but suggests that epiphyte diversity peaks at mid-elevations at around 1000-1500 m. However, no previous study covers an entire elevational transect from the lowlands to timberline, and there are methodological inconsistencies within some and among most of the studies, which makes a combined analysis of the different data sets problematic. The present study was designed to overcome these shortcomings by applying a consistent sampling method at three local scales (single tree, 400 m^2, 1 ha) to a complete elevational gradient from 350 m to 4000 m. These data are of interest both to ecologists seeking to understand the distribution and generation of patterns of plant diversity, and to conservationists faced with establishing conservation priorities in view of the ever-increasing deforestation in the Andes.

Methods

The study was conducted in six different sites on the eastern slopes of the Andes in the Departments of La Paz and Cochabamba, Bolivia, the so called "Yungas" (Krömer et al.

(continued on page 8)

GLOBAL CANOPY PROGRAMME UPDATE

THE AMAZON: SCIENCE, RISK AND LAW HOUSE OF COMMONS, LONDON, ENGLAND

Katherine Secoy
Research & Conservation Programme Manager
k.secoy@globalcanopy.org

The GCP held a very successful meeting entitled "The Amazon: Science, Risk and Law" at the UK Government's House of Commons, in July 2005 funded by the Global Opportunities Fund of the UK's Foreign and Commonwealth Office. The meeting was hosted by Bob Blizzard MP Chairman of the British Brazilian All Party Group, was opened by Rt. Hon, Elliot Morley, Minister of State for Climate Change and the Environment, and chaired by Sir Crispin Tickell, former UK Ambassador at the United Nations. Despite terrorist activity in London, the meeting was attended by 52 senior delegates from science, government, business, and NGO communities.

The aim of the meeting was to raise awareness of the scientific basis of concerns regarding the predicted impact of climate change on the Amazon and the risks this poses to neighbouring countries regionally and in Latin America, as well as globally. It also looked at possible adaptation measures that could be undertaken by science and business in the UK in collaboration with Brazil. Below are the key points and recommended outcomes that arose out of the meeting.

KEY POINTS

Brazil is becoming a major economic strength on the world stage, is a candidate country on the UN Security-Council and plays a prominent role within the World Trade Organisation. Because of the Amazon, Brazil is in a unique position in the world with regards to protection of the environment in the context of climate change.

The Amazon covers 5 mil km^2, 20 times the size of the UK. 16% is already converted, the rate of deforestation (approx. 20,000ha/yr.) is increasing. The carbon released currently exceeds the UK's annual emissions from fossil fuels by about 30%.

Much of existing deforestation is already illegal under Brazilian law. New laws are not required, resources for better implementation are.

Predictions are that the world will warm between 3 and 7 degrees Celsius by 2100. These models currently ignore biodiversity and the role of life on earth in mitigating climate change. 50% of estimated CO_2 is taken up by land ecosystems and oceans. Forest conversion and rising CO_2 may both alter the buffering effect of these ecosystems on climate change processes.

Some climate models predict significant forest dieback in the Amazon due to forest fragmentation and alterations to moist incoming winds from the northeast leading to catastrophic loss of tree cover by 2080. Recent models have not included the effect of forest fragmentation, which will accelerate drying and warming and reduce the ability of the Amazon to absorb CO_2.

With loss and fragmentation of the Amazon, it is emerging that the low level jet-streams are failing to bring water from the Amazon south to the La Plata Basin, which produces 70% of South America's GDP. Since 2004, the first ever recorded hurricane and tornado have been reported at Sao Paulo. Disruption of moist airflows to Nordic and Southern Africa could also occur.

New research is demonstrating that Volatile Organic Carbons (VOCs) produced by plants, act as condensation nu-

clei, creating gentle rain across the Amazon. Deforestation disrupts this process, releasing soot, which stimulates tall clouds and harsh rain-storms. Water is lost through runoff without the absorbing forest. The impact of VOCs is not included in climate models and how climate change will alter this process is unknown. VOCs also act to cleanse the air of pollutants such as nitrous oxides and ozone by reacting with them. The forest acts more like a liver than a lung.

Climate change litigation might arise under private law against businesses who continue to supply a good or service even though they know it causes harm. Increasingly in court, statistics such as those being used to predict climate change are being used to indicate knowledge of increased risk. Contributions to post 1990 emissions could be regarded as contributing to such a known risk. The law does not require 100% proof of causation. Climate change litigation could have a 'long tail' as in the case of asbestos and tobacco.

The United Nations Environment Programme (UNEP) and MunichRe have predicted the cost of climate change risk could be as much as $300 billion per year by 2050. Heatwaves, such as those seen in Europe in 2003 that killed thousands of people above the average for the time of the year, are expected to be 4 times more likely in the future.

Recommended Outcomes

The buffering effect of the Amazon and the biosphere generally on climate change needs to be quantified and included in future models. Where is the tipping point, where the biosphere goes from a sink to a source of carbon? An initial model-based estimate suggests that the global terrestrial biosphere moves from being a sink to a source of CO_2 at around 550ppmv.

Quantification of the social value of biodiversity in economic terms is needed to realise any potential for biodiversity credits trading. Creation of carbon markets has been preceded by such valuations and the market created by government legislation. Biodiversity trading could add considerable value to forests.

Objections were raised regarding offering financial rewards for deferred deforestation on the basis of "money now or the forest gets it". A solution might be to link credits for reduced deforestation emissions to a national baseline estimated from historical rates of deforestation.

Corporations, lenders and insurers need to increasingly recognise the potential future risk of litigation against them in relation to climate change. Clear records should be kept of modelling methodology and inputs as these may be required in future court cases, should they arise.

A global effort is needed to plug major gaps in scientific knowledge at the forest canopy/atmosphere interface. The GCP is working with UNEP to implement an $18 million global network of "Whole Forest Observatories" to monitor the impact of climate change on biodiversity. The first five of these will be in Brazil, Ghana, Madagascar, India and Malaysia. Financial support for this network is needed.

From a climate change perspective, it would appear to be in the Brazilian national interest to stem deforestation due to the potential negative impacts on its future economy. Any proposals to 'internationalise' the mitigating effects of the Amazon on predicted climate change will be counter productive and do far more political harm than good.

Finally, a World Environment Organisation should be created to work in partnership with the World Trade Organisation.

for more information visit:
<<www.globalcanopy.org>>

Dragonflies in the Canopy

Dennis Paulson
Slater Museum of Natural History
University of Puget Sound.

In the past few years, I have made dry-season visits to undisturbed rainforest sites in southern Venezuela and southern Peru, and it got me thinking about dragonflies and their use of three-dimensional space in forests. We know very little about this. When we see them in forested areas, it's either at or near ground level or - if in clearings or light gaps - perhaps in flight well above us, cruising around after flying insects.

These recent visits are the first ones during which I have actively searched for dragonflies in the tropical rainforest canopy. Unfortunately, I could do so only from ground level, as neither of these sites had canopy access, so I was limited to what I could see by scanning with binoculars. I know that many odonates perch on tips of leaves and twigs, so I spent time scanning such potential perches, and if conditions were right, I could sometimes see they were occupied.

It's well known that productivity is higher where there is sunlight, and of course there is much more sunlight at the upper levels of the canopy than down on the forest floor, where the aquatic breeding habitats for most dragonflies are located. Thus dragonflies feeding in rain forests should tend to move upward into the canopy, all other things being equal.

In Venezuela, where the forest was fairly open, we saw numerous anisopterans perched high in the trees, usually on twigs. They varied in size but were obviously libellulids, including at least *Erythrodiplax*, *Micrathyria*, and *Orthemis*. The most easily identifiable were the little black-winged beauties of the genus *Zenithoptera*, which perch with wings drooped and form tiny black parasols at the tips of upwrard-pointing twigs and vines. The pale line through midwing distinguishes them easily from *Diastatops*, a related genus with all black or black and red wings, which I saw once in a similar situation.

male *Megaloprepus caerulatus*, Blue-winged Helicopter (family Pseudostigmatidae). This species, with the greatest wingspread of all Odonata, occurs from southern Mexico to Bolivia and Guyana. It breeds in tree holes and is one of the best-studied of Neotropical dragonflies.

In Peru, we saw *Zenithoptera* again in the same sorts of places, as well as *Micrathyria*, *Misagria*, and *Orthemis* well up in the trees. However, *Erythrodiplax* in that forest usually perched low. At least some of these dragonflies were surely spending the dry season as immatures, delaying reproductive activity until the rains began, but others were probably reproductively active. While watching odonates at a sun-drenched grass bed in a small forest swamp completely surrounded by trees, I saw several *Zenithoptera fasciata* drop vertically out of the canopy like a falling leaf, land in the sun on the grass with wings closed, then droop them suddenly to catch the sun with their brilliant blue upper surfaces. Each of these individuals stayed for only a minute or two, then suddenly ascended back into the canopy, disappearing as mysteriously as they appeared. I assume they were visiting the mating rendezvous site, although surprisingly briefly.

I spent time along a small sandy stream in the Peruvian forest, and at one place the stream was wide enough to present a vertical wall of foliage on either side, well insolated at midday. I scanned this foliage wall with binoculars and found damselflies mostly of the genera *Argia* and *Hetaerina* spread all across it, perched on leaf tips. I saw none above about 10 meters in height, but it surely became more difficult to see them at higher levels if they were up there. Among them was a female *Heteragrion* and a female of the rare *Heliocharis amazona*. As I watched, one after another launched itself out into the open at intervals after flying insect prey. Open air, sunshine, and abundant perch sites combined to make this an ideal spot for a damselfly picnic.

These odonates all forage by sallying forth to capture flying insects, as far as I know, and their perches, right out in the open, are just as appropriately situated for them as they are for flycatchers, jacamars, and other sallying birds of the same habitat.

One morning it was exceptionally windy, with tall canopy trees swaying and creaking, and this was the final bit of evidence that convinced me the canopy was full of odonates. There were more individuals and more species in evidence along the trail than I saw at any other time, and I could explain their presence only by the hypothesis that the winds had forced them down to lower levels.

With limited evidence, I believe that rain forests are full of dragonflies at all levels, especially during the dry season when they're not breeding. They may be there as well during the wet season.

I know people who have observed dragonfly behavior in and above rainforest canopies from canopy walkways and towers, but I haven't been so fortunate. This remains a dream that I hope to fulfill sometime, somewhere.

(Diversity Patterns - continued from page 5)

2005). At each site, one to five plots of ca. 1 ha each were established at different elevations (350 m, 600-1200 m, 1300-1600 m, 1650-2200 m, 3000 m, 3500 m, 4050 m). We surveyed epiphytic vascular plant assemblages according to the protocol described in Gradstein et al. (2003) in (a) single trees located in (b) 90 subplots of 400 m² each located in (c) 14 plots of 1 ha each.

Results

We recorded about 800 epiphyte species in total, with up to 83 species found on a single tree. Species richness peaked at ca.

1500 m and declined by ca. 65% at 300 m and by ca. 99% at 4000 m, while forests on mountain ridges had richness values lowered by ca. 30% relative to slope forests at the same elevations. The hump-shaped richness pattern differed from a null-model of random species distribution within a bounded domain (the mid-domain effect) as well as from the pattern of mean annual precipitation by a shift of the diversity peak to lower elevations and by a more pronounced decline of species richness at higher elevations. With the exception of Araceae, which declined almost monotonically, all epiphyte taxa showed hump-shaped curves, albeit with slightly differing shapes. Orchids and pteridophytes were the most species-rich epiphytic taxa, but their relative contributions shifted with elevation from a predominance of orchids at low elevations to purely fern-dominated epiphyte assemblages at 4000 m. Within the pteridophytes, the polygrammoid clade was conspicuously overrepresented in dry or cold environments. Orchids, various small groups (Cyclanthaceae, Ericaceae, Melastomataceae, etc.), and Bromeliaceae (below 1000 m) were mostly restricted to the forest canopy, while Araceae and Pteridophyta were well-represented in the forest understory.

Main Conclusions

Our study confirms the hump-shaped elevational pattern of vascular epiphyte richness, but the causes of this are still poorly understood. We hypothesize that the decline of richness at high elevations is due to low temperatures, but the mechanism involved is unknown. The taxon-specific patterns suggest that some taxa have a phylogenetically determined propensity for survival under extreme conditions (low temperatures, low humidity, low-light levels in the forest interior). The three spatial sampling scales show some different patterns, highlighting the influence of the sampling methodology.

Acknowledgments

Field work was supported by the Deutscher Akademischer Austauschdienst, the A.F.W. Schimper-Stiftung (TK), and the Deutsche Forschungsgemeinschaft (MK). The epiphyte survey at Cordillera Mosetenes was funded by the CRE fund of the National Geographic Society, BIOPAT, the Weeden Foundation, and the Deutsche Bromeliengesellschaft.

Literature Cited

Gradstein, S.R., Nadkarni, N.M., Krömer, T., Holz, I. & Nöske, N. (2003) A protocol for rapid and representative sampling of vascular and non-vascular epiphyte diversity of tropical rain forests. Selbyana, 24, 190-195.

Krömer, T., Kessler, M., Gradstein, S.R. & A. Acebey (2005). Diversity patterns of vascular epiphytes along an elevational gradient in the Andes. Journal of Biogeography 32: 1799-1809.

Meetings and Events

Tree and Flying Squirrel Colloquia
22-29 March 2006
Periyar Tiger Reserve, India
‹‹http://www.squirrelcolloquia.co.in/››

ICAN Special Canopy Session :
Joint Annual Meeting - Society for Northwestern Vertebrate Biology & The Washintgon Chapter of The Wildlife Society.
27 March - 1 April 2006.
The Evergreen State College, Olympia, WA, USA.
‹‹www.evergreen.edu/ican› ‹www.snwvb.org››
Challenges of a Changing World:
Historical Perspectives and New Innovations.

Managing Forest Ecosystems:
The Challenges of Climate Change
3-7 April 2006
Palencia, Spain
‹‹http://www.palencia.uva.es/iufro2006/››

Climate Changes and Their Impacts on Boreal and Tropical Forests
5-7 June 2006.
Ekaterinburg, Russian Federation
‹‹http://ecoinf.uran.ru/conference/››

Association for Tropical Biology and Conservation Annual Meeting
18-21 July 2006. Kunming, China
‹‹http://atbc.xtbg.ac.cn/››
Advances in Forest Landscape Modeling: Approaches, Standardization, Validation, and Applications

9th International Pollination Symposium
23-28 July 2006. Iowa State University, USA
‹‹www.ucs.iastate.edu/mnet/plantbee/home.html››
Host-Pollinator Biology Relationships - Diversity in Action.

Ecological Society of America:
91st Annual Meeting
6-11 August 2006
Memphis, Tennessee USA
‹‹http://esa.org/memphis/››
Icons and Upstarts in Ecology

RECENT CITATIONS IN CANOPY SCIENCE

Since there is no central journal on canopy science, it is useful to publish citations on canopy studies in the recent literature. Some of the papers listed below were obtained from ICAN subscribers sending in reprints; most were discovered through weekly literature searches on Current Contents on Diskette (CCOD).

Canopy Structure

Grogan, J., R. M. Landis, M. S. Ashton, and J. Galvao. 2005. Growth response by big-leaf mahogany (*Swietenia macrophylla*) advance seedling regeneration to overhead canopy release in southeast Para, Brazil. Forest Ecology and Management 204:399-412.

Landis, R. M., and D. R. Peart. 2005. Early performance predicts canopy attainment across life histories in subalpine forest trees. Ecology 86:63-72.

Watt, M. S., J. R. Moore, and B. McKinlay. 2005. The influence of wind on branch characteristics of *Pinus radiata.* Trees 19:58-65.

Ecosystem Processes

Arain, A. A., and N. Restrepo-Coupe. 2005. Net ecosystem production in a temperate pine plantation in southeastern Canada. Agricultural and Forest Meteorology 128:223-241.

Holland, E. A., B. H. Braswell, J. Sulzman, and J. F. Lamarque. 2005. Nitrogen deposition onto the United States and western Europe: synthesis of observations and models. Ecological Applications 15:38-57.

Nordin, A., J. Strengbom, J. Witzell, T. Nasholm, and L. Ericson. 2005. Nitrogen deposition and the biodiversity of boreal forests: implications for the nitrogen critical load. Ambio *34:20-24.*

Ptacnik, R., G. D. Jenerette, A. M. Verschoor, A. F. Huberty, A. G. Solimini, and J. D. Brookes. 2005. Applications of ecological stoichiometry for sustainable acquisition of ecosystem services. Oikos 109:52-62.

Forest Management

Coxson, D. S., and S. K. Stevenson. 2005. Retention of canopy lichens after partial-cut harvesting in wet-belt interior cedar-hemlock forests, British Columbia, Canada. Forest Ecology and Management 204:97-112.

Fenton, N. J., and K. A. Frego. 2005. Bryophyte (Moss and liverwort) conservation under remnant canopy in managed forests. Biological Conservation 122:417-430.

Githiru, M., L. Lens, and W. Cresswell. 2005. Nest predation in a fragmented Afrotropical forest: evidence from natural and artificial nests. Biological Conservation 123:189-196.

Forest Structure

Bonino, E. E., and P. Araujo. 2005. Structural differences between a primary and a secondary forest in the Argentine Dry Chaco and management implications. Forest Ecology and Management 206:407-412.

Keeton, W. S., and J. F. Franklin. 2005. Do remnant old-growth trees accelerate rates of succession in mature Douglas-fir forests? Ecological Monographs 75:103-118.

Williams-Linera, G., M. Palacios-Rios, and R. Hernandez-Gomez. 2005. Fern richness, tree species surrogacy, and fragment complementarity in a Mexican tropical montane cloud forest. Biodiversity and Conservation 14:119-133.

Forest-Atmosphere Interactions

Girardin, M. P., and J. Tardif. 2005. Sensitivity of tree growth to the atmospheric vertical profile in the Boreal Plains of Manitoba, Canada. Canadian Journal of Forest Research 35:48-64.

Vuorinen, T., A. M. Nerg, E. Vapaavuori, and J. K. Holopainen. 2005. Emission of volatile organic compounds from two silver birch (*Betula pendula* Roth) clones grown under ambient and elevated CO_2 and different O_3 concentrations. Atmospheric Environment 39:1185-1197.

Hydrology

Caylor, K. K., H. H. Shugart, and I. Rodriguez-Iturbe. 2005. Tree canopy effects on simulated water stress in Southern African savannas. Ecosystems 8:17-32.

Deviaeminck, R., A. DeSchrijver, and M. Hermy. 2005. Variation in throughfall deposition across a deciduous beech (*Fagus sylvatica* L.) forest edge in Flanders. Science of the Total Environment 337:241-252.

Magarey, R. D., J. M. Russo, R. C. Seem, and D. M. Gadoury. 2005. Surface wetness duration under controlled environmental conditions. Agricultural and Forest Meteorology 128:111-122.

Mouli, P. C., S. V. Mohan, and S. J. Reddy. 2005. Rainwater chemistry at a regional representative urban site: influence of terrestrial sources on ionic composition. Atmospheric Environment 39:999-1008.

Invertebrates

Carpintero, S., J. Reyes-Lopez, and L. A. DeReyna. 2005. Impact of Argentine ants (*Linepithema humile*) on an arboreal ant community in Donana National Park, Spain. Biodiversity and Conservation 14:151-163.

Fayt, P., M. M. Machmer, and C. Steeger. 2005. Regulation of spruce bark beetles by woodpeckers - a literature review. Forest Ecology and Management 206:1-14.

Fermon, H., M. Waltert, R. I. Vane-Wright, and M. Muhlenberg. 2005. Forest use and vertical stratification in fruit-feeding butterflies of Sulawesi, Indonesia: impacts for conservation. Biodiversity and Conservation 14:333-350.

Prinzing, A. 2005. Corticolous arthropods under climatic fluctuations: compensation is more important than migration. Ecography 28:17-28.

Light Transmission

Niinemets, U., A. Sparrow, and A. Cescatti. 2005. Light capture efficiency decreases with increasing tree age and size in the southern hemisphere gymnosperm *Agathis australis*. Trees 19:177-190.

Serrano, L., and J. Penuelas. 2005. Assessing forest structure and function from spectral transmittance measurements: a case study in a Mediterranean holm oak forest. Tree Physiology 25:67-74.

Thomas, S. C. 2005. Increased leaf reflectance in tropical trees under elevated CO_2. Global Change Biology 11:197-202.

Modeling

Dube, P., A. Menard, A. B. Bouchard, and D. J. Marceau. 2005. Simulating the impact of small-scale extrinsic disturbances over forest species volumetric light environment. Ecological Modelling 182:113-129.

Giuliani, R., E. Magnanini, F. Nerozzi, E. Muzzi, and H. Sinoquet. 2005. Canopy probabilistic reconstruction inferred from Monte Carlo point-intercept leaf sampling. Agricultural and Forest Meteorology 128:17-32.

Segura, M., and M. Kanninen. 2005. Allometric models for tree volume and total aboveground biomass in a tropical humid forest in Costa Rica. Biotropica 37:2-8.

Snall, T., J. Pennanen, L. Kivisto, and I. Hanski. 2005. Modelling epiphyte metapopulation dynamics in a dynamic forest landscape. Oikos 109:209-222.

Zeide, B. 2005. How to measure stand density. Trees 19:1-14.

Nutrient Cycling

Feeley, K. J., and J. W. Terborgh. 2005. The effects of herbivore density on soil nutrients and tree growth in tropical forest fragments. Ecology 86:116-124.

Gaio-Oliveira, G., L. Dahlman, K. Palmqvist, M. Martins-Loucao, and C. Maguas. 2005. Nitrogen uptake in relation to excess supply and its effects on the lichens *Evernia prunastri* (L.) *Ach* and *Xanthoria parietina* (L.) Th. Fr. Planta 220:794-803.

Takahashi, K., T. Seino, and T. Kohyama. 2005. Plastic changes of leaf mass per area and leaf nitrogen content in response to canopy openings in saplings of eight deciduous broad-leaved tree species. Ecological Research 20:17-23.

Yano, Y., K. Lajtha, P. Sollins, and B. A. Caldwell. 2004. Chemical and seasonal controls on the dynamics of dissolved organic matter in a coniferous old-growth stand in the Pacific Northwest, USA. Biogeochemistry 71:197-223.

Plant Physiology

Bovard, B. D., P. S. Curtis, C. S. Vogel, H. B. Su, and H. P. Schmid. 2005. Environmental controls on sap flow in a northern hardwood forest. Tree Physiology 25:31-38.

Grossnickle, S. C., S. H. Fan, and J. H. Russell. 2005. Variation in gas exchange and water use efficiency patterns among populations of western redcedar. Trees 19:32-42.

Hikosaka, K. 2005. Leaf canopy as a dynamic system: ecophysiology and optimality in leaf turnover. Annals of Botany 95:521-533.

Ishida, A., T. Toma, and Marjenah. 2005. A comparison of in situ leaf photosynthesis and chlorophyll fluorescence at the top canopies in rainforest mature trees. Japan Agricultural Research Quarterly 39:57-67.

Taneda, H., and M. Tateno. 2005. Hydraulic conductivity, photosynthesis and leaf water balance in six evergreen woody species from fall to winter. Tree Physiology 25:299-306.

Plants

Chapman, C. A., L. J. Chapman, T. T. Struhsaker, A. E. Zanne, C. J. Clark, and J. R. Poulsen. 2005. A long-term evaluation of fruiting phenology: importance of climate change. Journal of Tropical Ecology 21:31-45.

Garcia, C., C. Sergio, and M. SimSim. 2005. Epiphytic bryophyte diversity in oak woodlands of centre and northern Portugal. First analyses from a national survey. Journal of the Hattori Botanical Laboratory:161-181.

Hassel, K., B. Pedersen, and L. Soderstrom. 2005. Changes in life-history traits in an expanding moss species: phenotypic plasticity or genetic differentiation? A reciprocal transplantation experiment with *Pogonatum dentatum*. Ecography 28:71-80.

Kushwaha, C. P., and K. P. Singh. 2005. Diversity of leaf phenology in a tropical deciduous forest in India. Journal of Tropical Ecology 21:47-56.

Lengiewicz, I., and M. Orlowska. 2005. Lichenoflora of Emperor's Road in Biebrza National Park. Polish Journal of Environmental Studies 14:231-235.

Setterfield, S. A., M. M. Douglas, L. B. Hutley, and M. A. Welch. 2005. Effects of canopy cover and ground disturbance on establishment of an invasive grass in an Australia savanna. Biotropica 37:25-31.

Walser, J. C., R. Holderegger, F. Gugerli, S. E. Hoebee, and C. Scheidegger. 2005. Microsatellites reveal regional population differentiation and isolation in *Lobaria pulmonaria,* an epiphytic lichen. Molecular Ecology 14:457-467.

Yamada, H., and T. Miyaura. 2005. Geographic variation in nut size of *Castanopsis* species in Japan. Ecological Research 20:3-9.

Remote Sensing

Gu, L. H., E. M. Falge, T. Boden, D. D. Baldocchi, T. A. Black, S. R. Saleska, T. Suni, S. B. Verma, T. Vesala, S. C. Wofsy, and L. K. Xu. 2005. Objective threshold determination for nighttime eddy flux filtering. Agricultural and Forest Meteorology 128:179-197.

Nobis, M., and U. Hunziker. 2005. Automatic thresholding for hemispherical canopy-photographs based on edge detection. Agricultural and Forest Meteorology 128:243-250.

Sano, Y., Y. Okamura, and Y. Utsumi. 2005. Visualizing water-conduction pathways of living trees: selection of dyes and tissue preparation methods. Tree Physiology 25:269-275.

Tree Architecture

Mutke, S., R. Sievanen, E. Nikinmaa, J. Perttunen, and L. Gil. 2005. Crown architecture of grafted Stone pine (*Pinus pinea* L.): shoot growth and bud differentiation. Trees 19:15-25.

Vertebrates

Biju, S. D., and F. Bossuyt. 2005. A new species of frog (Ranidae, Rhacophorinae, Philautus) from the rainforest canopy in the Western Ghats, India. Current Science 88:175-178.

Pavelka, M. S. M., and A. M. Behie. 2005. The effect of hurricane Iris on the food supply of black howlers *(Alouatta pigra)* in southern Belize. Biotropica 37:102-108.

Tejeda-Cruz, C., and W. J. Sutherland. 2005. Cloud forest bird responses to unusually severe storm damage. Biotropica 37:88-95.

Tisdell, C., C. Wilson, and H. S. Nantha. 2005. Policies for saving a rare Australian glider: economics and ecology. Biological Conservation 123:237-248.

Van Bael, S. A., and J. D. Brawn. 2005. The direct and indirect effects of insectivory by birds in two contrasting Neotropical forests. Oecologia 143:106-116.

The International Canopy Network
Subscriber Form

NAME:_____

ADDRESS:_____

_____

PHONE:_____

FAX:_____

E-MAIL:_____

VISA OR MC (circle one)#:_____

EXPIRATION DATE:_____

- ◯ $ 30 Regular Subscriber
- ◯ $ 20 Student Subscriber
- ◯ $ 50 Institutional/Corporate

- ◯ .PDF FORMAT
- ◯ HARD COPY

~Additional tax-deductible donations are welcomed~

PLEASE SEND A CHECK, MONEY ORDER, MC or VISA NUMBER TO:

ICAN
2103 Harrison Avenue NW
PMB 612
Olympia, WA 98502-2607 USA
Call in Visa or MC to (360) 867-6788
E-mail: <canopy@evergreen.edu>
Website: <<www.evergreen.edu/ican>>

INTERNATIONAL CANOPY NETWORK
2103 Harrison Avenue NW
PMB 612
Olympia, WA 98502-2607 USA