European Science Foundation

Standing Committee for Life, Earth and Environmental Sciences (LESC)

ESF LESC EXPLORATORY WORKSHOP

The Last Biotic Frontier:
Towards a Census of Canopy Life

Royal Belgian Institute of Natural Sciences
Brussels, Belgium, 5-9 July 2005

Convened by:

Maurice Leponce [1] and Yves Basset [2]

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http://www.naturalsciences.be/cb/ants/meetings/esf_exploratory_workshop.htm

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UNEP

GCP Global Canopy Programme

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United Nations Environment Programme

Mission: To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP has a historical interest in the topic of biodiversity of forest canopies through the IBISCA project. In view of UNEP's commitment to promote the scientific base of national decision making of biodiversity and the applications of the ecosystem approach to global/regional biodiversity assessments, it is encouraging to note that the workshop will address the crucial role of the biodiversity of insects, mites and spiders in a biome of global importance i.e. tropical rainforest ecosystem.

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Global Canopy Programme

A global alliance linking studies of forest canopies worldwide into a collaborative programme of research, education and conservation addressing biodiversity, climate change and poverty alleviation

The aim of the Global Canopy Programme (GCP) is to integrate forest studies across the world into a ten year linked program of research, conservation and education, focussed on understanding the critical role of forest canopies in biodiversity and climate change. It also aims to identify societal benefits from forest canopies, and transmit information to key stakeholders. This initiative evolved from an ESF / NSF funded International Canopy Science Workshop in Oxford, held in November 1999. At the workshop, a template for the GCP was produced by 29 international experts from 10 countries. They concluded that by working together, canopy researchers would be able to leverage more funding for a major collaborative Natural Science project to investigate "nature's last biotic frontier". They called for significant new funding on the scale of large Physical science projects (US$20-50 million) to undertake this pioneering task.

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Workshop Objectives:

The **aims** of the proposed *Exploratory Workshop* are twofold.

First, to summarize what has been learned from the IBISCA project overall and to plan the dissemination of this novel and important information.

Second, to use this material as a springboard to initiate new collaborative programs of research about the distribution of mega-biodiversity in tropical rainforests. In particular, this will **implement new research programs focused on forest canopies** performed at tropical research stations owned by, co-managed by or run to some extent in cooperation with European institutions (e.g., UK: Danum Valley; France: Les Nouragues; The Netherlands: Tropenbos stations; Germany: collaboration with INPA at Manaus, etc.).

This will also **foster collaborative research projects focused on mega-biodiversity in the tropics**. In particular, we will explore the advantages to base mega-biodiversity studies at permanent botanical plots in light of the results obtained by IBISCA.

We also intend to discuss future research programmes based on the Canopy Glider®, a new device for easy canopy access currently under development in France.

Workshop Agenda:

The first day of the workshop, we intend to make an overview of the new data generated by the IBISCA project related to beta-diversity, vertical gradients and interactions between organisms (15 min talks). The morning of the second day we intend to review the difficulties related to the analysis of mega-biodiversity distribution in the tropics and how to solve them (20 min. talks). The 3 next half-day sessions will be devoted to working groups aimed to develop new analyses of the IBISCA data, to summarize what has been learned from the IBISCA project overall, to plan the dissemination of this novel information, to identify promising lines of investigation and to foster new collaborative key projects related to tropical mega-biodiversity. At the end of the workshop, the results from the various working groups will be discussed and integrated and will lead to general conclusions.

A number of social events are scheduled, which will need to be confirmed, on the welcome day.

On Day 1, the presentations intend to summarize the scope of IBISCA data, but not necessarily to report on specific results. Hence they should be organized as to provide details of what was done, what still need to be done and discuss both a particular sampling programme and focal taxa (unrelated to sampling programmes) under the supervision of participants. In the programme, names underlined indicate suggested speaker(s) in case of multiple authorship.

On Day 2, short presentations in the morning will intend to emphasize particular themes relevant to IBISCA or future similar projects. The afternoon plenary session will provide the opportunity to debate on the ideal agenda that each working group should discuss in the next day. Tentative topics of discussion are provided for each group at the end of the workshop programme.

The final day will include discussions of working groups (morning) and integration of the results as a plenary session in the afternoon. To be more efficient, we have suggested tentative working groups and their composition. However, flexibility may be possible and participants may want to move between groups if useful.

Report publication:

It is planned to publish the proceedings of the workshop in electronic form. Depending on available funds, the organizers envisage also the publication of the proceedings in paper form.

FINAL PROGRAMME

Tuesday 5 July 2005

Afternoon	*Arrival*

Welcome day

17:30	**Welcome of participants** and visit of the **IBISCA exhibition** (sponsored by Solvay S.A.) at the Royal Belgian Institute of Natural Sciences (Museum, 6th level, insect hall).
19:00	**Welcome. The involvement of the Royal Belgian Institute of Natural Sciences in biodiversity studies** **Camille Pisani**, general director of the Museum
19:05	**The involvement of Solvay in the IBISCA project** **Robert Van Geyts**, communication manager, Solvay
19:10	**Presentation of the IBISCA approach** **Bruno Corbara**, scientific director of the Canopy Raft Consortium followed by a movie (DVD IBISCA) (Main auditorium, Museum)
19:30	**video "Mission: IBISCA" (Solvay, 2004)** (Main auditorium, Museum)
20:30	***Dinner*** *at the restaurant Kapolino*

Wednesday 6 July 2005

Distribution of tropical mega-biodiversity: available data

1. Introduction and background

08:20	**Presentation of the European Science Foundation (ESF)** **Lucien Hoffmann** (Standing Committee for the Life, Earth and Environmental Sciences)
08:30	**Presentation of the United Nation Environment Programme (UNEP)** **Margaret M. Oduk**, Programme Officer, Biodiversity and Biotechnology Unit, Division of Environmental Conventions, United Nations Environment Programme.
08:40	**Presentation of the Global Canopy Programme (GCP)**

	Andrew Mitchell, director of GCP
08:50	Introduction to and aims of the workshop (**Leponce** & **Basset**)
09:00	Presentation of workshop participants (led by **Basset** & **Leponce**)
09:15	Presentation of the IBISCA project: aims and general methods (**Corbara**)
09:30	IBISCA at a glance: results of the participant survey (**Basset** & **Leponce**)

2. Beta diversity

09:40	Beta diversity: basic concepts and tropical data **Novotny**
10:00	Beta-Diversity: Contributions from Ant Studies to the Debate **Delabie**
10:20	*Coffee Break*
10:40	The IBISCA Malaise trap programme and focal taxa **Springate**, **Basset** & **Pinzón**
11:00	The IBISCA canopy fogging programme and team focal taxa **Schmidl**, **Floren** & **Bail.**
11:20	The IBISCA Winkler programme and focal taxa **Aberlenc**, **Leponce**, **Orivel**, **Corbara**, **Roisin**
11:40	Other IBISCA programmes: ground flight-intercept traps, pitfall traps, vegetation and focal taxa **Tishechkin**, **Medianero** & **Samaniego**
12:00	*Lunch*

3. Vertical gradients

13:00	Overview of theory and current concepts of arthropod vertical stratification **Didham**
13:20	Higher Questions: unfinished business with canopy arthropods **Kitching**
13:40	Beating of dead branches in the understorey and canopy **Ødegaard**
14:00	The IBISCA light trap programme

	Kitching, **Oliviera**, **Cornejo**
14:20	The IBISCA flight-intercept trap programme (FL) and focal taxa (Psocoptera, Diptera) **Fagan**, **Didham**, **Rapp**, **Cuénoud**, **Swann**
14:40	The IBISCA sticky trap programme and focal taxa: Auchenorrhyncha and *Agrilus* (Hemiptera, Coleoptera) **Basset**, **Curletti**, **Barrios**, **Cizek**, **Aberlenc**, **Leponce** & **Barba**
15:00	*Coffee Break*
15:20	Gall species distribution in contrasting canopy types in a tropical rainforest **Ribeiro**
15:40	Other IBISCA programmes: wood rearing, beating, microarthropods and focal taxa **Cizek**, **Barrios**, **Winchester** & **Jordan**; presented by **Basset**

4. Interactions between organisms

16:00	Trophic interactions among tropical organisms **Lewis**
16:20	The IBISCA social insects programme: ants **J. Orivel, M. Leponce, J. Delabie, B. Corbara, Y. Roisin, I. Cardoso do Nascimento, S. Ribeiro, R. Campos, J. Schmidl; A. Floren & A. Dejean.**
16:40	Distribution of termites from the ground to the canopy of a Panamanian rainforest **Roisin**, **Dejean**, **Corbara**, **Orivel** & **Leponce**
17:00	Euglossine and meliponine bees diversity and abundance on the ground and in the canopy. **Frame** & **Roubik**

5. Integration for the sessions of the day

17:20	Beta diversity (led by **Delabie** & **Novotny**)
17:40	Vertical gradients (led by **Didham** & **Kitching**)
18:00	Tropical interactions (led by **Lewis** & **Orivel**)
20:00	*Dinner at "Stekerlapatte", in Marolles neighbourhood*

Thursday 7 July 2005

Survey and analyses of mega-biodiversity distribution in the tropics: pitfalls and remedies

08:30	What can adaptation at range margins tell us about the evolution of biodiversity and the scale of ecological interactions? **Bridle**
08:50	Implementing large-scale surveys and experiments in the tropics **Roslin**
09:20	Taxonomic impediment **Sørensen**
09:40	Working with parataxonomists **Missa**
10:10	*Coffee Break*
10:30	The IBISCA database **Leponce** & **Basset**
10:50	Characterizing community diversity in species rich systems – statistical pitfalls, remedies, and insights from a phylogenetic perspective. **Hardy**
11:10	Meta data and multivariate analyses of large datasets **Dufrêne**
11:30	Funding large scale biodiversity projects in the tropics **Mitchell**
11:50	*Lunch*
13:00	Integration of morning sessions (led by **Floren** & **Ødegaard**)
13:30	Plenary preparation of **working group 1**: Problems and remedies related to the analyses of IBISCA data (led by **Hardy** & **Lewinsohn**)
14:00	Plenary preparation of **working group 2**: Key analyses of IBISCA data: taxonomic aspects and interactions between organisms (led by **Roisin**)
14:30	Plenary preparation of **working group 3**: Key analyses of IBISCA data: arthropod distribution patterns (led by **Didham**)
15:00	*Coffee Break*

15:30	Plenary preparation of **working group 4**: Towards a census of canopy life (led by **Kitching** & **Mitchell**)
16:30	*Optional seminar* on working with the IBISCA database (**Leponce**)
20:00	*Dinner at "Les Salons d'Atalaïde"*

Friday 8 July 2005

Discussion, integration and conclusions

8:30-12:00	**Working group 1**: Problems and remedies related to the analyses of IBISCA data (led by **Hardy** & **Lewinsohn**, including **Dufrêne**, **Missa**, **Leponce**, **Ribeiro** & **Roslin**)
8:30-12:00	**Working group 2**: Key analyses of IBISCA data: taxonomic aspects and interactions between organisms (led by **Roisin**, including **Aberlenc**, **Cornejo**, **Curletti**, **Delabie**, **Schmidl**, **Sorensen**, **Samaniego** & **Springate**)
8:30-12:00	**Working group 3**: Key analyses of IBISCA data: arthropod distribution patterns (led by **Didham**, including **Bail**, **Basset**, **Bito Floren**, **Frame**, **Ødegaard**, **Orivel** & **Ozanne**)
8:30-12:00	**Working group 4**: Towards a census of canopy life (led by **Kitching** & **Mitchell**, including **Bridle**, **Corbara**, **Cuénoud**, **Gama de Oliveira**, **Lewis**, **Fagan**, **Medianeiro**, **Novotny**, **Pascal** & **Van Osselaer**)
10:00-10:20	*Break for all working groups*
12:00	*Lunch*
13:00	Report of working group 1 (led by **Hardy** & **Lewinsohn**)
13:25	Report of working group 2 (led by **Roisin**)
13:50	Report of working group 3 (led by **Didham**)
14:15	Report of working group 4 (led by **Kitching** & **Mitchell**)
15:00	*Coffee Break*
15:20	Discussion and integration of working group results (led by **Novotny** & **Basset**)
16:30	How to ensure an efficient dissemination of IBISCA data (led by **Corbara** & **Leponce**) [includes discussion about the workshop proceedings; perhaps

formation of 'writing groups', discussion of CD, web site, etc.]

17:30 Conclusions (led by **Kitching**)

19:00 *Beer at Le Roy d'Espagne, Grand Place.*

20:00 *Picture group in front of Manneken pis.*

20:30 *Dinner at "Le Manneken" near Grand Place*

Saturday 9 July 2005

Departure

Further information about the topics to be discussed by working groups:

(Tentative, non exhaustive and to be discussed in plenary session)

Each group will have to prioritize its tentative topics, so that our limited time is best used to discuss the most important topics.

Working group 1: Problems and remedies related to the analyses of IBISCA data

- How to maximize coordination/analyses between the different scientific programs
- Direction for common methods in statistical analyses, especially for participants less expert with statistics (database modules?)
- Independence of data points and how to test for it
- Meta –data style analyses allowing consideration of all sampling methods and specimens collected during IBISCA
- What may be the most robust statistics to use with IBISCA data
- How to control for the effects of scale and taxa?
- The problem of the information associated with singletons from a statistical viewpoint
- Could new phylogenetic analyses be used with real data sets from the tropics, such as IBISCA?
- Would Bayesian statistics be useful for some of IBISCA data?
- Do statistical analyses need to be standardized among sampling programmes/focal taxa?
- If yes, then provide a set of simple rules (and relevant statistical packages if needed)
- A practical example: should similarity be measured with the Morisita-Horn index (or an other index), or with the new indices developed by Chao et al. (2005, Ecol. Letters 8: 148-159)?

Working group 2:
Key analyses of IBISCA data: taxonomic aspects and interactions between organisms

- How to compare the distribution of different taxa in order to understand better the distribution of biodiversity at San Lorenzo
- Relative insect abundances in different communities
- Timeframe for progress: amount of time to process specimens highly unequal among focal taxa; should we wait for all results to come in, make subsamples or rely on other shortcuts?
- Possible interactions between organisms (and relevant data sets)
- Comparisons between sampling techniques and importance of complementarity among sampling methods
- Refining key biological question in IBISCA: taxonomic aspects and interactions between organisms

- Are there ant mosaics in the San Lorenzo forest and do they affect the observed results?
- Naming new species described from IBISCA material
- Deposition of holotypes and paratypes described from IBISCA material
- How to refine guild assignment for analyses

Working group 3:
Key analyses of IBISCA data: arthropod distribution patterns

- Influence of seasonality on arthropod vertical stratification (and beta-diversity?)
- Relationships with plant data, forest structure, canopy openness, etc.
- What are the most interesting hypotheses relevant to arthropod spatial distribution?
- The biological values of singleton and how to deal with them
- Refining key biological question in IBISCA: arthropod distribution patterns
- Identify major concepts/theory on which to base the results and conclusions of IBISCA
- Partitioning of components of diversity: alpha, beta, gamma
- How can we quantify variance due to beta-diversity and vertical stratification; and relationships between the two
- Spatial heterogeneity versus spatial autocorrelation
- Distinction between sampling pseudoturnover and beta diversity
- Can we predict distribution patterns form the set of variables measured at each site during IBISCA: vegetation characteristics, canopy openness, basal area, etc.
- Could these variables help to estimate the effects of logging and canopy aperture, and have implications for conservation?

Working group 4:
Towards a census of canopy life

- Possible integration of IBISCA data into ecological theory: ecosystem functioning, anthropogenic disturbance, etc.
- Maximizing the dissemination of IBISCA results: publication strategy (not in details); what is the best way to maximize the impact of the findings?
- Do IBISCA findings lead to new lines of investigations?
- Experiments to test insect-plant interactions in the canopy and methodological constraints
- Relationships between abiotic factors and the 'horizontal heterogeneity' of the tropical forest
- Linking arthropod species diversity and distribution with geological history and evolutive forces within tropical forests
- How assessments of local, regional and global biodiversity can be estimated or improved
- Relationships between biodiversity assessments and forest health and climate change; are vertical distribution patterns going to be altered by climate change?
- The evolution of specialization and its relationship to community structure and stability
- Methodological approaches to comprehensive, multi-species surveys of tropical ecosystems
- How to spread the IBISCA spirit
- How to fund specimen processing/taxonomical analyses in projects such as IBISCA
- How to put a value on local and regional biodiversity for conservation purposes
- Consider a plan for implementing future IBISCA-style projects as part of the proposed UNEP 'Whole Forest Observatory' project
- How biodiversity estimates can benefit people dependent on forests or governments applying CBD recommendations?
- New methods of biodiversity assessment which may be used in biodiversity credit trading systems
- Should the IBISCA team promotes itself as a "task force" for future biodiversity studies?
- Do we need an IBISCA advisory board and what would be its structure?

The following point(s) should ideally be discussed by all groups:

- Leading concepts for a joint, collaborative, summary article in a leading journal
- Timeline and outlets for publication (if applicable)
- A strategy to avoid 'flooding' of particular journals

European Science Foundation

Objectives of the ESF Standing Committee for Life, Earth and Environmental Sciences (LESC)

The main objectives of the **ESF Standing Committee for Life, Earth and Environmental Sciences (LESC) are**:

1. to identify and promote emerging scientific topics and high quality science deserving special attention in Europe;
2. to manage a wide ranging portfolio of activities of the European Science Foundation;
3. to examine and report on issues of strategic scientific importance within its fields of competence.

This committee's sphere of activities comprises the broad field of life, earth and environmental sciences:

- Biology
- Biotechnology
- Agriculture
- Earth sciences
- Climate research
- Glaciology
- Oceanography
- Environmental sciences, etc.

ESF Standing Committees support a limited number of **Exploratory Workshops** each year. These workshops allow leading European scientists to explore novel ideas at the European level with the challenging aim to "***spearhead***" new and preferably inter-disciplinary areas of research. Further details are available on the internet at http://www.esf.org/workshops.

One desirable outcome of an ESF Exploratory Workshop may be that participants submit **high quality proposals for further ESF activities** (such as "à la carte Programmes" or a EUROCORES initiative), or **research funding applications** for submission to the EU 6th Framework Programme or to other European or international funding organisations.

In the case of **ESF Programmes** ("à la carte" or EUROCORES), which are financed by, and coordinated through, the European Science Foundation, a draft proposal should be submitted to the LESC Secretariat for advice, to then subsequently undergo further external refereeing. If successful in obtaining LESC's scientific recommendation, the proposal will be submitted to ESF Member Organisations for funding on a voluntary basis. More details are available at http://www.esf.org/lesc.

ABSTRACTS

Wednesday 6 July 2005

Distribution of tropical mega-biodiversity: available data

2. *Introduction and background*

08:20 **Presentation of the European Science Foundation (ESF)**
Lucien Hoffmann
(Standing Committee for the Life, Earth and Environmental Sciences)

08:30 **Presentation of the United Nation Environment Programme (UNEP)**
Margaret M. Oduk, Programme Officer, Biodiversity and Biotechnology Unit, Division of Environmental Conventions, United Nations Environment Programme.

08:40 **Presentation of the Global Canopy Programme (GCP)**
Andrew Mitchell, director of GCP

08:50 Introduction to and aims of the workshop (**Leponce** & **Basset**)

09:00 Presentation of workshop participants (led by **Basset** & **Leponce**)

09:15 Presentation of the IBISCA project: aims and general methods (**Corbara**)

09:30 IBISCA at a glance: results of the participant survey (**Basset** & **Leponce**)

3. *Beta diversity*

09:40 Beta diversity: basic concepts and tropical data

V. Novotny
Department of Ecology and Conservation Biology
Institute of Entomology
Branisovska 31, CZ 370 05 Ceske Budejovice, Czech Republic

The paper reviews main causes of species turnover in space, including speciation, dispersal limitation, habitat availability and biotic interactions. Further, it outlines the basic approaches to measuring beta diversity, relying on pair-wise comparisons between communities or local-regional comparisons. Finally, the paper reviews the little we know about beta diversity of insects in tropical rainforests and discusses promising directions for the further study.

10:00 Beta-Diversity: Contributions from Ant Studies to the Debate

J. H. C. Delabie
Laboratorio de Mirmecologia, Centro de Pesquisas do Cacau, CEPLAC, & Departamento de Ciências Agrarias e Ambientais, Universidade Estadual de Santa Cruz, Ilheus, Bahia, Brazil.
Currently: Invited Professor, Laboratoire d'Evolution et Diversité Biologique, Université Paul Sabatier, Toulouse, France.

According the classical definition of MacArthur, the Beta Diversity is the component of total diversity that can be attributed to differences in species composition among the homogeneous units in the landscape [1]. Ants and other social insects are specially interesting for this kind of study in tropical habitats [2, 3]. Data of the ant communities of southern Bahia studied during the last 15 years for several purposes are used here for considerations about the Beta Diversity partition of ants in tropical latitudes and compared with data obtained through similar sampling efforts in a temperate region. Several topics have to be considered for ant communities studies, according the scale and distribution of the samplings, the vegetation strata, as well as the links with its natural complement concepts that are the alpha- and gamma-diversities. Ants are seen between the dominant organisms of tropical ecosystems. In tropical arborous eco/agrosystems, their communities are radically differently structured in the canopy and on/in the ground. In the former, they are strongly organized in mosaics around dominants and co-dominants species, while this kind of organization, even it exists sometimes in the latter, is much more discreet and can be seasonal. Another important element of the strata differences, consequences of the ant evolutionary history [4], is that their dynamics of reproduction and colonization, self-organization and resource uses are absolutely different, which makes hard a generalization of the Beta Diversity concepts using simultaneously hypogaeic, epigaeic and arborous ant assemblage data. Other studies focus the species turnover according a distance gradient in tropical and temperate homogenous habitats, as well as the community organization in function of the land degradation in a tropical region. Simple models are suggested for the Beta Diversity according the temperate/tropical and anthropization gradients. Finally, as ant ecologists have recently beneficed of the generalization of the Winkler trap method and ant collects standardization [5], some developments of the methods currently applied are suggested, aiming to reach comparative data of the Beta Diversity for further developments of ant communities' studies.

[1] Gering, J.C. & Crist, T.O. 2002. *Ecology Letters* 5: 433-444; [2] Schroeder, J.H. *et al*. 2004. *J. Biogeography* 31: 1219-1226; [3] Galbiati *et al.* 2005. *Sociobiology* 45: 925-936; [4] Wilson, E.O. & Hölldobler, B. 2005. *P.N.A.S.* 102: 7411-7414; [5] Agosti, D. *et al.* (orgs) *Ants: Standart Methods for Measuring and Monitoring Biodiversity*, Smithsonian Institution.

10:40 The IBISCA Malaise trap programme and focal taxa

Springate, **Basset, Pinzón**

In February, 2004, 9 Malaise traps were emplaced in the San Lorenzo

Protected Area in 'plots' in which plant diversity had been surveyed. The intentions were two-fold: (i) to provide additional material from the field-layer for the surveys of IBISCA focal taxa and (ii) to test possible correlations between the taxonomic and lifeway diversity of non-formicid Hymenoptera and that of angiosperms. Raw data and some provisional analyses, based on abundance of the focal taxa, are presented and discussed. Within rapid biodiversity assessment the need for an alternative approach to the analysis of taxa which occur at low abundance but at high species richness is discussed in the context of non-formicid Hymenoptera.

11:00 The IBISCA canopy fogging programme and team focal taxa

J. Schmidl[1], A. Floren[2], J. Bail[1].
[1]*Ecology & Nature Conservation, Institute for Zoology I, Staudtstr. 5, D-91058 Erlangen, Germany.*
[2]*Lehrstuhl für Tierökologie und Tropenbiologie, Universität Würzburg, Biozentrum, Am Hubland, D-97074 Würzburg, Germany.*

Fogging programme: A systematic canopy fogging programme was conducted within the IBISCA-project, sampling eight sites (F1,F2,F3,B1,B2,I1,R1,R3, each with 6 sub-samples of 5x5m plastic sheets installed in 1m height) in October 2003 and re-fogging six sites (F1,F2,F3,B2,I1,R3) in May and October 2004, using the identical location of the initial fogging. We used a Swingfog SN1 and a 1% natural Pyrethrum solution, dissolved in white oil Essobayol 82.

A total of approx. 79000 arthropods was collected by canopy fogging, in average 3942 per site and 657 per 20sqm-sampling-sheet. The table below gives the total numbers for the replications, sites and main insect orders and taxa. Due to the general interest, the *Formicidae* are listed separately. The total number will be up to 5% (estimated) higher, as the Blattodea and the Residuals were not counted in each season. Arachnida are not counted and separated properly, but *Araneae* form the main fraction, followed by Opilionids, Pseudoscorpions, Ricinulei and Scorpions. Exact numbers will be available after data input in the database. The rank order of the taxa and its totals is marked greyish.

With each re-fogging the number of arthropods sampled in each sub-sample was rising. It is unlikely that this a seasonal phenomenon, as the results for October 2003 and October 2004 show. It highlights the low long-term impact of Pyrethrum both on arthropod communities and ecosystem. A re-colonisation takes places immediately, and the general bionomics represented by different higher arthropod taxa re-establish a +- stable rank order and dominance structure.

Table: Overview results of canopy fogging October 2003, May 2004 and October 2004, with numbers for each replication and main insect orders/taxa. Ranking of main taxa and underlying total numbers marked greyish. nc: not counted.

October 2003: F123 B12 I1 R13 8 sites 48 sheets		**May2004: F123 B2 I1 R3 6 sites 36 sheets**		**October 2004: F123 B2 I1 R3 6 sites 36 sheets**		**total 120 sheets / 20sqm**
Formicidae	9226	Formicidae	8783	Diptera	9681	**24578**
Diptera	4532	Diptera	5922	Formicidae	6569	**20135**
Coleoptera	4425	Hymenoptera	2981	Hymenoptera	2893	**9781**
Hymenoptera	2854	Coleoptera	2802	Coleoptera	2554	**8728**
Arachnida	1232	Arachnida	1308	Homoptera	1739	**4132**
Homoptera	832	Homoptera	712	Orthopteroidea	630	**3283**
Orthopteroidea	892	Orthopteroidea	789	Arachnida	1592	**2311**
Heteroptera	313	Heteroptera	478	Heteroptera	380	**1171**
Thysanoptera	81	Thysanoptera	151	Thysanoptera	130	**362**
Isoptera	12	Isoptera	3	Isoptera	30	**45**
Residual	*1669*	*Residual*	*nc*	*Residual*	*nc*	***1669***
Blattodea	*nc*	*Blattodea*	*706*	*Blattodea*	*444*	***1150***
n total	**26080**		**24635**		**28117**	**78832**
n per sheet	**543**		**684**		**781**	

Focal taxa covered by "Fogging-team": JSchmidl: ARXXXX, BLXXXX, OPXXXX, COADER, COANOB, COANTC, COARTE, COBOST ,COBYRR ,COCANT, COCERO, COCHEL, COCIID, COCLER, COCOLY, CODASC, CODERM, CODRYO, COELAT, COELMI, COEUCI, COEUCN, COHETE, COLAGR, COLAMP, COLIMN, COLISS, COLYCI, COLYME, COMELA, COMELO, COMELY, COMONO, COMORD, COMYCE, COMYCT, CONOSO, COOEDE, CORHIC, CORHIP, COSALP, COSCIR, COSCRA, (COTENE), COTHRO, COTROG, COZOPH; **AFloren**: COCHRY; **JBail**: MAMANT, ORACRI, OREUMA, ORGRYA, ORGRYL, ORGRYT, ORPROS, ORPYRG, ORTETR, ORTETT, ORTRID.

11:20 The IBISCA Winkler programme and focal taxa
Aberlenc, **Leponce**, **Orivel**, **Corbara** & **Roisin**

11:40 Other IBISCA programmes: ground flight-intercept traps, pitfall traps, vegetation and focal taxa
Tishechkin, **Medianero** & **Samaniego**; presented by **Medianero**

3. Vertical gradients

13:00 Overview of theory and current concepts of arthropod vertical stratification
R. Didham
University of Canterbury, Christchurch, New Zealand

In this talk I will give an overview of central concepts in the study of vertical stratification in forests, and how these may relate to the analysis and interpretation of data from project IBISCA and future 'mega-biodiversity' initiatives. Although there has been contentious debate about whether true stratification in forest structure exists at all, it is now generally accepted that non-uniform patterns in the abundance and diversity of organisms across vertical heights do occur at some times and places in most forests. Exactly how to define these patterns of stratification, and how to interpret their ecological and evolutionary significance, is another matter altogether. This talk will be phrased as a series of discussion questions, rather than as a definitive statement of current knowledge, reflecting the poorly-defined state of the subject. First, I will comment on the forest structural templet on which arthropod vertical stratification is overlaid, and then discuss how best to define stratification and what the key determinants of vertical stratification might be. Subsequently, I will present a series of discussion questions (and caveats) on how to measure, test and interpret vertical trends in the IBISCA data, with particular consideration of the appropriate null model(s) we should be using to test for the existence (and magnitude) of vertical stratification. Finally, I will comment on the relevance of vertical stratification to the global distribution of biodiversity, with the conclusion that the importance of vertical stratification cannot be judged independently from the relative magnitude of beta diversity across vertical heights.

13:20 Higher Questions: unfinished business with canopy arthropods

R. Kitching
Griffith University

There are many exciting areas of ecology and environmental science in which canopies and canopy arthropods play vital roles. This talk presents a personal view of some exciting questions for the post-IBISCA era.

The evaluation of 'good' canopy science rests on four pillars: connecting pattern with process, connecting data with theory, pursuing achievable goals, and demonstrating societal relevance without compromising scientific quality.

Decomposition processes in the canopy are intriguing. Studies of perched litter in *Asplenium* allow a range of exciting questions to be pursued - relating to biodiversity patterns, biodiversity/process connections and the testing of 'geand' ecological theories. Recent ground-breaking work on herbivory leads directly(like all good science)to more questions. Ready canopy access and potential collaborations with plant eco-physiologists allow us to target local scale heterogeneity in the herbivory process. Scaling up from herbivory studies, there are huge opportunities to do food-web work based on guild analyses in forest canopies. Community webs in microhabitats and both source and sink webs in the broader canopy environment can be constructed. Forest to forest comparisons using the forest observatory network will be rewarding.

Perhaps the biggest challenge of all for students of canopy arthropods is quantifying the connections between arthropod-driven processes in the canopy and local climate. The connection is indicated in recent work on volatile organic carbons. Mid-length carbon compounds, VOC's, are involved as cloud seeds over tropical forests - maintaining forest quality and ameliorating climate change. In forests VOC's are biogenic products produced in response to plant-animal interactions. Following either forest clearance or direct anthropogenic VOC production, these compounds combine with nitrogen oxides to release ozone - exacerbating global warming. We need to know the biologically connections involved. A network of canopy observatories will permit key observations and manipulations to quantify these connections.

13:40

Beating of dead branches in the understorey and canopy
F. Ødegaard

The aim of this side project of IBISCA was to compare the vertical stratification of saproxylic beetles within and between different tree species. The study was preformed during October 2003 and May 2004 at the Canopy Crane site in the San Lorenzo forest in Panama. For each of 18 different tree species, four freshly cut branches were suspended in the canopy (15 to 25m above ground) and placed in the understorey (1m above ground) of their parent tree, respectively. All branches were beaten regularly (approximately every third day) for four weeks in both sampling periods. There were a total of 10 bouts of beating on each bunch of branches. All Coleoptera associated with dead wood and senescing leaves were collected. The study yielded *ca*. 4,937 beetles belonging to *ca*. 661 species. The results showed that both abundance and species richness was significantly higher in the canopy than in the understorey. The canopy fauna was more host specific than the understorey fauna. Species richness, abundance and host specificity did not change across seasons. Detrended correspondence analyses showed that the beetle fauna within strata (canopy and understorey) of different tree species were more similar than between strata of conspesific tree species.

A summary of the status of sorting, identification and databasing of my focal taxa is presented below. This includes all material received by 9. June 2005. The rest of the unsorted material, which includes about 5-10 000 individuals, I expect to receive soon.

Group	Species	Individuals	Identified	% id.	% db	Unsorted?
Carabidae	88	398	34	38.6	100	100
Scydmaenidae	85	492	3	3.5	100	100
Scaraboeoidea	86	632	74	86.0	100	1000
Bruchidae	9	17	6	66.7	100	10
Hispinae	19	35	13	68.4	100	10
Chlamysinae	3	4	0	0.0	100	0
Cerambycidae	124	410	89	71.8	100	50
Anthribidae	32	71	9	28.1	100	50
Attelabidae	8	93	6	75.0	100	10
Scolytinae	193	12000	82	42.5	5	5000
Platypodidae	20	261	18	90.0	100	100

There are no big problems in the sorting and identification process, but several factors contribute to slow down the progress. 1) Lack of funding for sorting. 2) Lack of time for handling such huge material 3) I haven't received the last parcels that includes about 25% of the total material. I expect data to be ready for final analyses earliest by end of 2005 and latest by end of April 2006.

14:00 The IBISCA light trap programme

R. Kitching[1], E. Oliviera[2], A. Cornejo[3]
[1]Griffith University, [2] University of Ouro Preto, [3]University of Panama

As of the end of June, a total of 5246 specimens sampled by light traps had been added to the data base. Of these 2185 were Lepidoptera and, of these 1784 belonged to the four target families. There were 421 arctiids, 385 geometrids, 774 crambids and 204 pyralids (s.s.). In addition 493 non-target Lepidoptera have been processed but, generally, not identified. No doubt many more data from Orders other than Lepidoptera await attention.

With the aid of the NMNH collections in Washington, 63% of target taxa have been identified to species, 78% to genera. Comparable percentages for each family are: Arctiidae - 82 & 94, Geometridae - 78 & 97, Crambidae - 57 & 75, Pyralidae - 32 & 38. The pyralid subfamilies Phycitinae, Acentrominae (=Nymphulinae) and Epipaschiinae proved most intractable for identification.

Clear vertical patterns exist in the data even though more formal analysis is yet to be done. The Geometridae, for example, show a clear pattern at the level of the subfamily with sterrhines dominating the ground fauna, ennomines the canopy.

Formal statistical analysis can now be done involving ordination and Estimates approaches.

14:20 The IBISCA flight-intercept trap programme (FL) and focal taxa (Psocoptera, Diptera)

L. Fagan[1], R. Didham[2], M. Rapp[3], P. Cuénoud[4], J. Swann[5]
[1]Crop & Food Research, Lincoln, New Zealand
[2]Canterbury University, Christchurch, New Zealand
[3]Canterbury University, Christchurch, New Zealand
[4]Conservatoire et Jardin botaniques dela Ville de Genève, Genève, Switzerland
[5]University of British Columbia, Vancouver, Canada

Ordinal abundance patterns from 1,659 flight-intercept trap (FL) samples for all IBISCA focal taxa are briefly summarized. A total of 71, 721 specimens were captured in FL traps at six heights from the forest floor to the canopy, from September 2003 to October 2004. Coleoptera, Hymenoptera and Diptera represented 75% of the FL catch. Proportional representation of taxa was relatively constant between sites, but varied markedly between vertical heights. In particular, Coleoptera increased two-fold in abundance and proportional representation from the ground to the canopy. Focal Coleoptera families will be the most important taxa to analyse from FL samples. With respect to focal Psocoptera from FL traps, there was also a strong increase in abundance an species richness with increasing vertical height. For focal Diptera taxa across all IBISCA trapping programmes (N=190,461), we present a brief breakdown of progress on sample sorting, focal families to be sorted to morphospecies and results obtained so far. There were strong patterns of vertical stratification at the family-level for all Diptera and at the genus/species-level for Milichiidae (Diptera). Apparent canopy-dominant families include Dolichopodidae, Chloropidae, Milichiidae and Scatopsidae. Ground-dominant families include Cecidomyiidae, Drosophilidae, Phoridae, Sphaeroceridae. For Milichiidae, species composition is extremely unusual for a Neotropical assemblage, and canopy-level sampling has forced a re-evaluation of major sampling methods the are useful for collecting Milichiidae, and of the relative dominance of the genera *Phyllomyza* and *Pholeomyia* in the Neotropics.

14:40 The IBISCA sticky trap programme and focal taxa: Auchenorrhyncha and *Agrilus* (Hemiptera, Coleoptera)

Y. Basset[1], G. Curletti[2], H. Barrios[3], L. Cizek[4], H.-P. Aberlenc[5], M. Leponce[6], A. Barba[7]
[1]Smithsonian Tropical Research Institute, Panama, PA.
[2]Museum of Carmagnola, Carmagnola, IT
[3]University of Panama, Panama, PA
[4]Czech Academy of Sciences, Ceske Budejovice, CZ
[5]CIRAD, Montpellier, FR
[6]Royal Belgian Institute of Natural Sciences, Brussels, BE
[7]University of Panama, Panama, PA

This contribution summarizes progress with the IBISCA sticky trap programme and presents preliminary results for two focal taxa: Auchenorrhyncha and *Agrilus* (Buprestidae). In total, the sticky trap programme surveyed 993 traps at 9 sites and yielded *ca*. 55,000 arthropods. Arthropod abundance/activity along the vertical transect follows a bimodal distribution and is significantly higher (and of similar magnitude) at the levels of soil/litter and upper canopy. Patterns of vertical stratification greatly differ among arthropod groups with different ecologies. Incident light measured below the traps appears to be a good predictor of the abundance/activity of arthropods collected per trap. About 15,000 homopterans (Auchenorrhyncha and Psylloidea) representing 446 morphospecies were collected with a variety of sampling methods during the IBISCA project. About 72% and 29% of this material was identified at the generic and species levels, respectively. Taxonomical studies are on-going. Stratification and faunal turnover is obvious at familial, subfamilial and specific levels. More species were collected in the understorey (where sampling effort was highest), but rarefaction curves were similar for the understorey and the upper canopy, with the mid-canopy being enriched from both habitats. Adults whose nymphs are fungal/root feeders are prevalent near the forest ground, whereas meristem-feeders dominate in the upper canopy. The distance (perhaps related to floristic composition) and the illumination of the sites appear important to predict homopteran species richness at each site, not numbers of plant species per se. Extreme specialists appear uncommon and specialization appears to occur more towards vertical distribution than site. Fifty-eight species of *Agrilus* are known from Panama. Most *Agrilus* gathered during IBISCA (n = 56 specimens) were collected with sticky traps. This material included 19 species, out of which 12 are new for Science and will be described shortly. More individuals and species were collected in the understorey, especially in forest gaps, than in the upper canopy. We estimate that at least 58 species of *Agrilus* must occur in the San Lorenzo forest. These results emphasize that (a) the *Agrilus* fauna is very poorly known in Panama; (b) that this fauna appears to be richer in the understorey than in the upper canopy; and (c) that tree-fall gaps are important for the maintenance of local diversity.

15:20 Gall species distribution in contrasting canopy types in a tropical rainforest

S. Ribeiro
Universidade Federal de Ouro Preto

The present protocol explores canopy versus understorey vegetation and habitat structure, and herbivory/galling insect data. All galls were counted and measured, and data entry for vegetation sample is finished. 2004 data needs analyses, but general figures are already available. Some plant data won't be trivial to analyse, and causa mortis for galls are not easy to identify. Final analyses may be finish by August/September.
Using the "canopy/understorey cylinder" method, a specific forest volume could be quantified and compared. Understorey had in average 7.3 times more plant individuals than the canopy, but the canopy presented 8.5 times more leaves in this same volume, in average for all studied sites. Site B1 understorey had the greatest leaf area index (nearly double than the average, and 6 times greater than C3, the least dense understorey). Similarly, the leaf area index for B1 canopy was the greatest, being 2.3 times greater than the average, and 2.7 times greater than the raft site, the least dense canopy.
Data support the hypothesis that gall-forming insect population distribution and survivorship is highly correlated to sampling height within the forest: there are more galls in high branches (multiple linear regression, $F_{2,27}=6.9$, $p < 0.02$), which also had the most sclerophyllous leaves in the whole forest (simple linear regression, $F_{1,28}=7.09$, $p < 0.01$). Galls in the understorey had greater mortality rates than in the canopy. Nevertheless, high infestation was detected only on saplings of canopy tree species. Host tree effect is important but needs further analyses at this stage.
Sclerophylly has been proposed as an important mechanism in favour of gall-forming survivorship, and the present data comes in support of this hypothesis. In addition, sclerophylly could prevent free-feeding herbivores (chewing) activity, which could also be an auxiliary mechanism in favour of gall forming oviposition site choice, based on finding harsh habitats, where sclerophyllous leaves will prevail. Accordingly, herbivory rates were significantly higher in the understorey plants, consistently across all sites, and regardless the significantly smaller amount of resources in this forest habitat (ANOVA mixed model, $F_{5,237}=3.0$, $p<0.01$). Furthermore, herbivory rates

decreased significantly in the canopy with sample height (simple linear regression, $F_{1,247}=33.4$, $p < 0.001$).
The present work may change the perception of ecophysiological patterns along canopy vertical gradients, and the proper methods to study such habitat. Within-plant traits may be as much or more relevant for insect herbivore distribution than micro-climatic conditions. In addition, data calls for more studies on the highly specialists endophagous insects.

15:40 Other IBISCA programmes: wood rearing, beating, microarthropods and focal taxa
Cizek, Barrios, Winchester & **Jordan**; presented by **Basset**

4. Interactions between organisms

16:00 Trophic interactions among tropical organisms
O. Lewis
Institution (s) University of Oxford

Tropical insect herbivores, their host plants and their predators and parasitoids account for the vast majority of the earth's biodiversity. Studying trophic (feeding) interactions among these species in diverse tropical ecosystems creates special challenges, but has the potential to further our understanding of the processes structuring and maintaining patterns of diversity and abundance. I will briefly review approaches used to study plant-herbivore and herbivore-parasitoid interactions in tropical forests, and describe the use of food webs to quantify interactions across multiple trophic levels. Such studies allow us, for the first time, to make robust and testable predictions about the implications of adding or removing species from ecological communities. I will consider how IBISCA data might contribute to ongoing work on trophic interactions, and how data on tropical insects might in future be collected to maximise its value to the study of trophic interactions.

16:20 The IBISCA social insects programme: ants
J. Orivel, M. Leponce, J. Delabie, B. Corbara, Y. Roisin, I. Cardoso do Nascimento, S. Ribeiro, R. Campos, J. Schmidl; A. Floren & A. Dejean.

16:40 Distribution of termites from the ground to the canopy of a Panamanian rainforest
Y. Roisin[1], A. Dejean[2], B. Corbara[3], J. Orivel[2], M. Leponce[4]
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Termites are inhabitants of warm temperate or tropical ecosystems.

Numerous studies focusing on fallen logs, leaf litter or humus have established their importance as decomposers at ground level, but almost no attention has been paid to their presence in the upper strata of tropical forests. Within the framework of the IBISCA project in the San Lorenzo Protected Area (Panama), we conducted the first systematic sampling campaign to evaluate the diversity and richness of a termite fauna, from the ground to the canopy. Dead wood or termite-built covered runways were examined on a total of 125 trees along two transects, whereas quadrats provided samples of the ground fauna at the same sites, for comparative purposes. Canopy collections (here defined as higher than 10 m above ground) yielded 63 occurrences (colony samples) representing 10 termite species, whereas 29 species were recorded in 243 occurrences from the ground. Five species were recorded in both habitats. Species accumulation curves revealed that the inventory of canopy species was near completion, whereas ground species were still accumulating in a logarithmic pattern. Remarkable components of the canopy fauna include several drywood species (Kalotermitidae), forming small colonies within dead branches or stumps. By contrast, soil feeders were exclusively found in ground samples, where they were abundant (19 species, 110 occurrences). Wood feeders displayed a similar species richness at both levels, although most species showed a clear preference for either ground or canopy. Further data still to be analyzed include: 5 ground transects (> 350 series) in other sites of the same forest, to evaluate Beta-diversity; 27 series of additional hand-collected canopy samples; 78 series of non-flying termites collected by standardized sampling methods (Berlese, Winkler, pitfalls, etc.); and > 370 samples of flying termites (alates) collected by light or flight interception traps, yet to be identified. Put together, those data should provide an integrated picture of the termite fauna of this forest, including vertical and horizontal richness and distribution patterns.

17:00 Euglossine and meliponine bees diversity and abundance on the ground and in the canopy.

D. Frame & Roubik D.
STRI and Herbarium, Insitut de Botanique, Univ. de Montpellier II

As part of the IBISCA project, we surveyed euglossine and melipoinine bee diversity and abundance on the ground and in the canopy. I will present a description of the protocol we used to sample these bees and our sampling results. The data was analyzed using a similarity index, the so-called Morsita Horn Index. The aim of this presentation is to provide a basis for discussion of how to best integrate the bee results into the overall IBISCA framework and data analysis.

5. Integration for the sessions of the day

17:20 Beta diversity (led by **Delabie** & **Novotny**)

17:40 Vertical gradients (led by **Didham** & **Kitching**)

18:00 Tropical interactions (led by **Lewis & Orivel**)

Thursday 7 July 2005

Survey and analyses of mega-biodiversity distribution in the tropics: pitfalls and remedies

08:30 What can adaptation at range margins tell us about the evolution of biodiversity and the scale of ecological interactions?

J. Bridle
Institute of Zoology, ZSL, London NW1 4RY

A central question in population genetics concerns what limits evolutionary responses to ecological change. Traditionally this issue has been considered in terms of adaptation to a single selective dimension, based on a balance between natural selection and migration between populations along a spatial gradient. In the long term, the way that populations can track changing conditions in time determines the generation and maintenance of diversity (speciation), and therefore the degree of specialisation and complexity observed in natural communities. I will discuss some of the evolutionary factors they may constrain the niche width of species, and discuss how the selective gradient might be extended to measure the selective gradient in terms of ecological interactions between and within species, in addition to the effects of gene flow within species.

08:50 Implementing large-scale surveys and experiments in the tropics

T. Roslin
Metapopulation Research Group,Department of Biological and Environmental Sciences
PO Box 65 (Viikinkaari 1),FI-00014 University of Helsinki, Finland

How can we identify the processes behind the megadiversity that this workshop focuses on? In my talk, I will try to identify some broad types of approaches to experiments and surveys of arthropod communities in the tropical forest. As a population biologist, I will focus less on studies on mere species richness, and more on studies attempting to combine information on individual species and their habits with patterns of species diversity. And as a temperate biologist, I will borrow freely from studies conducted by others. In particular, I will examine the role of 'model systems', as compared to a more even focus on a larger set of species and/or sites. Overall, I will claim that flagship projects such as IBISCA are urgently needed to increase the public appeal, credibility and competitiveness of biodiversity research, but that results from single locations must eventually be validated by studies conducted at a broader range of sites. I will also contend that as far as the circumstances permit, work at the community level should be linked to an assessment of species-specific ecology and population-level processes. I will try to illustrate the (partial) feasibility of (some of) these claims by a recent project on the dung beetles of Madagascar.

09:20 Taxonomic impediment

L. Sørensen
The Natural History Museum of Denmark , University of Copenhagen, Denmark

The taxonomic impediment comprises two components, one spatial

and one temporal. The first of these is that the majority of the world's biodiversity is confined to the tropics, while most taxonomic capacity is found in the "developed" world. The second is that taxonomic capacity is decreasing, while the need for taxonomic information is increasing. This taxonomic impediment has stimulated ongoing discussions and initiatives to ameliorate the problem, such as digitizing museum collections, DNA "bar coding" of species, biodiversity megadatabases. How will these initiatives help when taxonomic capacity is so limited and knowledge of fauna and flora so incomplete for most of the biodiverse tropical countries. Will we have to wait until all species are described? What are the ways forward and are there any shortcuts? This paper gives an overview of possible strategies and tools to reduce the problems arising from the taxonomic impediment

09:40 Working with parataxonomists
O. Missa

Parataxonomists are typically local people with no formal education in biology, who stand "at the side" of professional taxonomists and biologists and help them in the acquisition of biological information. In the past, the parataxonomist's role has often been limited to helping biologists collect samples in the field. More recently, however, parataxonomist activities have expanded to include sorting (at a variety of levels from families to morpho-species), databasing, preparing specimen and even digital imaging. Given the proper training and feedback there are few repetitive tasks that parataxonomists could not perform reliably for professional biologists. Although involving parataxonomists in a biodiversity inventory can be very productive, it is also paved with potential pitfalls. A strategy must therefore be put in place to guarantee that data quality is high and remains constant throughout a project. I conclude this short talk by presenting my own personal views on how to involve parataxonomists with maximum efficiency in a project like IBISCA.

10:30 The IBISCA database
M. Leponce & Y. Basset

The IBISCA database currently contents more than 50,000 records including 400,000 specimens classified into 2,189 taxa (species or higher level). Taxa already identified up to species level are principally: Coleoptera (Anthribidae, Carabidae, Cerambycidae, Chrysomelidae, Curculionidae, Scarabaeidae, Scydmaenidae), Hemiptera (Achilidae, Cicadellidae, Cixiidae, Delphacidae, Derbidae, Flatidae, Issidae, Membracidae, Psyllidae), Hymenoptera (Apidae, Formicidae), Isoptera and Lepidoptera (Arctiidae, Geometridae, Pyralidae).

10:50 Characterizing community diversity in species rich systems – statistical pitfalls, remedies, and insights from a phylogenetic perspective.
O. Hardy
Eco-éthologie Evolutive. Université Libre de Bruxelles.

Assessing species diversity of rich communities is a difficult task due to the numerous sources of biases that can occur when collecting data and when analyzing them. I will overview the common pitfalls and discuss some remedies, essentially from a statistical point of view (which estimators to choose). Some links between diversity coefficients and neutral community models will be mentioned. I will show the potential interest of partitioning diversity coefficients into alpha and beta components (within versus among sites, sampling units, local habitats,…) for inferential purposes. I will also illustrate the potential insights that can be obtained by integrating phylogenetic information into the analysis of community structure. Finally, I will try to demonstrate that all this can be overviewed in 15 minutes.

11:10 Meta data and multivariate analyses of large datasets

M. Dufrêne
Centre de Recherche de la Nature, des Forêts et du Bois, Ministère de la Région wallonne, Gembloux

Broad species inventories produce huge datasets with many information on species presence or frequencies in numerous samples. The identification of main biological structures or ecological relationships can be then quite difficult. In such a situation multivariate analyses aim 1) to summarize main biological or ecological structures or 2) to reveal relationship between ecological factors and biological structure.

All data matrix where rows are samples and columns are biological descriptor (as species abundance), ecological factor (as environmental factor values) or metadata (as species number or life history features) can be visualized in a graphical way, using columns as coordinate axes where samples are projected in function of their column values. All samples form then a cloud of point-objects that can have peculiar structure, revealing strong gradients (when descriptors are well correlated) or aggregated sub-clouds or clusters (when only several samples share the same descriptor combination) or a combination of gradients and clusters or no structure at all. To reveal main gradients, the sample cloud is swivelled on its barycentre to be viewed to maximize its larger lengths (= its variance) : samples are then projected in a new coordinate system with the first main axes pointing to the larger lengths and where these axes are simply a linear combination of the original descriptors. On these main axes, the rank or the ordination of samples allow to identify those that are the most different and located at the extremes of the gradients. Classical descriptive methods for extracting main gradients are *Principal Components Analysis* (matrix of ecological descriptors, linear relationship), *Correspondence Analysis* (matrix of species frequencies, unimodal distribution) and *Principal Coordinate Analysis* (based on any metric distance matrix). For cluster approach, a large diversity of similarity indices and cluster methods (hierarchical or not) exist and it is important to choose those corresponding to descriptor properties (value distribution, ordinal or not, ...). Gradient and cluster analyses are really two complementary ways to describe a data matrix structure because the first one privileges great distances between samples then the second reveals strong similarities among samples.

The interpretation of biological or ecological structure revealed by ordination analyses can be done respectively with simple *correlation* between the sample rank on main axes and other independent descriptors that have not been included on the ordination analysis. By example, one can revealed the main biological gradient opposing samples on the basis of species frequencies with a *CA* on a samples/species abundance dataset (what are the samples that are the most different when we use a species abundance list ?). Such true species gradient can be after correlated with several ecological descriptors or their combination (*multiple regression*) to identify what could be the responsible main limiting ecological factors or the ecological factors that explain the ecological niche partitioning. For sample clusters, simple classical *Anova* (one independent factor at the same time) or better *discriminant analyses* (to identify a combination of independent factors) are often sufficient. One classical example is the identification of ecological factors that explains sample clusters obtained after the realization of an *UPGMA* or *Ward clustering method* on a *Steinhaus* or *Bray-Curtis similarity* matrix computed on a samples/species abundance dataset. A peculiar case of sample cluster interpretation is the identification of indicator species, i.e. species that can be almost systematically associated to groups of samples. *Twinspan* and *IndVal* approaches are two methods largely used to solve this problem.

In all the cases listed above, the aim is to explain one depend variable (the position on a gradient or the membership to a sample group) by one or a combination of explaining factors. Such approaches are generally called *indirect (gradient* or *cluster) analyses*; the main biological or ecological structure are identified and after, one searches to interpret it. Recent developments of different techniques allow now a *direct (gradient) analyses*, i.e. the explanation of a collection of depend variables by a combination of explaining factors. One of the most known technique is the *Canonical Correspondence Analysis* where the *CA* axes (privileging unimodal response between species and ecological factors) obtained on a samples/species abundance dataset are constrained and modified to be also the better linear combination of available ecological factors. In such case, the main axes of the sample cloud are not defined by the most extreme species but by the most extreme species that can be explained by a linear combination of available ecological factors. The quality of the ecological response is maximized but it depends on the quality of the species dataset and also, on the quality of the ecological factor dataset. Similar approaches exist for linear relationship between dependent and independent variables (*Redundancy Analysis*) or between similarity matrix (*Mantel test*) or between dendrograms (*consensus indices*). *RA* is by example an interesting way to identify relationship between several expressions of species number (guilds, families, life history features, ...) and ecological variables describing the environment of samples. A key characteristic of such approaches is the possibility to measure the relation between two datasets independently of a third one (i.e. partial relation), to control by example spatial autocorrelation or a sampling structure (covariable dataset). In some case, this will allow a quite complete partitioning of the dataset variance (% explained by some kind of factors, by spatial location, by sampling structure, ...).

In spite of their strong capacity to clarify the biological and ecological structures, these multivariate methods depend crucially on the quality of the experimental protocols and thus of the formulation of the starting assumptions. The power of the methods is expressed as well as possible only when the questions are clear and that the experimental protocols or of inventories were conceived to answer it positively or negatively. Such approaches cannot correct datasets obtained with protocols not well structured. Too often, the ratio between number of samples and explaining factors is far to be sufficient. It should be greater than 3 and better when there are10 times more samples than explaining factors.

11:30 Funding large scale biodiversity projects in the tropics
Mitchell

List of Participants

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