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

ESF LESC EXPLORATORY WORKSHOP

The Last Biotic Frontier: Towards a Census of Canopy Life

Scientific Report

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

Convened by:
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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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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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1. Executive summary

A three-day workshop was organized at the Royal Belgian Institute of Natural Sciences, Brussels, 6-8 July 2005, with financial support from the European Science Foundation and United Nations Environment Programme (`www.naturalsciences.be/cb/ants/meetings/esf_exploratory_workshop.htm`). The workshop focused on the international project **IBISCA** (Investigating the BIodiversity of Soil and Canopy Arthopods; public site at `www.naturalsciences.be/cb/ants /projects/ibisca_main.htm`). 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 canopy life**'. The workshop consisted of 30 presentations and plenary and group discussions.

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 1,080 species. We estimate that the final product should shed light on the spatial and seasonal distribution of about half a million of specimens and several thousands of species, distributed among ca 60 focal groups of different phylogeny and ecology. This database has currently 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, with different pace. 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 at that time 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.

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 6 scientific articles and 13 magazine articles. We expect that most of IBISCA results should be disseminated during 2006-2008 (multi-authored research papers, high-profile collective article in a leading journal, collective book, etc.).

Towards a census of canopy life. The 'IBISCA' brand should be retained as it is valuable and should be used in further projects. The IBISCA research group (ca 80 scientists) should also get organized into a non-profit association. The most pressing priority of the organization would be rising funding as to quickly complete the IBISCA-Panama project. Future priorities would be, among others, to persist with the IBISCA-approach beyond the Panama project and to join new biodiversity-related projects, detailed in the text. 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 geological and evolutionary questions. An ambitious project such as a 'census of canopy life' should be implemented in three incremental steps: (1) organize formally the collective group of experts known as 'IBISCA' and provide this group with substantial funding; (2) initiate IBISCA-style projects and pilot studies at different locations worldwide and refine the different protocols used in these projects and studies; (3) Develop an aggressive programme aiming at censuing canopy life at key locations in the tropics, based on lessons learn previously. To our knowledge, there are no other alternatives to the above steps if the scientific community is serious about cataloguing canopy arthropods before habitat loss and global climate change extinguish most of this mega-biodiversity.

2. Scientific content

The three-day workshop (6-8 July 2005) was attended by 37 scientists from 16 countries. The aims were threefold (hereafter Aims 1-3):

1) to summarize what has been learned from the IBISCA project overall;
2) to plan meta-data analyses and the dissemination of this novel and important information;
3) 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 canopy life' modeled after the lessons learned from IBISCA.

The participants reviewed progresses and impediments of the IBISCA project (Aim 1) during one day and a half, further discussed analyses, dissemination and future projects (Aims 2 & 3) during another day and a half. The workshop consisted of 30 presentations (20 min. each, all available on a CD forwarded to each participant) and plenary and group discussions. Four working groups were established:

- **Gr. 1: IBISCA: a common framework for data analysis**: led by Hardy & Lewinsohn, including Dufrêne, Missa, Leponce, Ribeiro & Roslin.
- **Gr. 2: IBISCA: taxonomy and interactions between organisms**: led by Roisin, including Aberlenc, Cornejo, Curletti, Delabie, Schmidl, Sorensen, Samaniego & Springate.
- **Gr. 3: IBISCA: arthropod distribution patterns**: led by Didham, including Bail, Basset, Bito, Floren, Frame, Ødegaard, & Ozanne.
- **Gr. 4: Towards a census of canopy life**: led by Kitching & Mitchell, including Bridle, Corbara, Cuénoud, Lewis, Fagan, Medianero, Novotny, Oliveira, Pascal & Van Osselaer.

Each working group made recommendations relevant to one or several of the aims of the workshop. In the following section, these recommendations are summarized with regard to the three aims of the workshop.

3. Results and future directions

1. Aim 1: What has been learned from IBISCA?

1.1. Databasing. As of 14 March 2005, the IBISCA database which summarizes horizontal (beta diversity), vertical (vertical stratification) and seasonal distribution of arthropods in the San Lorenzo forest included 85 contributors (ecologists and taxonomists), 14 sampling programmes, 7,233 samples, 422,217 specimens and 1,080 species. We estimate that the final product should shed light on the spatial and seasonal distribution of about half a million of specimens and several thousands of species, distributed among ca 60 focal groups of different phylogeny and ecology.

1.2. Sampling programmes. The IBISCA project consisted of 15 arthropod sampling programme and one vegetation census at all studied sites in the San Lorenzo forest (n=12, one site = 20mx20m). One sampling programme was aborted (butterfly traps) and another one has been re-started in 2005 (rearing of saproxylophagous insects). The results of other sampling programmes are progressively being databased, but with different pace.

1.3. Return of information in the database. So far, Malaise traps, fogging, sticky, light and flight-intercept traps have produced most of the specimens databased, while the number of species databased has been highest for light traps (faster return of information in the database). The vegetation and bee programmes can be considered as being completed, while the results of ground flight-intercept traps and Berlese will be much slower to return to the database, for example.

1.4. Taxonomic analyses. 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, with different pace (example: Apoidea fast, Staphylinidae slow). Identifications, when possible, will be much slower. At present, the proportion of morphospecies identified at the species level varies widely (0%: many groups; 25%: Tenebrionidae; 82%: Arctiidae; 100%: Euglossinae and Meliponinae). We expect that databasing of most IBISCA-related information could be completed by June 2006, and that participants will be able at that time to analyze collectively their major findings and report them in a leading scientific journal.

1.5. Positive aspects. The positive aspects of the IBISCA project were in order of decreasing importance (as reflected in the number of opinions voiced by participants): great team spirit, exposure to other colleagues and methods, the integrative nature of the project, and, more distantly, the good logistics of the project.

1.6. Bottlenecks and problems. The most cited impediments were as follows:
a) in the field: a1 - pre-sorting of the material could have been better organized, a2 - travel from laboratory to field time-consuming/tedious;
b) processing of the material: b1 - lack of time, b2 - lack of funding, b3 - high number of samples and specimens, b4 - label information difficult to match or lost, b5 - quality of insect material low, and b6 - high number of juvenile (inadequate for taxonomy) in the samples;
c) taxonomic analyses: c1 - taxonomic knowledge/literature of the Neotropical fauna poor/outdated, c2 - lack of funding to visit collections.

1.7. Remedies to these problems. Problems related to items a1, b1, b3, b4 and b5 above could be eased by working with local parataxonomists trained beforehand to sort and process focal groups. Additional funding would ease problems related to items b2 and c2. Further projects should pay attention to item a2, while items b6 (bar-coding a possible remedy, costs very high) and c1 have no immediate, straightforward solutions.

Items 1.8 to 1.11 represent a selection of preliminary results that should be confirmed by rigorous analyses, as agreed by the IBISCA team (item 2.3.1).

1.8. New species. Many species collected during the IBISCA project are new to science and will be described in due course (Oribatida, Milichiidae, etc.). This often includes specimens originating from the upper canopy, but not always. New species may often be cryptic, for example the many species of Anobiidae collected by fogging.

1.9. Beta diversity. Despite the short distance between study sites (< 2km), different sampling methods (Malaise, sticky and flight-intercept traps, fogging, etc.) indicate that arthropod abundance/activity differ greatly between sites. The meaning of this observation is yet obscure, but it may be related to difference in forest productivity, as there appears, for example, to have a positive correlation between arthropod abundance and the Normalized Difference Vegetation Index, as estimated from Landsat pictures (Malaise trap data, Fig. 1). These differences may be stable since fogging data suggest that arthropod recolonization after fogging takes place immediately and re-establish a stable rank order and dominance structure.

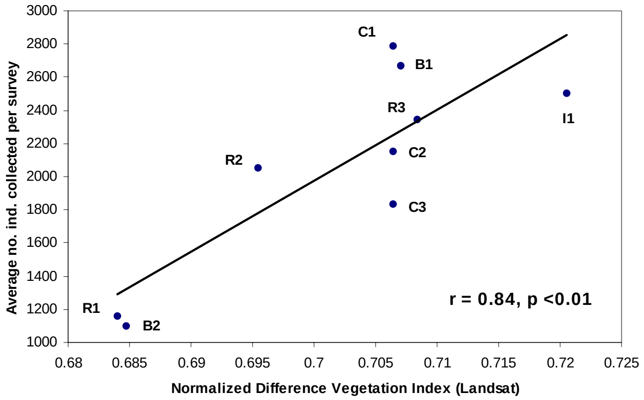

Fig.1. Relationship between the average no. of arthropods collected at each site with Malaise traps and forest productivity, as estimated by the Normalized Difference Vegetation index.

1.10. Vertical stratification. Several sampling programmes (light, sticky and flight-intercept traps, beating, notably) suggest rather low faunal overlap along the vertical profile of the forest. This is apparent not only at the species level, but also for higher taxa. For example, the higher taxonomic composition of flight-intercept traps varies much more markedly between vertical heights than horizontally between sites. Arthropod activity follows a bimodal distribution, with greatest activity near the ground and in the upper canopy (flight-intercept and sticky traps, Fig. 2). Patterns of stratification differ among taxonomical and ecological groups, with some ground- or canopy-dominant groups. For example, buprestids of the genus Agrilus, Derbidae, Formicidae, Isoptera, Euglossinae, Oribatida appears more abundant or species-rich near ground, whereas active leaf-galls, Psylloidea, Kalotermitidae, Meliponinae are more abundant/species-rich in the canopy/upper canopy.

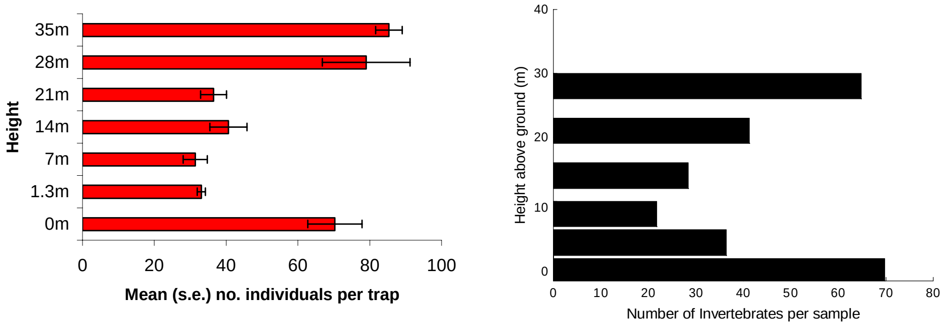

Fig.2. Number of arthropods collected at different heights with sticky (left) and flight-intercept traps (right).

1.11. Seasonality. Fogging data appear to emphasize the important role of yearly variation in rainfall on arthropod abundance at San Lorenzo.

1.12. Further analyses. Calculating robust statistics to infer sound arthropod distribution is a challenge, since sample size differs among sampling methods, sites and habitats (soil, understrorey, mid-canopy, upper canopy).

2. Aim 2: Analyses and dissemination of IBISCA results

2.1. Completion of the IBISCA-Panama project

A certain number of steps are needed to complete the IBISCA-Panama project, so that the questions listed in section 2.2 may be optimally answered. Funds should be raised to this end (item 3.6).

2.1.1. Additional field work. Ideally, the following field studies should be completed in the field in Panama (but perhaps use available data as a guide to simplify field work):

(a) measure gradient of disturbance at the sites (e.g., distance to edge, etc.);
(b) assess soil typology and slope;
(c) complete canopy pin point studies for 4 sites not surveyed during 2003-2004 (Ribeiro).
(d) conduct complementary studies (e.g. ant mosaic)

2.1.2. Taxonomical analyses and specimen databasing. Funds should be raised to:

(a) speed up the processing and morphotyping of specimens (Oribatida, Hymenoptera Parasitica; ants, etc.);
(b) speed up databasing of specimens (e.g. Ødegaard's beetle focal taxa);
(c) visit insect collections (Braconidae: Texas; Curculionoidea+Auchenorrhyncha: InBio in San José, etc.);
(d) expand the range of focal taxa (e.g., Collembola).

2.1.3. Processing of ecological variables. All hemispherical digital pictures should be processed to get estimates of canopy openness for the different study sites, and at the different heights sampled (Basset). The acquisition and processing of new remote sensing data (Chust?), with higher resolution pictures than Landsat ones (Ribeiro) may be important to assess forest productivity (Normalized Difference Vegetation Index) at the study sites and possible differences in floral and faunal composition.

2.1.4. Database. A certain number of improvements will be needed for the IBISCA database:

(a) determine which plant specimens are located in the understorey/mid-canopy/upper canopy on the basis of regression equations between DBH and height, and calibration in the field (Basset);
(b) manage better the field 'height' (merge some heights) and have a clear definition of 'habitats' or 'strata' so that we know what are the common heights (strata) across methods;
(c) add meteorological and phenological (tree) data in the database (Basset/Wright);
(d) propose other ways of expressing arthropod dispersal (e.g. geography, distance) and add such a field in the database;
(e) add the fields 'habitat specificity' and 'host specificity' for each species;

(f) measurement of body size and digitized pictures for each morphospecies (item 2.4.3);
(g) clean-up of the database (Leponce/Basset);
(h) implementation of statistical modules (item 2.3.1).

2.1.5. Guild systems for ecological analysis. Group 2 emphasized that guild systems are essential for structure-, community- and function-related analyses. The extraction of a guild system derived from collected (field) data is better than a theoretical system alone. Schmidl & Springate will prepare a survey sheet and send it to the IBISCA team. Each participant should propose guilds, elements, functions to analyse her/his data appropriately. Schmidl & Springate will compile and implement (after overall agreement from the team) the guild system in the database. Eventually, participants will assign their species/groups to the designated guilds in the database. For comparisons with other studies, the system of arboreal guilds of Moran & Southwood may be retained as a distinct field in the database.

2.1.6. Web site. Ideally, a single IBISCA web site should be implemented (currently two sites are active, one public, one password-protected). This site should include items related to the IBISCA association (item 3.1); the IBISCA database, media reports and scientific articles, etc. Access to different web pages should be either public or password-protected, depending on the sensitivity of the information. As far as possible, the web site should also include digitized pictures of all IBISCA morphospecies (item 2.4.3). It should display a number of important links, especially taxonomic links and funding sources. A person should be hired to develop the interface, manage the web site and the correspondence associated to it (funds needed).

2.2. Analyses of the IBISCA results – questions and hypotheses

Group 3 discussed more particularly the questions that IBISCA needs to address from the viewpoint of arthropod distribution (items 2.2.1-2.2.6).

2.2.1. Key questions. Group 3 recommended asking the two following key questions that will optimize the use of information included in the IBISCA dataset:

- 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?

- 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?

2.2.2. Partitioning spatial and temporal components of diversity. See item 2.3.7 (Group 1) for quantifying variance due to beta-diversity and vertical stratification. For the purposes of defining the ‘groups/units’ among which to partition components of diversity, we have 3 major spatio-temporal ‘axes’ of interest:

- spatial turnover among sites
- vertical stratification
- temporal variation among sampling replications

We need to quantify these gradients with ecological variables, NOT with arbitrary categories, and we need to identify who is going to lead or help with analyses in these three areas.

2.2.3. Examples. A replication number currently defines temporal variation. It could be better defined by the amount of rainfall during sampling periods (Fig. 3):

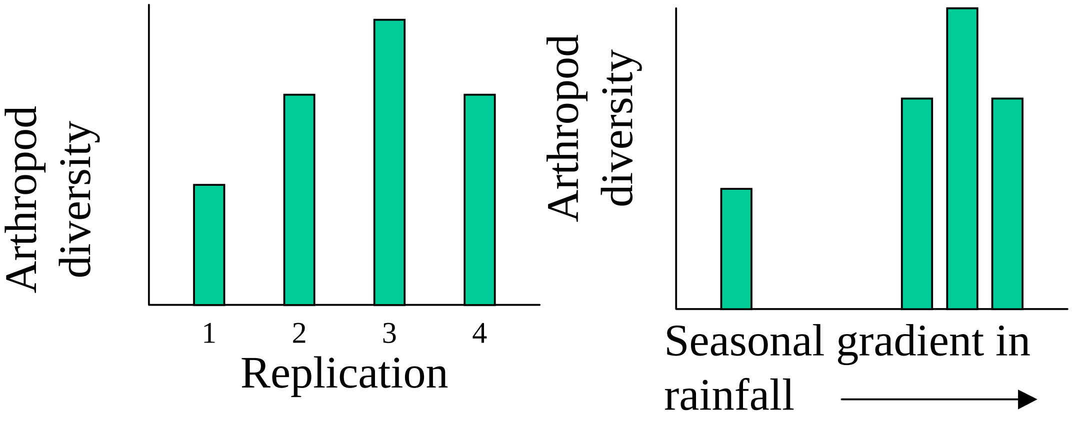

Fig.3. Hypothetical relations between arthropod diversity and a gradient of temporal variation..

Another example: vertical stratification: we should abandon height as a surrogate for vertical stratification.. Instead, we should measure the direct biotic and abiotic factors to which species respond (e.g., light, canopy openness, see below). If strata must be delimited, define them as segments of continuous gradients (Didham presentation).

2.2.4. Potential variables to quantify each gradient:

Spatial turnover among sites	▪ Differences in floristic composition ▪ Plant-related variables, e.g., basal area ▪ NDVI (remote sensing) ▪ Spatial location / distance between sites
Vertical stratification	▪ Light (limited data) ▪ Canopy openness (crucial to analyze) ▪ Leaf area index (Ribeiro - only 5 sites)
Temporal variation among sampling replications	▪ Rainfall ▪ Temperature ▪ Tree phenology (flowering, seeding at crane sites)

Hence, arthropod distribution patterns may be predicted from the set of variables measured at each IBISCA site: floristic composition, canopy openness, basal area, etc.

2.2.5. The biological values of singletons and how to deal with them. Although it is obvious that nothing can be said about the life history or biology of singletons (rare species), we should not exclude them from ordination analyses. Ideally, we should:

- analyze proportions of singletons in relation to the three ecological gradients;
- quantify the reasons why some species appear to be singletons at certain times/places;
- use other data collected on host specificity at the San Lorenzo crane (Ødegaard, Barrios, Basset, etc.) to interpret why some species are singletons in the IBISCA dataset.

2.2.6. Possible interesting extensions of IBISCA data. The predictive or applied value of IBISCA data could be emphasized to ask the following question:

What are the implications for conservation of spatial and temporal partitioning of arthropod communities, with respect to biodiversity loss resulting from logging (canopy openness), land use, or climate change?

Data should relate to focal taxa, feeding groups (guild structure), patchiness of forest processes, etc.

Group 2 discussed more particularly the questions that IBISCA needs to address from the viewpoint of taxonomy and interactions between species (items 2.2.7-2.2.10).

2.2.7. Comparison and complementarity of sampling techniques. Group 2 recommended that each participant should screen his/her material for efficiency of methods in the collection of his/her focal taxa, in terms of ecological & taxonomical questions. Ideally, this should be compiled as a chapter in the collective IBISCA book planned (item 2.4.5), with an emphasis on:

- selecting focal taxa for different assessments;
- selecting methods for sampling these focal taxa;
- presenting a manual for optimal sampling protocol(s) in future projects.

This chapter should aim at answering how similar are trapping methods and what is their complementarity (could use Chi-square approach in order to compare methods, item 2.3.8).

2.2.8. Interactions between organisms. Group 2 pondered whether it was possible to infer species interactions from distribution patterns in the dataset, by screeening it for correlations of species and guilds. It was thought that, with the exception of a few studies (Ribeiro: galls and plants; Tishechkin: Nitidulidae in ant's nests; Dejean *et al.*: ants and plants), interaction data were not measured directly. Since this was not within the aims and scope of IBISCA, the group recommended not to spend too much time on this topic.

2.2.9. Ant mosaics. Group 2 similarly discussed whether ant mosaics exist in the San Lorenzo forest and whether they have an impact on arthropod distribution. This is a complicated search for patterns: e.g. do patches with ant nests support smaller numbers of arthropods (except ants)? It was not clear whether there are enough data and whether it will be possible to extract this information by linking datasets (statistical/mathematical approach). However, given that the majority of IBISCA participant feel that this is an important subject, it may be worth to invest more time on this topic than on item 2.2.8.

2.2.10. Undescribed species. Group 2 was interested to discuss the ratio between described/undescribed species and its bearing on global estimates of biodiversity. These ratios are highly taxon dependent and sound proportions cannot be estimated after thorough taxonomic revisions of the material. If this happens at all, this is unlikely to be within a timeframe of 10 years or more. It was thought that this taxonomic impediment can only be met in part by barcoding, which appears not very realistic or practical for this end. Hence, this topic should not be of high priority to the IBISCA team.

In addition to the topics discussed in more details by Groups 2 and 3, there were other items that the IBISCA participants collectively thought were important (items 2.2.11and 2.2.12).

2.2.11. General questions to answer:

- How to standardise measurements?
- Will patterns change based on the chosen standardisation?
- How much species turnover is there?

- How many species are there in the San Lorenzo forest?
- What is the rate of species addition when vertical strata are added to the ground data?
- What is the magnitude of reported patterns for vertical stratification?
- What is the top of the canopy?
- Is light a surrogate indicator for measuring biodiversity?
- Is there a control treatment for IBISCA?
- Do we agree on spatial beta diversity across all 9 sites or a nested analysis with heterogeneity across sites?

2.2.12. Further ideas/questions to consider:

- Make an effort to consider questions regarding taxonomic aspects. For example: write a taxonomic paper to detail how long it takes to identify specimens to a suitable resolution for such a large project and costs involved, etc.
- Do a comparison between insects within guilds to separate the effects of competition (metadata analysis).
- Use the IBISCA taxonomy to build an arthropod phylogeny. Locate the nearest genetic distance for each species from GenBank to produce an overall paper.
- For a general paper that will detail the species richness of focal taxa and turnover among 9 sites: how unique are species to sites, habitats (canopy/understorey) and seasonal components? What are the striking differences among taxa?
- Provide questions on specialisation (canopy vs. ground), processes, herbivory, edges, climate.

2.3. Analyses of the IBISCA results – statistical considerations

2.3.1. Working group 1. This group will implement a common set of statistical analyses (on the IBISCA web site) that will allow the IBISCA group to report collectively their results in a leading scientific journal around mid-2006. The recommendations of working groups 2 and 3 will be used to perform key analyses for this article. Group 1 should communicate with other IBISCA participants via the IBISCA web site. Ideally, funding should be raised so that this group could meet very soon in Brussels, where the majority of group participants reside.

2.3.2. Species accumulation curves. They will constitute the basis of many analyses and should be computed across taxa, sites and habitats.

2.3.3. Steps for analyses. Group 1 suggested:

1. Defining first the basic units of sampling (4 dimensions: sampling methods; habitats (understorey/upper canopy); time (replications); and space: horizontal, study sites).
2. To consider the description of the sampling (its intensity and ecological variables associated), in order to appreciate the ecological distribution (e.g. linked to plant distribution) vs. spatial distribution.

3. To ask what is the biodiversity of the San Lorenzo forest and use descriptive statistics of sampling results.
4. To consider the sampling efficiency and evaluate methods (or combination of methods) for future projects.
5. To characterize diversity patterns.
6. To explain species assemblages.

2.3.4. Example. For a summary paper on diversity patterns in canopy vs. lower layers, Group 1 recommended:

1. To reduce the complexity of the sampling. This would include to analyze separately 1 focal taxon collected with one sampling technique, keep one season (September-October 2003), and keep only data relevant to canopy and lower layer (understorey, ground). However, this suggestion was not well received by all participants, some fearing loss of information.
2. To describe the samples, using a raw characterization of the number of species and individuals, per taxon-technique-stratum.
3. To perform statistical analyzes, including diversity comparisons, diversity partitioning, and comparison of horizontal and vertical turnover (items 2.3.5-2.3.7).

2.3.5. Diversity comparisons. First, calculate rarefaction curves for all samples per basic unit, canopy vs. lower layer (comparison per sampling unit and/or individual). Second, compare Fisher’s alpha, and Simpson’ diversity. Procedure: extract the data from database and use the software EstimateS.

2.3.6. Diversity partitioning. Either the species richness or Simpson’s diversity could be partitioned between two factors: vertical effects (canopy vs. lower) and horizontal effects (5-9 study sites). Thus, total diversity may consist of alpha diversity (within sample units), horizontal beta diversity, and vertical beta diversity (Fig. 4). The interaction between horizontal and vertical beta diversity is of special interest. Procedure: check within software PRIMER.

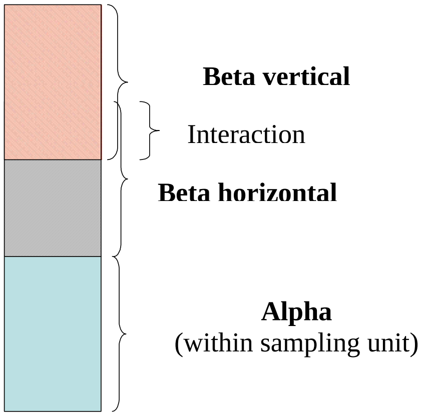

Fig.4. Partitioning of species richness or diversity with relevance to IBISCA data..

2.3.7. Comparison of horizontal and vertical turnover. Consider the pairwise similarity coefficient between sampling units [Morisita-Horn (= NESS(1) or NESS (100?)]. Plot this similarity vs. the spatial distance (or log (distance)) (Fig. 5).

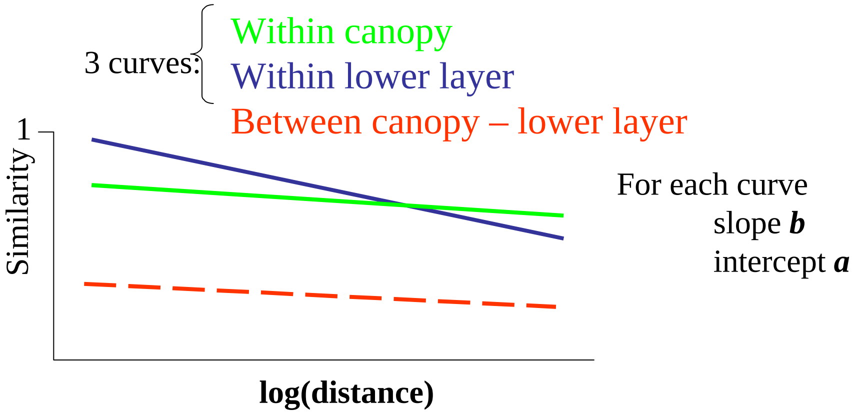

Fig.5. Plot of faunal similarity against distance for different situations.

Procedures: Morisita-Horn is calculated with EstimateS, NESS (100) with COMPAH96. Regressions and Mantel tests can be calculated in Excel and PC-ORD. ANOVAs on the intercept a and slope b may be calculated for different guilds (are there general trends?).

2.3.8. Chi-square analyses. Didham and Fagan also suggested considering a simple test: comparing the observed frequency of catches of a particular taxon at different forest levels with the expected catches of that taxon (based on total catches of all arthropods at different forest levels) with a Chi-square test (Fig. 6).

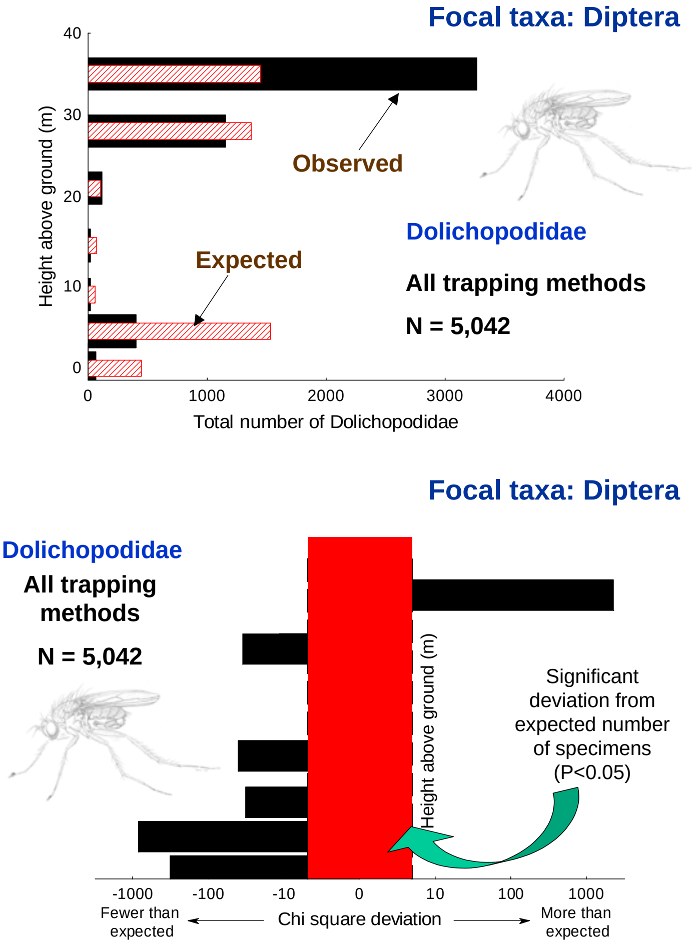

Fig.6. Chi-squared test of the occurrence of dolichopodid catches at various height above the ground..

2.3.9. Ideas/questions to consider. These include notably:

- how to analyze distances between sites (nested, combined, other);
- which beta diversity calculation will be used and reported collectively;
- should we attempt to analyze data for phylogeny and independent contrasts: if possible yes and look at different insect traits: body size, distribution, life history, dispersal, etc;
- the 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: standardize taxa abundance by reporting the relative abundance per sample, not sums;
- what is the best way to visually present our data?

2.4. Dissemination of IBISCA results

2.4.1. Present dissemination and expected output. So far, the IBISCA project has been presented in 6 scientific articles and 13 magazine articles (see recent pubs in section V). A number of manuscripts have been initiated. We expect that most of IBISCA results should be disseminated during 2006-2008.

2.4.2. New species and deposition of material. Group 2 discussed this topic and it was agreed that Sorensen will prepare guidelines to be sent to taxonomists together with IBISCA material:

- deposition of holotypes
- reference collection for Panama
- copyright issues?
- selling names to fund IBISCA taxonomists?

2.4.3. Virtual reference collection and web site. Group 2 and the majority of IBISCA participants thought that a IBISCA web site should be maintained (item 2.1.6) and that it should also include an internet catalogue of IBISCA morphospecies/species as a virtual reference collection. Ideally, an export routine from the database into html files should be written. It would display data / pictures (upper/underside, details) / descriptions / references / literature, etc., as well as (important) information on the collection where the material is deposited. If possible, look for existing models and collaborate with other groups, (Binatang Research Center, ALAS).

2.4.4. Strategies for dissemination. Collectively, IBISCA participants should use the following strategies to disseminate IBISCA results (in order of decreasing importance):

- Multi-authored research papers in peer-reviewed scientific journals.
- High-profile collective article in a leading journal.
- Collective book, equivalent to the proceedings of the present workshop.
- Publications in scientific magazines of wider scope such as Trends in Ecology and Evolution or Scientific American.
- IBISCA web site (items 2.1.6, 2.4.3).

2.4.5. Research papers. The general strategy to publish research papers would be as follows:

1) Draw up a list of potential papers. Participants outline and submit paper ideas to Basset, who list them on the IBISCA web site.

2) Each participant to highlight which paper they want to be included as an author. The authorship will be finalised by all working on the paper. Any disagreement could result in authorship being alphabetized.

3) As far as possible, funds should be raised to cover page fees (if any) for the main IBISCA articles.

2.4.5. High-profile collective article. Hopefully, this collective article could be drafted towards mid-2006. Basset suggested that the authorship of this paper should refer as 'IBISCA', with an appendix listing all participants (including taxonomists) involved in the article (perhaps 50-60 authors). There have been precedents, such as papers published by 'APG' (Angiosperm Phylogeny Group). This would help to retain the brand name 'IBISCA' for future projects (item 3.1).

2.4.5. Collective book. IBISCA has so far raised ca $15,000 towards editing a collective book free of copyright on the preliminary results from the IBISCA-Panama project. The project will be innovative as providing in one package:

- First rate science: preliminary results of IBISCA and reports originating from the present workshop. Perhaps 40 multi-authored chapters of 10 pages each, plus references and index.
- Attractive iconography: many colour pictures, perhaps organized in plates (2-3 plates per chapter if possible).
- Searchable companion CD.
- Public access to downloadable pdf files and additional information (pictures, updated species lists), hosted on the IBISCA web site.
- Free dissemination to targeted readers and groups (scientists and institutions in developing countries: university librairies, IBISCA participants): perhaps 500 copies.
- Nominal fee for other readers: perhaps 500 copies at $5-10 each, to cover mailing expenses associated with the above item.

The final product should be aimed as a cross between a standard edited scientific book and a richly illustrated 'coffee table' book. This represents one of the best ways to promote the study of canopy tropical biology. Further funding should be raised as to secure first rate iconography from professional photographers who participated to IBISCA fieldwork, book handling and mailing expenses, and the creation of html files and CDs. Publication could be achieved towards the end of 2006. Basset will compare the different publishing options (Bulletin RBINS, Panama/Colombia, BioForm, Pensoft, etc.) and prepare an example of chapter.

3. Aim 3: Toward a census of canopy life

3.1. The IBISCA 'brand'. Group 4 advised to retain the 'IBISCA' brand as it is valuable (the exact acronymic meaning is unimportant) and should be used in further projects. The advantages of this strategy are related to:

- the whole-forest focus;
- the scale of scientific collaboration (which is not exclusive);

- the fact that it is not just a census (integrative approach);
- the future: same approach but different questions.

Subsequent discussions among IBISCA participants in the meetings of Leipzig & Uberlandia in July 2005 also established the need for the IBISCA research group (ca 80 scientists) to get organized into a non-profit association, or some similar sort of formal organization. The exact procedure will be explored by Basset, Corbara, Barrios & Leponce, but is likely to include secretarial costs, including the implementation of the new organization.

3.2. Present priorities. Group 4 also listed the following items as present priorities for IBISCA:

- Complete the IBISCA-Panama project (section 2.1) and a high profile manuscript (item 2.4.5) by July 2006, if possible.
- Scan the IBISCA data for inferences & hypotheses about disturbance, in order to secure a potential integrating theme for a future project.
- Consider ecosystem functioning. This is rather challenging but our guild analyses have the potential to be better than others and could be of great help.
- Consider the integration of IBISCA data with other datasets. However, the comparability or integration of data may be more an issue for a future analysis/strategy.
- Raise funding as to quickly complete the IBISCA-Panama project and, in particular, taxonomic analyses (item 3.7).

3.3. Future priorities. Group 4 listed the following items as future priorities for IBISCA:

- Persist with the IBISCA-approach beyond the Panama project
- The primary (& saleable) issues for future IBISCA-style projects should be the following key organising principles: disturbance, climate change and ecosystem function.
- The experimental approach is powerful and could be pursued by IBISCA-style projects, thus adding value to existing plots/project. For example, the Kyoto plots, Danum biodiversity experiment, Critical Size of Ecosystem projects come to mind.
- Address evolutionary questions and preserve specimens to allow molecular work
- Include medical entomologists in future projects, since disease/vector issues are related to disturbance and climate change (connection with human welfare).
- Consider the opportunity to join new biodiversity-related projects (item 3.5).

3.4. Perspectives and improvement of future research. The majority of IBISCA participants agreed on the following points, which were further discussed by Group 4:

- Follow-up projects in Panama would be welcome, as they would be supported by existing and mounting information related to the San Lorenzo forest.
- Work on a broader geographic scale is also advisable.
- It is crucial to consider parataxonomist help to facilitate future IBISCA-type projects. It could be project-related or developed as an international 'parataxonomy facility'.
- IBISCA may need smaller working groups to develop future work plans, for example: ecosystem function / disturbance /climate; refining inventory methods; and future projects.
- Example: the future BATH project calls for process-related research ideas.
- Design better IBISCA-style projects to help answer geological and evolutionary questions.
- Sign a declaration for taxonomic sharing in canopy research in all the major countries involved and send this declaration to each government.
- Consider the use of a social scientist for the future IBISCA projects to help avoid conflicts, confrontations, framework for group dynamics, etc.

3.5. New projects. In addition to new projects in Panama taking advantage of the mounting information on the San Lorenzo forest, new projects keen to involve the IBISCA model may be initiated at the following locations:

- Australia: 'BATH' project (Kitching, 2006-2007): connection with climate change.
- Brazil, Malaysia, India, Madagascar, Ghana: 'Whole Forest Observatories' (Global Canopy Programme/GEF, 2006-2011): develop baseline surveys.
- Vanuatu: project SANTO (Corbara, 2006-2007).
- French Guiana: Tree glider (Corbara, 2007).
- Panama (ANAM/GEF, 2008?).

However, this will involve shifting emphasis on ecosystem functioning (i.e., studying processes from ground to upper canopy) and a greater use of the parataxonomist taskforce, as developed by Novotny & Missa in New Guinea and Gabon, for example.

3.6. Donations and fund-raising. During the workshop, one observer, C. Van Osselaer – Biotrac sprl, made a donation of 1,000 € to IBISCA, in order to encourage further activities of the team. IBISCA should raise further funds to:

- complete the IBISCA-Panama project and in particular to speed up taxonomical activities, the processing of ecological variable and improving the database;
- disseminate the results of the above project;
- explore parataxonomist training in the context of large projects such as IBISCA;
- do a pilot study in Panama: expanding canopy access points from crane perimeters;
- do a pilot study in Australia, related to BATH project: ecosystem functions;
- do a pilot study in French Guiana with the Tree Glider: mobile canopy access;

- do a pilot study for a follow-up of IBISCA in Panama (ANAM-GEF);
- cover costs for the IBISCA web site and the organization of the association;

A detailed budget, probably in the order of 300-500K € is has been prepared by Basset and will be circulated to all participants for comments. Biotrac sprl or the Patron of IBISCA, Prof. E.O. Wilson, could help identifying potential donors. Alternatively, these activities could be sponsored by a joint application of multiple European laboratories to ESF ('À la carte Scientific Programmes').

OVERALL CONCLUSIONS

IBISCA started as a relatively modest project in Panama, with limited participants, funding and opportunities to extend it as to cover a substantial part of arthropod diversity and address the effects of seasonality. Due to the great team spirit and the enthusiasm of participants, IBISCA later grew into a full-scale international project with a core funding of ca $300,000. In the field, IBISCA has demonstrated the value of an integrated project to survey tropical arthropods and has provided answers as to how to tackle the study of this mega-diversity efficiently. The lively intellectual exchanges witnessed during the present workshop promise that the IBISCA team will complete the Panamanian project and disseminate the important mounting information on the arthropods of the San Lorenzo forest.

An ambitious project such as a 'census of canopy life', which essentially includes collecting countless unknown arboreal tropical arthropods, should be implemented in three incremental steps:

1) Organize formally the collective group of experts (ca 80) known as 'IBISCA' and provide this group with substantial funding.

2) Initiate IBISCA-style projects and pilot studies at different locations worldwide and refine the different protocols used in these projects and studies.

3) Develop an aggressive programme aiming at censuing canopy life at key locations in the tropics, based on lessons learn previously.

To our knowledge, there are no other alternatives to the above steps if the scientific community is serious about cataloguing canopy arthropods before habitat loss and global climate change extinguish most of this mega-biodiversity.

RECENT IBISCA PUBLICATIONS

Cízek, L. & Hauck, D. 2005. Jeráby v pralese. *Vesmir*, 84, 38-43. [in Czech]

Corbara, B., Basset, Y. & Barrios, H. 2005. IBISCA: a large-scale study of arthropod mega-diversity in a neotropical rainforest. *In*: Tropical Biodiversity: Science, Data, Conservation. Abstract Volume. 3rd GBIF Science Symposium, 18-19 April 2005, Brussels, Belgium (ed by H. Segers), pp. 31-32. Belgian Clearing-

House to the Convention on Biological Diversity, Royal Belgian Institute of Natural Sciences & Global Biodiversity Information Facility, Brussels.

Ribeiro, S.P. & Corbara, B. 2005. Dossel florestal: a fronteira desconhecida. *Ciencia Hoje*, 217, 54-58.

Roisin, Y., Dejean, A., Corbara, B., Orivel, J. & Leponce, M. 2005. Arthropod biodiversity in tropical rainforest canopies: Panamanian termites in the framework of the IBISCA project. *In*: Tropical Biodiversity: Science, Data, Conservation. Abstract Volume. 3rd GBIF Science Symposium, 18-19 April 2005, Brussels, Belgium (ed by H. Segers), p. 32. Belgian Clearing-House to the Convention on Biological Diversity, Royal Belgian Institute of Natural Sciences & Global Biodiversity Information Facility, Brussels.

Schmidl, J. & Corbara, B. 2005. IBISCA - Artenvielfalt der Boden- und Baumkronen-Arthropoden in einem tropischen Regenwald (San Lorenzo NP, Panama). *Entomologische Zeitschrift*, Stuttgart, 115, 104-108.

Pennisi, E. 2005. Sky-high experiments. *Science*, 309, 1314-1315

A full list of IBISCA publications may be downloaded at

`http://www.naturalsciences.be/cb/ants/projects/ibisca_reprints.htm`

4. Final programme

The workshop was preceded by a public exhibition in the Parc du Cinquantenaire / Jubelpark in Brussels (23-29 June 2005). The exhibition presented the Solvin-Bretzel ("canopy raft") and informed the public about arthropod biodiversity in tropical forests and the IBISCA project. It was organized by the Royal Belgian Institute of Natural Sciences (RBINS) with the support of Solvay (`www.sciencesnaturelles.be/cb/ants/exhibition/ibisca.htm`). The posters of the exhibition were presented for a further week at the RBINS (1-8 July 2005).

The canopy raft and the IBISCA exhibition in Parc du Cinquantenaire, Brussels.

The three-day workshop (6-8 July 2005) started with a pre-workshop welcome day where participants visited the RBINS exhibition and were greeted by Dr Camille Pisani (Director, RBINS), Robert Van Geyts (communication manager, Solvay) and Dr Bruno Corbara (Co-PI, IBISCA project). Dr Corbara presented the IBISCA approach and his talk was followed by a short video, "Mission: IBISCA" (Solvay, 2004).

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

08:30	**Presentation of the European Science Foundation (ESF)** **Lucien Hoffmann** (Standing Committee for the Life, Earth and Environmental Sciences)
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: focal taxa and non-formicid hymenoptera.
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 The pitfall trap, ground flight-intercept trap, vegetation programmes plus focal taxa: Histeridae, Nitidulidae, Pselaphinae, Ceratocanthidae and Braconidae.
Medianero, **Tishechkin**, **Samaniego**, **Hernandez**, **Cuenoud**, **Ribeiro**, **Barrios** & **Basset**

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 Vertical stratification of beetles in dead branches
(The IBISCA beating programme)
Ødegaard

14:00 Moth assemblages. Target groups: Geometridae, Arctiidae, Pyraloidea

(The IBISCA light trap programme)
Kitching, **Oliviera**, **Basset** & **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 Herbivory rates and gall-forming species and density distribution in the canopies of Neotropical ecosystems: from savannas, semi-deciduous forests to wet rainforests.
Ribeiro & **Vieira**

15:40 The microarthropod, beating and wood-rearing programmes plus focal taxa: Oribatida, Tenebrionidae, Clavicornia, Isopoda, Myriapoda & Curculionoidea (minus Scolytinae).
Winchester, **Jordan**, **Cizek**, **Barrios**, **Ødegaard Curletti** & **Basset**

4. Interactions between organisms

16:00 Trophic interactions among tropical organisms
Lewis

16:20 The IBISCA social insects programme: ants
Orivel, Leponce, Delabie, Corbara, Roisin, Cardoso do Nascimento, Ribeiro, Seniuk, Esteves, Campos, Samaniego, Jordan, Winchester, Schmidl, Floren & **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 neighbourhoud*

Thursday 7 July 2005

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

08:30	Evolution along selective gradients: linking population genetics with community ecology **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	Whole forest observatories: An international network for monitoring canopy biodiversity and global climate change **Mitchell**
11:50	*Lunch*
13:00	Plenary preparation of **working group 1**: Problems and remedies related to the analyses of IBISCA data (led by **Hardy** & **Lewinsohn**)
13:40	Plenary preparation of **working group 2**: Key analyses of IBISCA data: taxonomic aspects and interactions between organisms (led by **Roisin**)
14:20	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**)

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** & **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	Working groups 1-4: preparation of a summary of the discussions
14:15	Report of working group 1 (led by **Hardy** & **Lewinsohn**)
14:50	Report of working group 2 (led by **Roisin**)
15:25	*Coffee Break*
15:45	Report of working group 3 (led by **Didham**)
16:20	Report of working group 4 (led by **Kitching** & **Mitchell**)
16:55	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	Intervention of participants who did not give a talk
18:00	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”, Grand Place*

5. Abstracts of presentations

All presentations are available online (password protected):
http://www.naturalsciences.be/cb/ants/meetings/EW04-049-presentations.htm

Distribution of tropical mega-biodiversity: available data

Beta diversity

Beta diversity: basic concepts and tropical data

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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.

Beta-Diversity: Contributions from ant studies to the debate

J. H. C. Delabie
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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.

The IBISCA Malaise trap programme: focal taxa and non-formicid hymenoptera.

N. Springate, **Y. Basset** & **S. 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.

The IBISCA canopy fogging programme and team focal taxa

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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.

The IBISCA Winkler programme and focal taxa

H.P. Aberlenc, **M. Leponce**, **J. Orivel**, **B. Corbara** & **Y. Roisin**

The pitfall trap, ground flight-intercept trap, vegetation programmes plus focal taxa: Histeridae, Nitidulidae, Pselaphinae, Ceratocanthidae and Braconidae.

E. Medianero, **A. Tishechkin**, **M. Samaniego**, **Hernandez**, **Ph. Cuenoud**, **S. Ribeiro**, **H. Barrios** & **Y. Basset**

Vertical gradients

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.

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.

Vertical stratification of beetles in dead branches (The IBISCA beating programme)

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.

Moth assemblages. Target groups: Geometridae, Arctiidae, Pyraloidea (The IBISCA light trap programme)

R. Kitching[1], E. Oliviera[2], Y. Basset[3], A. Cornejo[4]
[1]*Griffith University*, [2] *University of Ouro Preto*, [3]*Smithsonian Tropical Research Institute*, [4]*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.

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]
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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.

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

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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.

Herbivory rates and gall-forming species and density distribution in the canopies of Neotropical ecosystems: from savannas, semi-deciduous forests to wet rainforests.

S. Ribeiro & **A. Vieira**
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, $F2,27=6.9$, $p < 0.02$), which also had the most sclerophyllous leaves in the whole forest (simple linear regression, $F1,28=7.09$, $p < 0.01$). 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, $F5,237=3.0$, $p<0.01$). Furthermore, herbivory rates decreased significantly in the canopy with sample height (simple linear regression, $F1,247=33.4$, $p < 0.001$).

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.

The microarthropod, beating and wood-rearing programmes plus focal taxa: Oribatida, Tenebrionidae, Clavicornia, Isopoda, Myriapoda & Curculionoidea (minus Scolytinae).

N. Winchester, **K. Jordan**, **L. Cizek**, **H. Barrios**, **F. Ødegaard G. Curletti** & **Y. Basset**

Interactions between organisms

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.

The IBISCA social insects programme: ants

J. Orivel, M. Leponce, J.H.C. Delabie, B. Corbara, Y. Roisin, I. Cardoso do Nascimento, S. Ribeiro, Seniuk, Esteves, R. Campos, M. Samaniego, K. Jordan, N. Winchester, J. Schmidl, A. Floren & **A. Dejean.**

Distribution of termites from the ground to the canopy of a Panamanian rainforest

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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.

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

D. Frame & D.Roubik
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.

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

Evolution along selective gradients: linking population genetics with community ecology

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.

Implementing large-scale surveys and experiments in the tropics

T. Roslin
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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.

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 amelioriate 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

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.

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).

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.

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.

Whole forest observatories: An international network for monitoring canopy biodiversity and global climate change

A. Mitchell

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7. Statistical information on participants

Disciplines represented

Entomology, ecology; taxonomy; management (of international tropical research programme, NGO or private companies) ; statistics/modeling; botany.

Distribution by nationality

	Country	Number
1	Australia	1
2	Belgium	5
3	Brasil	3
4	Czech Republic	1
5	Denmark	1
6	Finland	1
7	France	5
8	Germany	3
9	Italy	1
10	Luxembourg	1
11	New Zealand	2
12	Norway	1
13	Panama	4
14	Papua New Guinea	1
15	Switzerland	1
16	United Kingdom	6
		37

Distribution by gender

6 females, 31 males

Distribution by age groups

Age	Number
20-30	3
30-40	10
40-50	22
50-60	2
	37

Participants in front of Manneken Pis, near Brussels' Grand Place, 8 July 2005