THE IMPORTANCE OF ORGANIC MATERIAL FOR ARTHROPODS ON ATTALEA PHALERATA (ARECACEAE) IN THE PANTANAL OF MATO GROSSO, BRAZIL

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INTRODUCTION

The canopy architecture of palm trees differ from other plant species and according to Amedegnato (1997) form a distinct habitat in tropical forests. The presence of various microhabitats makes possible their use by different groups of animals, and because of this palm trees are considered key-species in tropical ecosystems (Alonso et al. 2001; Svenning 2001).

The unique architecture of the crown of some palm trees is another factor that must be emphasized when analyzing Attalea phalerata Mart. (Arecales), with the presence of leaf sheaths located on the trunk that remain fixed even after the death of leaves. The presence of dead and green leaf sheaths provides for the creation of new environments, allowing the accumulation of organic material (such as leaves, branches, flowers, and seeds) and consequently their use as a habitat for arthropods. Although the sheaths are not part of the crown they are a favorably habitat for arthropods, which can increase and influence the spatial distribution and composition of the faunal community associated with the canopy.

MATERIALS AND METHODS

The study was carried out at the Retiro Novo Farm, Nossa Senhora do Livramento, Mato Grosso (MT; 16°15'-17°54'S and 56°36'-57°56'W). The northern Pantanal is marked by having well defined abiotic periods, with a...
rainy season between October and April and an aquatic phase (high-water) between December and March (0.6-1.5 m in height; Heckman 1998).

Six canopies of *A. phalerata* were sampled with the thermofogging method ("canopy fogging") during the aquatic phase (February, 2001), using synthetic pyrethrins (Lambdalialotrine 0.5%). At the time of fogging, flood waters were 30-50 m distant from the palm trees sampled. The selection of the sampled palm trees followed the criteria proposed by Adis et al. (1998). Canopy fogging and sampling procedures were those given in Battirola et al. (2004). For collecting, the base of each palm tree was surrounded by 16-17 nylon funnels (each 1 m in diameter), according to the spread of each canopy. Each funnel had a numbered plastic bottle with 92% EOD attached to its mouth. Funnel location on the collecting site was mapped.

To evaluate the position of each collecting funnel and consequently the influence of organic material in leaf sheaths on the spatial distribution and composition of the arthropod community, an ANOVA analysis was performed and statistical differences evaluated with the Tamhane-test (Sokal & Rolf 1995) using SPSS Version 10.0. Voucher material of arthropods was deposited at the Entomology Laboratory (21A) of the Federal University of Mato Grosso, Cuiabá.

**RESULTS AND DISCUSSION**

According to the mapping of the collecting funnels the following positions were defined: (a) those located close to the stem; (b) those in an intermediary position, and (c) those distant from the stem on the edges of the canopy, according to the schematic drawing presented by Battirola et al. (2004, 2005). Funnels close to the stem covered 30 m², the intermediaries 55 m² and the ones distant from the stem covered 14 m². This difference of sampled area was due to the varying crown architecture in *A. phalerata*, that resulted in a heterogeneous spatial distribution of the funnels.

A total of 32,595 arthropods (54.9% of the total catch; 1,086.5 ind./m²) were sampled in funnels close to the stem, 21,160 arthropods (35.6%; 384.7 ind./m²) in the intermediaries and 5,644 specimens (9.5%; 403.1 ind./m²) in funnels more distant from the stem (Table 1). The major arthropod density in funnels close to the stem can be related to organic material accumulating leaf sheaths at the

<table>
<thead>
<tr>
<th>Taxons</th>
<th>Position of the funnels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Close (ind./m²)</td>
</tr>
<tr>
<td>Acari</td>
<td>350.1</td>
</tr>
<tr>
<td>Coleoptera (A+L)*</td>
<td>178.8</td>
</tr>
<tr>
<td>Collembola</td>
<td>120.5</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>101.6</td>
</tr>
<tr>
<td>Pscoptera</td>
<td>96.5</td>
</tr>
<tr>
<td>Diptera (A+L)</td>
<td>79.5</td>
</tr>
<tr>
<td>Thysanoptera</td>
<td>66.1</td>
</tr>
<tr>
<td>Araneae</td>
<td>20.0</td>
</tr>
<tr>
<td>Lepidoptera (A+L)</td>
<td>15.7</td>
</tr>
<tr>
<td>Homoptera (A+N)*</td>
<td>11.0</td>
</tr>
<tr>
<td>Pseudoscorpiones</td>
<td>17.0</td>
</tr>
<tr>
<td>Orthoptera (A+N)</td>
<td>6.5</td>
</tr>
<tr>
<td>Isoptera</td>
<td>8.8</td>
</tr>
<tr>
<td>Heteroptera (A+N)</td>
<td>4.8</td>
</tr>
<tr>
<td>Blattodea (A+N)</td>
<td>6.1</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>0.7</td>
</tr>
<tr>
<td>Dermaptera</td>
<td>0.9</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>0.2</td>
</tr>
<tr>
<td>Embioptera</td>
<td>0.6</td>
</tr>
<tr>
<td>Isopoda</td>
<td>0.5</td>
</tr>
<tr>
<td>Neuroptera (L)</td>
<td>0.2</td>
</tr>
<tr>
<td>Opiliones</td>
<td>0.1</td>
</tr>
<tr>
<td>Mantodea (N)</td>
<td>0.0</td>
</tr>
<tr>
<td>Odonata</td>
<td>0.0</td>
</tr>
<tr>
<td>Polydesmida (L)</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

**Total** | **1088.5** | **384.7** | **403.1**
stem, which provides a greater diversity of habitats and available resources for the arthropods. This is mirrored by the higher density of arthropod groups such as Acari, Coleoptera, Collembola, and Psocoptera, usually associated with organic material, where they frequently carry out the role of decomposers and therefore depend on this substrate for their survival. Apart from these groups, Diptera and Hymenoptera also presented a high density, as they use these environments for foraging and reproduction (Table 1).

In funnels intermediary and distant from the stem, the dominant groups were the same but with quite reduced densities when compared to funnels placed close to the stem. This probably occurred due to the larger area sampled, and to the smaller availability of resources found in these positions (Table 1).

<table>
<thead>
<tr>
<th>Table 2 – Density of immature arthropods obtained from six canopies of Attalea phalerata (Areaceae) during the aquatic phase in the Pantanal of Poconé – MT, according to the position of the collecting funnels.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taxons</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Coleoptera</td>
</tr>
<tr>
<td>Diptera</td>
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<tr>
<td>Lepidoptera</td>
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<tr>
<td>Homoptera</td>
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<tr>
<td>Orthoptera</td>
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<tr>
<td>Blattodea</td>
</tr>
<tr>
<td>Heteroptera</td>
</tr>
<tr>
<td>Formicidae</td>
</tr>
<tr>
<td>Neuroptera</td>
</tr>
</tbody>
</table>

Regarding the distribution of immatures (larvae and nymphs), there was a higher arthropod density in funnels situated closer to the stem. This indicates that, apart from the greater availability of resources, the accumulated organic material in leaf sheaths is used as a reproduction site by some groups, mainly Coleoptera and Diptera, since many of their larvae develop in the soil. Other groups such as Lepidoptera and Orthoptera, showed a high density of immatures, but were distributed in a less heterogeneous way within the sampled area, probably as they are herbivorous and use the leaves of A. phalerata as food (Table 2).

The analysis of variance demonstrated a significant difference (p<0.001) between the position of the collecting funnels in relation to the frequency of the sampled arthropods. The occurrence of patterns in relation to the position of funnels indicated that arthropods sampled close to the stem differed from those obtained in intermediary and distant funnels. This reinforces the importance of accumulated organic material in leaf sheaths of A. phalerata on the composition and spatial distribution of the arthropod community associated with this palm species (Table 3).

**Conclusions**

The accumulated organic material in dead and green leaf sheaths of A. phalerata influences the composition, spatial distribution and development stages of arthropods on A. phalerata. This belief was confirmed by the catches in collecting funnels located close to the stem of palm trees, which showed differences in relation to frequency and density of obtained taxa.

*see page 7 for Bibliographic information*
Development of a Novel Method for Assessing Stand-Level Herbivory in Forests

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2 Department of Environmental Initiatives, New College of Florida, 500 North Tamiami Trail, Sarasota, FL 34242
3 Department of Forest Science, 321 Richardson Hall, Oregon State University, Corvallis, OR 97331
4 Department of Biological Sciences, Central Washington University, 400 East University Way, Ellensburg, WA 98926

Stand-level rates of insect herbivory in temperate and tropical forests have long been difficult to estimate due to problems of canopy access and to tedious sampling methodologies (Lowman and Moffett 1993; Lowman et al. 1998; Ernest 2004; Rinker and Lowman 2004; Shaw et al. 2006). In addition, comparisons among sites have been weak statistically because researchers lack a standard protocol. Our goal was to work out a new method for estimating stand-level herbivory (i.e., percentage of foliage removed by insect herbivores under normal, non-outbreak conditions) that is rapid and can be used to compare forests around the globe. We developed the methodology with statistical consultation in a subtropical forest in Florida and then tested the new protocol in two structurally and functionally dissimilar forests: a tropical rainforest in northeastern Australia and a temperate conifer forest in the State of Washington (Ernest 2004; Shaw et al. 2006). For each test site, we employed the local canopy crane research facility, all members of the International Canopy Crane Network, as further homogeneity in our sampling exercises. Details of the protocol were discussed during the June 2002 and July 2005 International Forest Canopy Conferences (Cairns, Australia and Leipzig, Germany, respectively), then disseminated to colleagues at other crane sites for ongoing field-testing.

Within the three-dimensional canopy space of each forest under the swing of a canopy crane, we randomly chose at least 200 points to guarantee that we could sample foliage at our target of 100 locations since not all sampling points would be accessible from the crane gondola (Figures 1 and 2; see Ernest 2004). At every location we carefully measured the percent of leaf area missing due to herbivory on each of three different branch units (1 unit = 10 random leaves within a ¼ meter cube) accessible from the crane gondola. Samples included all vascular plants (e.g., trees, vines, epiphytes, photosynthetic plant parasites, and understory plants) within the sample location to ensure measurements of all plant primary productivity within the forest. We sampled 93 locations at the Cape Tribulation Canopy Crane (Cairns, Australia) in July 2002 and 101 at the Wind River Canopy Crane (Carson, WA) in September 2002 for a minimum of 50 hours, respectively, collecting enough samples until variance and estimated percent herbivory leveled off (estimated graphically). The average of all these experimental points provided the percent herbivory at the stand level. Our results: 8.6% stand-level herbivory for Cape Tribulation, 1.6% for Wind River (Shaw et al. 2006).

The research is scientifically important in several ways. First, we proposed a standard protocol for the rapid assessment of
insect herbivory at the level of a forest stand—without the difficulty imposed by the traditional methods of sampling up from leaves and branches and using fairly complicated subsampling. After the technique is refined, applying it at all canopy crane sites throughout the world in the next phase of research, it may be possible to modify the protocol for use with other canopy access tools including the canopy raft and walkways (see Rinker 1995, 2001). Second, this research will help to set baseline numbers for one of the key processes that regulate ecosystem function. Primary productivity may be regulated by herbivory yet we lack accurate measurements of insect damage at the stand level due to difficulty in logistics and the extensive sampling required. Third, herbivory is often neglected as an important educational objective. Two disparate popular views of herbivory exist: a static view that the world is green and herbivory insignificant and a catastrophic view that herbivore outbreaks destroy forests and crops. By providing a rapid method for measuring “normal” levels of herbivory in forests, we connect herbivory to other ecological concepts such as biodiversity, food webs, ecosystem function, and the differences between temperate and tropical ecosystems.

This research has important implications for the management of forests and for global climate change. Global climate change, especially increasing atmospheric CO₂, is likely to affect rates of herbivory. One hypothesis states that, over time, leaves will have more carbon in relation to the amount of other nutrients that will then require herbivores to consume more leaves to get the same amount of nutrients. Increased levels of herbivory will have consequences for forest productivity. Policy-makers need to know how management will influence herbivory at local, regional, and global scales. The knowledge gap is tremendous, and we must provide better information so forest managers and policy-makers can make sound long-term decisions for natural resources.

**ACKNOWLEDGEMENTS**

This research was supported by the Global Canopy Programme, John Krebs Field Station, Wytham, Oxford, United Kingdom; the Australian Canopy Crane Research Facility (Queensland, Australia); and the Wind River Canopy Crane Research Facility (Carson, Washington). Saul Lowitt assisted with the experimental design.

**LITERATURE CITED**


NEWLY LAUNCHED: IMPROVED ICAN WEBSITE
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Hannah E. Anderson
The International Canopy Network
canopy@evergreen.edu

ICAN has launched a new version of our website <www.evergreen.edu/ican>. We have changed the look and updated the content of the site. We hope you find the new interface easy to navigate and full of useful information. ICAN works closely with the Big Canopy Database <www.canopy.evergreen.edu/bcd>, part of the Canopy Database Project, and is linked directly with that source for up-to-date canopy-related information including upcoming meetings, scientific glossary, and the canopy citations database. We have also added a new feature: the ICAN Store, which includes the ability to buy items, donate, and subscribe to ICAN online.

We have organized our website into six topical areas: the ICAN main page; Research; Education; Conservation; Outreach; and Access.

Click the Research tab to find information about researchers connected with ICAN and research happening around the globe. You can also use our on-line citations database to search through over 6700 canopy-related journal article citations. Hard copies are available free to ICAN members. Categories include: canopy access, canopy structure, eco-informatics, ecosystem processes, forest management, forest structure, forest-atmosphere interactions, hydrology, invertebrates, light transmission, micrometeorology, miscellaneous, modeling, nutrient cycling, plant physiology, plants, remote sensing, research equipment and methodology, tree architecture, and vertebrates.

Our Education tab offers information about our “Ask Dr. Canopy” program, in which students of all ages can direct their questions directly to Dr. Canopy, a consortium of canopy researchers involved with the project. Questions are routed to the researchers themselves, creating a viable link between students and scientists. Queries are taken both by regular post and email to <canopy@evergreen.edu> ICAN has also compiled a Temperate Rainforest Curriculum Project. The material includes interactive activities for schoolteachers and children, and a downloadable curriculum designed for students in grades 4-12. These have been designed to comply with the formal environmental education learning goals for Washington State. ICAN educational materials also include the ongoing compilation of a graduate course in canopy studies.

Under the ICAN main tab you will find information on how to become a member, downloadable back issues of What’s Up?, contact information for our Board of Directors, Advisory Board, and staff, and the ICAN Store. ICAN offers textbooks and children’s books relating to canopy studies, T-shirts, and posters.

The Conservation tab of ICAN lists information on forest degradation and the effects of logging and slash/burn agriculture. Also check out our TrecTop Talks, media created by forest canopy researchers, in an
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ICAN is always open to suggestions to better serve our members. Please send your comments, edits, and questions to Hannah Anderson at <canopy@evergreen.edu>. Let us know what you would like to find on our site, what you like, and what you don’t. We look forward to hearing from you.

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The International Canopy Network is currently seeking articles and information for the upcoming issue of What’s Up?, set for publication June 2006. ICAN accepts articles, meeting, workshop and job announcements, relevant website addresses, and citations. Contributions can be sent via e-mail attachment, fax, or snail mail. Articles up to 1500 words are accepted (WORD format preferred) and graphics are welcomed (JPG format please). The deadline for submissions is May 15, 2006.

For further information or to send contributions, please contact the ICAN office: Hannah Anderson Program Manager/Editor; 2103 Harrison Avenue NW, PMB 612, Olympia, WA 98502; (360) 867-6788; <canopy@evergreen.edu>.

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**BIBLIOGRAPHY**


MEETINGS AND EVENTS

ICAN Sponsored Canopy Access Workshop
27 March - 1 April 2006.
The Evergreen State College, Olympia, WA, USA.
<www.evergreen.edu/ican> <www.snwvb.org>
Challenges of a Changing World: Historical Perspectives and New Innovations.

The International Panel on Climate Change
3-7 April 2006. Palencia, Spain
<http://www.palencia.uva.es/iufro2006/>
Managing Forest Ecosystems: The Challenges of Climate Change

Biodiversity at the Ecosystem Level
- Patterns and Processes
26 & 27 April 2006. Aarhus, Denmark
<http://www.danbif.dk/conference2006>

Carbon Workshop - SFRP
31 May - 2 June 2006. Asheville, North Carolina, USA
<http://sfrponline.net/events.htm>

Climate Changes and Their Impact on Boreal and Temperate Forests
5-7 June 2006. Ekaterinburg, Russian Federation
<http://ecoinf.uran.ru/conference/>

Society for Conservation Biology
- 20th Annual Meeting
24-28 June 2006. San Jose, California, USA
<http://conbio.org/2006/>
Conservation Without Borders

Association for Tropical Biology and Conservation Annual Meeting
18-21 July 2006. Kunming, China
<http://atbc.xtbg.ac.cn/>
Tropical Biology: Meeting the Needs of Changing Tropical Ecosystems.

Special Symposium at ATBC Annual Meeting
18-21 July 2006. Kunming, China
<http://atbc.xtbg.ac.cn/>
Epiphyte diversity -- global patterns, global change
Climate change and conversion of tropical forests affect epiphytic plants by altering the climatic conditions towards which these plants are particularly sensitive, and by changing the structural basis of their existence in the form of fragmentation and conversion of primary forests to secondary forests with different host tree spectra.
The goal of the symposium is to present an overview of current epiphyte research, especially in the fields of distribution patterns and epiphytes in secondary habitats.
Talks will include the impact of climate change on epiphyte vegetation, epiphytes in plantations, epiphyte physiology and resilience to environmental change.
If you are interested in contributing to the symposium, please contact the organizer of the symposium, Jürgen Nieder (Nees-Institute for the Biodiversity of Plants, Bonn, Germany; jnieder@uni-bonn.de).
The deadline for abstract submission is April 15th, 2006.

9th International Pollination Symposium
23-28 July 2006. Iowa State University, USA
<http://www.ucs.iastate.edu/mtet/plantbee/home.html>
Host-Pollinator Biology Relationships - Diversity in Action.

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

International Conference on Forests and Water in a Changing Environment
8 - 10 August 2006. Beijing, China.
<http://www.caf.ac.cn/fwce/fwce_e.cfm>

Whitebark Pine: A Pacific Coast Perspective
27 - 31 August 2006. Ashland, Oregon, USA.
<http://www.fs.fed.us/r6/nr/fid/wbpine>
Coming in May 2006
From Sinauer Associates:
Essentials of Conservation Biology,
Fourth Edition

Richard B. Primack, Boston University
530 pages (est.), 282 illustrations
ISBN 0-87893-720-X, $82.95 casebound

Essentials of Conservation Biology, Fourth Edition combines theory and applied research to explain the connections between conservation biology and environmental economics, education, ethics, law, and the social sciences. This new edition stresses the need for an interdisciplinary approach in identifying and solving conservation problems. A major theme throughout the book is the active role that scientists, local people, the general public, conservation organizations, and governments can play in protecting biological diversity, even while providing for human needs. The author presents positive suggestions to show the reader how threats to species and biological communities are being dealt with, and conveys an enthusiasm for the exciting new developments in the field of conservation biology.

Each chapter begins with general ideas and principles, which are illustrated with choice examples from the current literature. The most instructive examples are discussed in boxes highlighting species and issues of particular significance. Chapters end with summaries, an annotated list of suggested readings, and discussion questions.

Essentials of Conservation Biology, Fourth Edition is beautifully illustrated and is written in clear, non-technical language. It is suitable for undergraduate biology students, as well as students in other disciplines. The book’s broad, up-to-date coverage and its extensive bibliography with over 1,000 references also make it valuable to graduate students and researchers. This new edition now comes with a Glossary.

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RECENT CITATIONS IN CANOPY SCIENCE

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

CANOPY STRUCTURE


ECOSYSTEM PROCESSES


FOREST MANAGEMENT


FOREST STRUCTURE


FOREST-ATMOSPHERE INTERACTIONS


INVERTEBRATES


LIGHT TRANSMISSION


MODELING


**NUTRIENT CYCLING**


**PLANT PHYSIOLOGY**


**PLANTS**


Hantz, M. 2005. Epiphytic lichen diversity on dead and dying conifers under different levels of atmospheric pollution. Environmental Pollution 135:111-119.


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