Selbyana 28(2): 161–168. 2007.

HORTI SELBYANI

BUILDING CAPACITY IN CANOPY RESEARCH: THE BRAZILIAN EXPERIENCE

TALITA FONTOURA,*

Universidade Estadual de Santa Cruz, Departamento de Ciências Biológicas, Rod. Ilhéus-Itabuna km16, CEP 45650-000, Ilhéus, BA, Brasil. Email: talita_fontoura@uol.com.br

FLAVIO A.M. SANTOS, AND

Universidade Estadual de Campinas, Instituto de Biologia, Depto. de Botânica, CP6109, CEP13083-970, Campinas, SP, Brasil.

SÉRVIO PONTES RIBEIRO

Universidade Federal de Ouro Preto, Instituto de Ciências Exatas e Biolgicas, Departamento de Ciências Biológicas, Campus Morro do Cruzeiro, Laboratório de Ecologia Evolutiva de Insetos de Dossel e Successão Natural, 35400-000, Ouro Preto, MG, Brasil.

ABSTRACT. This article describes the necessary logistics and comments on the scientific-educational aspects to run the field course "research in canopy" first carried out at the Reserva Particular do Patrimônio Natural da Serra do Teimoso (state of Bahia) in northeastern Brazil. The field course is divided into three weeks: one devoted to climbing techniques; the second to developing "short" projects in the canopy; and the third to formulating hypotheses and developing "long" projects in the canopy. Different field course versions indicate that twelve "short" projects are developed during the second week of canopy investigation and about six "long" projects during the third week. During the course we involved postgraduate students in the learning process of undergraduate students. In order to conciliate safety protocols and data collection in the tree crowns, strict safety protocols had to be followed. Groups could not exceed 3–4 students. For the first time, Brazilian students were faced with canopy research, data analysis, and testing hypotheses. Their activities also furnished valuable information about canopy organisms to the field station owner, who develops environmental education on his property. Our experience indicates that canopy ecology can be a sub-discipline within ecology in regular post-graduate courses, in order to foster research projects and ecological questions.

Key words: Atlantic rainforest, climbing techniques, plant physiology, canopy insects, epiphytes, microclimate, birds

INTRODUCTION

During the International Forest Canopy Conference held in Sarasota (United States) in 1998, a group of South American researchers began a discussion to integrate canopy research on this continent. In July 2000, the First Brazilian Workshop on Canopy Ecology took place in Campinas (state of São Paulo, Brazil), which involved biologists and professionals specialized in climbing techniques. This meeting helped increase the awareness of researchers and students on the current state of canopy research. In fact, although research involving canopy organisms in Brazil began in the 1940s (Hertel 1949), few joint efforts have been made since then to use climbing techniques for scientific purposes.

A few months after this meeting, a complementary theoretical course called "Insect Biodiversity in Tropical Forests: Theory and Perspectives in Quantitative Analyses and Techniques of Access to Canopy" was created in September, in the state of Minas Gerais.

After these encounters, the organizers and post-graduate students from different institutions created an informal electronic site where various opinions could be debated. Both the organizers and the participants agreed that although scientific or technical discussions were very productive, they would not suffice to constitute long term development of canopy research in Brazil. Thus, they decided that, to develop canopy research in Brazil, it would be more effective to establish a network of Brazilian institutions to study the different canopies, taking advantage of the natural heterogeneity of Brazilian forests (Fontoura & Ribeiro 2001).

* Corresponding author.

At the end of 2000 and beginning of 2001, several educational or recreational activities linked to tree crowns took place in different localities of Brazil and were reported in newspapers, reviews, and on the Internet. In April 2001, the idea to hold an annual encounter in the form of a training course at the Universidade Estadual de Campinas was formulated and, in July 2001, proposed to the Steering Group of the Global Canopy Programme (GCP). It was readily supported and took the form of a field research course on canopy in March 2002. In November 2001, two other scientific events gathered researchers, undergraduate and post-graduate students: the 24th Regional Congress of Botany, held in the state of Bahia, promoted a three-day course on tree-climbing techniques; and the 5th Brazilian Congress of Ecology, in the state of Rio Grande do Sul, organized a round table to discuss canopy ecology research with more than 200 people. These early discussions and solutions of methodological or scientific problems helped promote research on canopy in Brazil.

Besides the different types of tropical forest existing in Brazil and the ongoing discussions, three other facts indicated that a training course based on the canopy research could encourage other research activities. The first was the presence of field courses developed in Brazilian universities and run by ecology professors who advised students on ecological questions in the field. The second was the absence of other field courses based on canopy exploration which motivated both experienced and younger professors to become involved. Finally, the first Workshop on Canopy Ecology in 2000 established contacts with some professional climbers interested in helping canopy researchers and was decisive in creating the first field course.

The field course "Research in Canopy" was first offered at the Reserva Natural da Serra do Teimoso (Brazil) in 2002 and today is in its fourth version. Because its organization and development represent different aspects of logistics, didactics, science, and climbing techniques, we will focus on the methodological and logistic activities involved in running such a course. We will also comment on the scientific-educational aspects.

It is expected that this article will encourage other groups, acting as a model to train qualified staff for research in forest canopies at the graduate or postgraduate level. The entire course was based on climbing techniques with safety procedures; variations of those protocols can easily be replicated around the world.

The Study Area

The Natural Reserve of the Serra do Teimoso (RNST) is part of the 520.3 ha of the Teimoso Farm, in the city of Jussari, in the southern state of Bahia (15°12′S, 39°29′W; FIGURE 1). Created in August 1997 with the support of a non-governmental organization, it covers 200 ha. Altitude varies between 250–800 a.s.l. (Jardim 2003). Mean annual temperature is 23.5°C, climate type is Am (tropical rainy forest, with 1 to 3 dry months) according to the Köppen climate classification system; and local rainfall varies from 1200 to 1600 mm annually (Landau 2003). Vegetation is the Dense Ombrophilous Forest type (Veloso et al. 1991), and constitutes a transition area between hygrophilous and mesophilous woods (CEPLAC & IICA 1976, Jardim 2003). The foothill presents a floristic composition and an appearance close to mesophilous woods, while the hilltop is covered with typical hygrophilous forest (Jardim 2003). Trees are 20 to 60 m high, form a discontinuous canopy, and present a great number of vascular epiphytes. The tops of hills are characterized by the presence of briophytes, heart-palm (*Euterpe edulis* Mart), and different species of epiphytic bromeliads and gesneriads (Jardim 2003). The RNST shelters various threatened plants and primates species, including brazil wood (*Caesalpinia echinata* Lam.); masked titi monkeys (*Callicebus personatus melanochir* Geoffroy, 1812); golden-headed-lion-tamarin (*Leonthopithecus chrysomelas* Kuhl, 1820); and woolly spider monkeys (*Brachythelles arachoides* Geoffroy, 1806).

Methods

Selection of Professors and Students

Professors were chosen based on their previous experience in field courses and/or in tree crown research.

We invited some climbers who had experience in assisting researchers in tree crowns and who had participated in the First Brazilian Workshop on Canopy Ecology (Fontoura & Ribeiro 2001). Unlike climbing activity in sports, industry or leisure, climbing for purposes of research requires: 1) experience in assessing the forest conditions, which few climbers have; 2) experience in assisting the sampling of different types of organisms; 3) capacity to deal with different kinds of researchers for extended periods in field conditions; 4) capacity to bear the conditions of a field course that may at times demand more than 8 continuous hours of activity.

Positions for postgraduate students in ecology were offered at the Universidade Estadual de Campinas (UNICAMP). Some positions were also reserved for students from the Universidade Estadual de Santa Cruz (UESC), located about 90 km from the RNST. All together, 20 positions

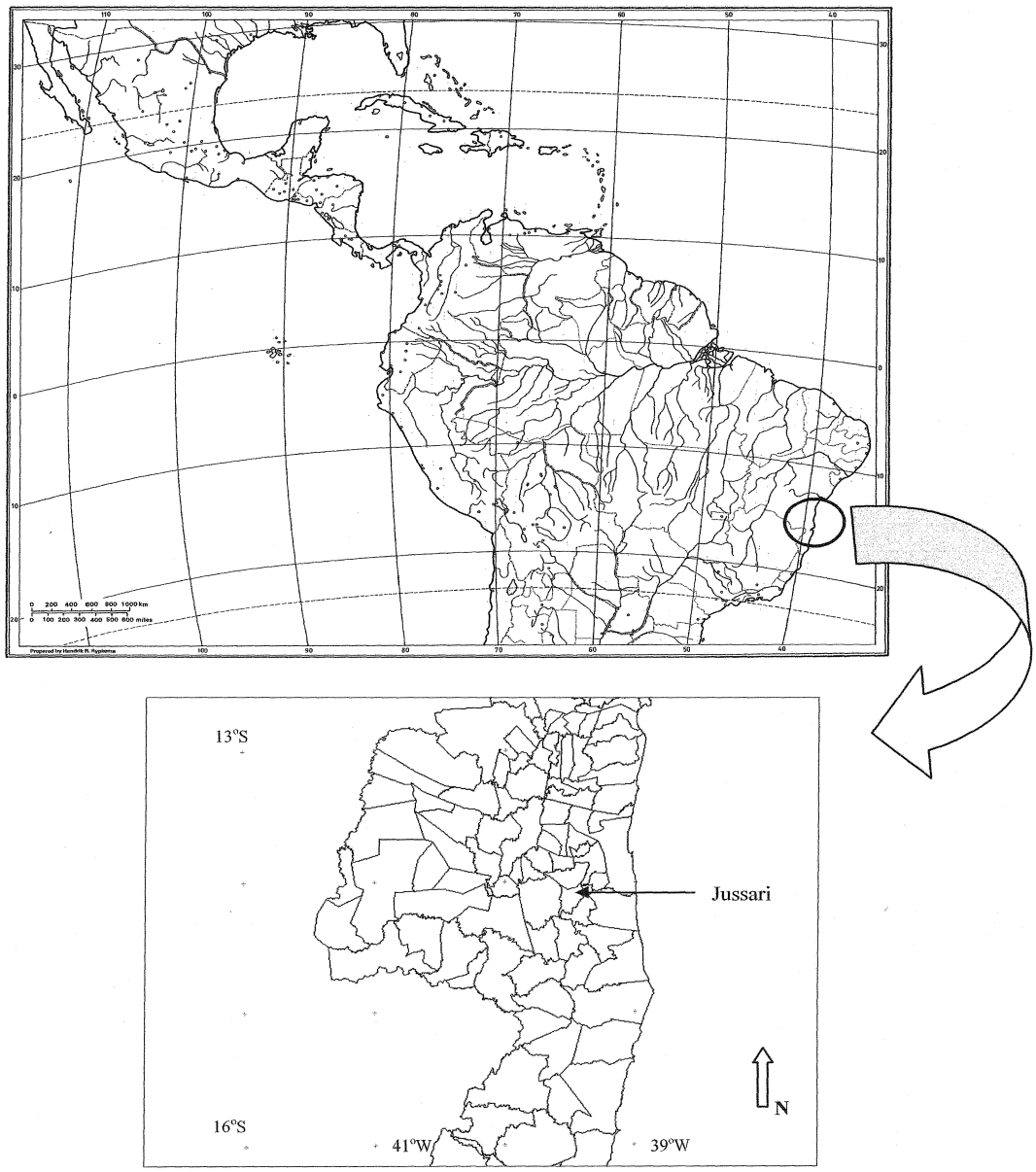

FIGURE 1. Map of the study area: Jussari municipality in south Bahia state.

were offered; selection for the course was mainly based on the students' research experience.

As the field course was a discipline in UNICAMP with UESC collaboration, the announcement of the first field course was made at both Universities and had three phases: 1) publicity; 2) pre-selection of candidates; and 3) registration.

Phase one started about six months before the enrollment period through informal electronic messages, charts, and folders sent to Brazilian universities that described the course's general characteristics. A website hosted by Unicamp (http://www.ib.unicamp.br/profs/fsantos/ne313/) informed that the organization would provide transport between Ilhéus (the closest city with airport and bus station) and the RNST, accommodation, and food, but that students would have to bear the transportation costs between their hometowns and Ilhéus.

Phase two, almost two months before the en-

TABLE 1. General schedule of the canopy field course developed in Brazil.

Day period	Week period		
	Week 1	Week 2	Week 3
Morning	Climbing activities	Short projects	Long projects
Afternoon	Climbing activities	Short projects	Long projects
Night	Lecture of invited professors	Lecture of invited professors—project presentations	Lecture of invited professors—project presentations

rollment period, required that interested students should send the following to the coordinators: 1) a research project to be developed during the 5–6 days in the field; 2) two recommendation letters from other researchers; and 3) a letter describing their interest in the field course (to assess the candidate's experience or intentions with regard to canopy research). Some undergraduate students were selected and guaranteed credits in their future graduation course.

Phase three was the registration of the selected candidates in the discipline of the graduate and post-graduate program of Unicamp through the Internet. Those selected received basic papers about canopy research before the field course to augment their basic information about canopy biology.

On the arrival day, candidates had to present evidence of life insurance and sign agreements acknowledging the risks involved in field activities and exempting the organizers and professional climbers from any liability in case of any personal injury that might occur during the field activities. Without these documents, the student would participate in the field course but from the ground.

RESULTS

Field Activities

Field courses were divided into three one week steps (TABLE 1). The first one was dedicated to learning climbing techniques, the second one to developing ecology short projects, and the third one to developing longer ecology projects based on 5–6 days of data collection. Lectures were presented by the invited professors and climbing instructors almost every night.

Climbing Training

The first period of the course was intended to train students in the basic climbing techniques (TABLE 2). Students were expected to learn how to make the basic knots and perform the basic safety protocols to ascend to and descend from a tree top.

Seven days before students arrived, appropriate spots to train students were prepared. Climbers chose some appropriate places to train vertical ascent under controlled conditions (e.g., walls, low trees) and selected forest trees that could be explored for different field projects. The chosen forest trees usually contained fruits, flowers, lianes, or had an unusual point of observation of animals in some part of the tree crown. All spots were previously surveyed to assess any possible risk of fall, the tree's health, and climbing conditions. Fishing lines were then passed in the chosen places to allow rope changes when students were in the field.

On the first effective day of the field course, students received classroom instructions on the different kinds of equipment, climbing techniques, and safety protocols. The second and third days provided simulated climbing in controlled conditions, using walls and short trees

TABLE 2. Schedule of the first week devoted to learning of climbing techniques of the canopy field course developed in Brazil.

Day period	Day				
	1	2	3	4	5
Morning	Introductory activities	Climbing gear presentation and basic knots	Ascent and descent practices in top rope in short trees	Moviment in the crown and descent in short trees	Ascent and descent in tall trees and tyrolean
Afternoon	Climbing gear presentation and basic knots	Indoor ascent and descent practices	Ascent and descent practices in top rope in short trees	Moviment in the crown and descent in short trees	Ascent and descent in tall trees and tyrolean

TABLE 3. Schedule of the third week devoted to the development of long projects in the canopy field course developed in Brazil. Duration of "hypothesis and formulation" periods varies among students.

	Day						
Day period	1	2	3	4	5	6	7
Morning	Hypothesis formulation	Hypothesis formulation	Data collection	Data collection	Data collection	Data collection	Data collection
Afternoon	Discussion	Discussion	Data collection	Data collection	Data collection	Data collection	Data collection

previously chosen. These simulations included knot techniques, ascent, descent, and movements within tree crowns. Safety protocols were repeatedly stressed while practicing. The last days exposed the students to actual difficulties arising in the forest when one needs to shoot a fishing line through tree branches and then provided practice climbing selected trees. In the last day of the first period, all students were initiated in a lateral mountaineering maneuver (Tyrolean traverse), descending in top rope. This maneuver involves moving between two points by traveling across two ropes strung between them, while always staying on top of the trees.

Short Projects

Students were usually advised by professors to investigate the structure of different communities of organisms, or to examine how some abiotic characteristic varied in a short gradient of the forest. The vertical space was explored with or without the use of climbing gear to demonstrate how the tree tops are usually different from the ground in their biotic or abiotic structure characteristics.

Professors arrived one or two days before the period of short projects so that each of them could assess the area and structure the projects to be developed in a one day data collection. The students were organized in groups of four or five participants in such a way that each group contained at least one postgraduate student. Each group was supervised by a different professor each day and monitored by a climbing professional. All project goals and methods were presented to the group before the activity so that the members of the group and the climbing professional could discuss any necessary methodological adjustments. The execution of the projects was divided into data collection in the morning, data analysis during the afternoon, and report presentation in the evening. Comments and discussion of each project followed the presentations.

Usually, twelve short projects were developed during the second week of canopy field courses. In the first course, they sought to include abiotic characterization (microclimatic variations within canopy, canopy openness), spatial distribution of organisms (hemiepiphytes, epiphytes, lichens, epiphyllous, galls, and ants), reproductive allocation, and plant morphology. Studies in the canopy were enabled by a 32 m high platform existing in a Lecythidaceae (jequitibá, *Cariniana legalis* (Martius) Kuntze), by the use of climbing techniques, and the help of high pruners. Data collection was completed by ground-based observation with binoculars, trap hanging, and hemispheric photos.

Long Projects

The long projects were carried out during the third week of the course and sought to answer more complex issues (TABLE 3). As time available to data collection was longer, students were encouraged to determine the names of the species components; to accomplish projects with sufficient observations to ensure data analysis; to complement their statistical analysis to understand observed patterns; and to investigate new organisms not seen in the previous course section.

In the beginning of this last week, groups of two or three students were formed and one to two days were reserved to raise questions, to discuss, to elaborate hypotheses, and to test methodological adjustments. During the week, each professor gave a lecture as an extra activity at the end of each day. After 5 or 6 days of data collection, all students were given 20 to 30 days to send their final reports to the course coordinators.

The first field course resulted in six long projects. One explored resource utilization by birds, another the distribution of epiphytic species among trees, a third the vertical differences in distribution of organisms, plant physiology, and color preferences of fruit-attracted birds. Nevertheless, all field course versions produced approximately the same number of reports in both project periods. All reports, including figures and tables, are available in: http://www.ib.unicamp.br/profs/fsantos/ne313/

DISCUSSION

A great variety of postgraduate field courses in ecology are offered throughout Latin America. They usually seek to expose students to the conditions and challenges of field work and to the features of particular ecosystems. Furthermore, students are trained in aspects of ecological theory, scientific method, sampling design, and data analysis. However, our canopy training course differed in many aspects compared to the usual field courses.

Logistics

Besides these constraints to the execution of the project, at least one week of logistical preparation and field recognition by the climbing staff proved necessary, which increased the cost per person. The overall course costs also increased because the ecology lecturer and climbing trainers were requested to give close assistance to small student groups. In fact, the groups could not exceed 3 or 4 students because the practice of climbing involves safety, new terms, and clear explanation of equipment utilization, and demands correct climbing practices.

In addition, because all activities required the presence of both climbing experts and scientists, and because strict safety protocols had to be followed, the logistics of conducting a canopy course were made more complex. In the tropics, ecological field courses are usually organized around one-day projects, with sampling, data analysis, and presentation undertaken in the same day. However, at least twice this much time is needed to undertake the same kind of practices in the canopy because of the detailed climbing gear preparation and safety protocols to be followed. Thus, a new time schedule is recommended where students develop short projects during one day followed by a data analysis-presentation day. The timing of the course needs to be carefully planned and adjusted to ensure that the physical demands placed on students and climbing trainers are not excessive. Finally, climbing trainers were consulted and adjustments made whenever lecturers proposed a project, as to the trade-offs between potential knowledge and climbing challenges.

Field courses requiring ground transportation or long walks to the data collection spots require that research stations candidates must be assessed very carefully. To ensure that all students can leave relatively quickly the next morning, the climbing material must be made ready the previous night (which does not always happen). Nevertheless, small delays are common in the morning since the climbing material usually has to be shared by some groups in some way (for instance, one "gri-gri" and one "stop" for three groups). If morning delay is added to long transportation to and from the spot of data collection, the result is troublesome delay to data analysis and presentation of reports at day's end.

Science and Education

We trained undergraduate and postgraduate students together through the involvement of postgraduate students in the learning process of juniors. Within each group, two postgraduates were assigned the responsibility of mentoring one undergraduate. Undergraduates engaged in all project activities as assistants and were encouraged to consult the two postgraduates about any aspect of the project or methodology s/he did not understand. This process encouraged subject mastery by the postgraduate students and improved the learning experience of the undergraduates.

The development of short projects is an efficient way to teach students how to observe patterns, discuss data, and formulate hypotheses. The first Brazilian canopy course resulted in the collection of two data sets, which are being prepared for formal publication; information on poorly known groups (e.g. on the Muscidae); a demonstration of the uniqueness of the canopy fauna, at least for some taxonomic groups (e.g., the Formicidae); and the identification of some interesting and novel ecological issues (e.g., questions on fruit development, frugivory, and seed dispersal).

Night lectures are common in some Brazilian field courses because they enhance students' interest in the research projects, but these presentations are also time consuming. One of the authors (TF) has the opinion that lectures are more effective and generate more fruitful discussions in the first and last weeks, and are less effective in the second phase of the field course when data analysis is time consuming.

Participating park managers (who frequently host local school groups or tourists) and local farm owners benefited from the course, which increased their knowledge about the Atlantic Rainforest canopy. As a result, they can provide a better explanation of the canopy to the tourists who visit the area.

Canopy biology requires more precision and fewer "warming waves" (Stork 2001); scientists predict that a series of years with concentrated research will meet scientific requirements such as replication, standardization, and better data analysis over a long period of time (Mitchell 2001).

Climbing and Science

A unique feature of this canopy course was that climbing professionals (and the organizers) were responsible for the safety of more than ten people (students) engaged in a potentially dangerous practice—the tree-climbing. This responsibility required a very tight security protocol.

Perry (1978) and Perry and Williams (1981) developed the single rope technique to access the outer parts of tree canopies (Sutton 2001). This method must be accompanied by rigorous safety procedures requiring, for example, a second person with a dynamic rope to guarantee the safety of the climber. Only experienced professionals may be allowed to climb without such a partner. A full description of these safety procedures can be found in Padget and Smith (1989). Pioneer canopy ecologists overstressed the novelty and excitement of their experiences but often under-represented the safety issues. As the number of participants in canopy science expands, so does the likelihood of accident by enthusiastic but inexperienced students. Stringent safety protocols significantly reduce the risk of accidents. These issues must be reflected in the level of care taken by climbing professionals and training institutions when dealing with potentially fatal risk.

The various course versions have demonstrated that the more integration between the research coordination and climbers, the better the general conduct of the course. Generally speaking, field courses require that different people stay together for various days in (sometimes difficult) field conditions. In such situations, one needs to know the skills and limitations of each participant in the group. Thus, as for climbing activities, climbers and research coordinators must form a harmonic group that programs and discusses the activities every night, before working out the research project or climbing activity.

Another important point is that, in canopy field courses as they currently exist, experienced climbers both help during the student climbing activities and act as instructors, since the basic climbing and security rules must be fully understood by all the students. The action of climbers, who instruct students and help with climbing activities on various days, is thus clearly different from that of climbers in research projects. In the latter case, climbers do not need to deal with different groups of people on different days nor to act as instructors.

Conclusion

Our experience with canopy training courses indicates that funds necessary to run the field course for four weeks is a considerable amount in terms of Latin America (ca. U.S. $20,000–25,000). Perhaps students could be assessed fees to partially mitigate expenses.

The arrangement of groups (graduate and post-graduate students) can be easily adapted to other realities. In terms of Brazil, it was an easy way to encourage young students into ecology and canopy studies.

Based on three years of field courses and observing the different skills of students, a specific climbing training course is highly recommended because, while some students have natural climbing skills, others need more time to master the climbing techniques.

The study of canopy as a sub-discipline within ecology must be promoted. In fact, although the number of scientific publications in canopy science has grown geometrically (Nadkarni & Lowman 1995), this topic is not usually taught in regular biology courses. A regular discipline in post-graduation university courses would certainly disseminate existing knowledge, improve research projects, and establish new ecological questions.

Acknowledgements

We thank the owners of the Reserva Natural da Serra do Teimoso, Henrique and Lucélia Berbert, who hosted the 25 participants hungry for information on the field course; the field guides Chicão and Val for their generosity and kind assistance in the forest; the Global Canopy Programme and the Fundação O Boticário de Proteção à Natureza for their financial support; and the climbing teams, Soluções Verticais ltda and Jardins Suspensos-Jardinagem Vertical ltda, for their endless patience in advising all students and the large amounts of climbing gear they loaned to the field course. We are also grateful to Unicamp/Programa de Pós-Graduação em Ecologia (Dr. J.R. Trigo), which loaned a huge amount of field material; and to the Universidade Estadual de Santa Cruz/Departamento de Ciências Biológicas (Prof. L. Correa) for the loan of an infrared gas analyzer, precision scales, and line sensor quantum meter. Special thanks also to the climbing monitor Marcial C. Jorge who was contaminated by the "climbing fever," to Dr. Roger Kitching (Griffith University) for his precious comments on the manuscript; and to reviewers who improved the original manuscript.

Literature Cited

CEPLAC and IICA. 1976. Diagnóstico Sócio Econômico da Região Cacaueira. Recursos Florestais, Vol. 7. IICA/CEPLAC, Ilhéus.

Fontoura, T. and S.P. Ribeiro. 2001. Brazilian canopy workshop summaries. What's up? The Newsletter of the International Canopy Network 7(2): 7.

Hertel, R.J.G. 1949. "Contribuição à Ecologia da Flora Epífita da Serra do Mar (Vertente Oeste) do Paraná". Livre Docência diss., Univ. Federal do Paraná, Paraná, PR, Brazil.

Jardim, J.G. 2003. Uma caracterização parcial da vegetação na região sul da Bahia, Brasil. CD-ROM publication *in* P.I. Prado, E.C. Landau, R.T. Moura, L.P.S. Pinto, G.A.B. Fonseca, K. Alger, orgs. Corredor de Biodiversidade da Mata Atlântica do Sul da Bahia. IESB/CI/CABS/UFMG/UNICAMP, Ilhéus.

Landau, E.C. 2003. Padrões de ocupação espacial da paisagem da Mata Atlântica do sudeste da Bahia, Brasil. CD-ROM publication *in* P.I. Prado, E.C. Landau, R.T. Moura, L.P.S. Pinto, G.A.B. Fonseca, K. Alger, orgs. Corredor de Biodiversidade da Mata Atlântica do Sul da Bahia. IESB/CI/CABS/UFMG/UNICAMP, Ilhéus

Mitchell, A. 2001. Canopy science: time to shape up. Plant Ecol. 153: 5–11.

Nadkarni, N.M. and M. Lowman. 1995. Canopy science: a summary of its role in research and education. Pp. 609–614 *in* M.D. Lowman and N.M. Nadkarni, eds. Forest Canopies. Academic Press, San Diego.

Padget, A. and B. Smith. 1989. On Rope. National Speleological Society, Washington.

Perry, D.R. 1978. A method of access into the crowns of emergent and canopy trees. Biotropica 10: 155–157.

———. and J. Williams. 1981. The tropical rainforest canopy: a method providing total access. Biotropica 13: 283–285.

Stork, N. 2001. The management implications of canopy research. Plant Ecol. 153: 313–317.

Sutton, S.L. 2001. Alice grows up: canopy science in transition from Wonderland to reality. Plant Ecol. 153: 13–21.

Veloso, H.P., A.L.R. Rangel Filho, and J.C.A. Lima. 1991. Classificação da Vegetação Brasileira Adaptada a um Sistema Universal. Instituto Brasileiro de Geografia e Estatística (IBGE), Rio de Janeiro.