
BIODIVERSITY AT A GLANCE



São Paulo - Brazil
2006

THE STATE OF SÃO PAULO
RESEARCH FOUNDATION

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Placing a value on knowledge

From Amazonia to the Cerrado (the Brazilian savannah), from the Atlantic Rainforest to Caatinga, from the Pantanal to the Southern grasslands, Brazil displays one of the richest diversities in the world, in natural environments and in plant and animal species. Since the 18th century this variety of landscapes and ways of life has attracted European naturalists. One of them, the German botanist Carl Friedrich Philipp von Martius, wrote what is to date the most complete survey of Brazilian plants, the *Flora Brasiliensis*, based on a three-year expedition through the country's forests. Explored also by French, Russian, English and Portuguese botanists, zoologists, ethnologists and artists, these forests nowadays mobilize Brazilian specialists, who seek to get a more precise measure of this rare natural patrimony – the first step in ensuring that it can be preserved and exploited in the best possible manner.

The State of São Paulo Research Foundation (FAPESP), one of the main Brazilian agencies for promoting scientific and technological research, has played an outstanding role in this effort to map this biological diversity, which is essential for the survival of the human species. In addition to funding individual research projects that lead to a better understanding of Brazilian nature, as it has done for four decades, FAPESP contributes to the funding of multi-institutional projects such as *Flora Brasiliensis On-line*, which should facilitate world-wide research on the plants of Brazil. In other instances, FAPESP funds collective research projects of long duration such as Phanerogamic Flora in the State of São Paulo and Biota-FAPESP program.

Phanerogamic Flora in the State of São Paulo is a survey on the diversity of flowering plants – phanerogams – which began in 1994 and will not be concluded until 2016. It revealed a surprising richness in the State, where botanists found around 8000 species of phanerogams, and became a model for teamwork which led to the creation of an even more wide-ranging research program, Biota-FAPESP.

Started in 1999, Biota-FAPESP does not restrict itself to mapping and analyzing the origins, diversity and distribution of the State of São Paulo's flora and fauna. It also aims to assess the possibilities of exploiting those plants or the animals with economic potential, and to subsidize the formulation of policies for the conservation or restoration of forest remnants.

The results of research projects, such as those introduced in the following pages, are disseminated by means of scientific papers, books, internet pages, debates between specialists or exhibitions open to the public. Together, these represent the forms through which knowledge can make a contribution to the drawing up of new proposals for the sustainable use of natural resources and for a new model of social and economic development.

■ *Flora Brasiliensis On-line*

A rare work
on the internet



Cassia appendiculata



Anthurium harrisii

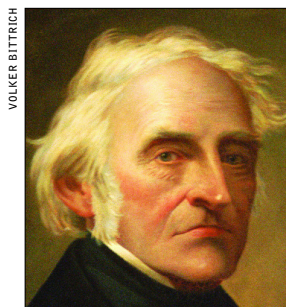


Langsdorffia hypogaea

Botany for all

Exactly one hundred years ago, in Germany, the publication of *Flora Brasiliensis* was completed, its forty volumes constituting the most complete work on Brazilian plants. Originally coordinated by the German botanist, Carl Friedrich Philipp von Martius, it had begun to be published in 1906. This rare work, of incalculable scientific value, with descriptions of 22,767 species of Brazilian plants, has become more accessible now, through the internet, thanks to the *Flora Brasiliensis On-line* project. The electronic version was planned so that specialists and the general public would feel as though they were in front of the original drawings.

Financed by FAPESP, by the Vitae Foundation Culture, Education and Social Development and by Natura Cosméticos, this work consists of two parts. The first is the development of an on-



VOLKER BITTRICH

Carl von Martius,
coordinator of *Flora
Brasiliensis*

line information system, which includes a database of the names of the species identified by von Martius or by his collaborators, linked to the images of 3,811 plates with the drawings of leaves, fruit and flowers, digitalized in high resolution. The illustrations can be consulted on the basis of the scientific name of each species or by the volume or the page of the original work in which it was described. The development and the management of the online information system is undertaken by the Reference Center for Environmental Information (Cria), which also oversees the integration of *Flora Brasiliensis on-line* with other information systems on Brazilian plants. The second part of the project, for which botanists from the Institute of Biology of Campinas State University (Unicamp) are responsible, consists in the updating of the



Caesalpinia echinata, brazilwood

scientific names of the plants – it is estimated that it will be necessary to alter half of them, given that there have been great changes in the classification of many species since the original work began to be published.

This will not be the first electronic *Flora*, given that in 1995 the French National Library placed on-line an almost complete version of the work of von Martius. The new version offers images with a high graphic resolution, linked to a database with the original names from the work, featuring the taxonomic knowledge of the era, in addition to its updated name according to current nomenclature. *Flora on-line* will be one of the bases for the integration of floristic data collection in progress in the majority of the states of Brazil. The 22,767 species described by von Martius represent the entirety of the plants known by the middle of the nineteenth century, but, according to recent assessments, such as that

carried out by George Shepherd, a botanist from Unicamp and one of the project coordinators, the diversity of plants in Brazil could be almost double and reach 50,000 species.

Sensibility and scientific rigor

When at the age of 19 he concluded his medical studies, Carl Friedrich Philipp von Martius, born in 1794 in Bavaria, could scarcely have imagined that he would become one of the greatest botanists in history and the author of a monumental work, the *Flora Brasiliensis*. Four years later, by now with some experience in botany, von Martius was chosen by the Austrian emperor to join the scientific expedition and to accompany the Austrian archduchess Leopoldina, who was to travel to Brazil to marry the future Brazilian emperor, D. Pedro I.

They disembarked on 15 July in 1817 in Rio de Janeiro, where the archduchess – who would arrive in November – remained. The naturalists – among them the zoologist Johann Baptiste von Spix – then headed into the countryside to study the tropical flora and fauna. In three years, they covered around 10 thousand kilometers of the Cerrado, Caatinga and the Atlantic and Amazonian rainforests in eight states – Rio de Janeiro, São Paulo, Minas Gerais, Pernambuco, Piauí, Maranhão, Pará and Amazonas. It was from the plant samples and the impressions recorded in this journey that, years later, the *Flora Brasiliensis* would be born.

Following the path of his fellow countryman, Alexander von Humboldt, one of the first naturalists to explore the tropical forests, von Martius believed that taste and sensibility are inseparable from knowledge. As a botanist, doctor and anthropologist, he wrote about inhabitants and described not only the plants but also the forest compositions – or physiognomies – typical of Brazil. He was one of the first to attribute the predominance of one species or another of tree to the climate, to the soil or to the topography. Von Martius was passionate about palm trees, to which he dedicated the three volumes of his other great work, the *Historia Naturalis Palmarum*, written in Latin and published between 1823 and 1853.



Vegetation on the outskirts of the city of Rio de Janeiro (*in the background the aqueduct*), as drawn by Benjamin Mary

Forty volumes in 66 years

Returning to Germany in 1820, von Martius dedicated the next 48 years of his life to writing about the discoveries he had made in Brazil. His most extensive work, the *Flora Brasiliensis*, began to be published in 1840 with the support of Ferdinand I, emperor of Austria, Ludovico I, king of Bavaria, and Dom Pedro II, emperor of Brazil. The work does not just contain plant descriptions. In a fascicule of the first volume published posthumously in 1906, von Martius presents the 59 *Tabulae Physiognomicae* (physiognomic engravings), in which he describes the principal types of vegetation native to Brazil – Cerrado, Caatinga and the Atlantic and Amazon rainforests – a classification still valid today. The descriptions are illustrated with pen-and-ink drawings made by a team of illustrators such as Thomas Ender and Benjamin Mary

and enriched with quotations from Plato, Goethe and Socrates.

To continue the publication, von Martius formed a body of editors and collaborators, which ran to 65 botanists from various countries. He edited the first volumes himself, until he died in 1868; August Eichler continued his work and Ignatz Urban completed it in 1906. The complete collection contains 20,773 pages, 3,811 plates and describes 22,767 species of plants.

The majority of the 20 thousand or so plant samples collected by von Martius in Brazil and which served as the basis of the Flora can be found in collections maintained in Munich (Germany) and Brussels (Belgium), with duplicates in Kew (England), Leiden (Holland) and Leipzig (Germany).

■ Phanerogamic Flora in the State of São Paulo

The flower of the earth

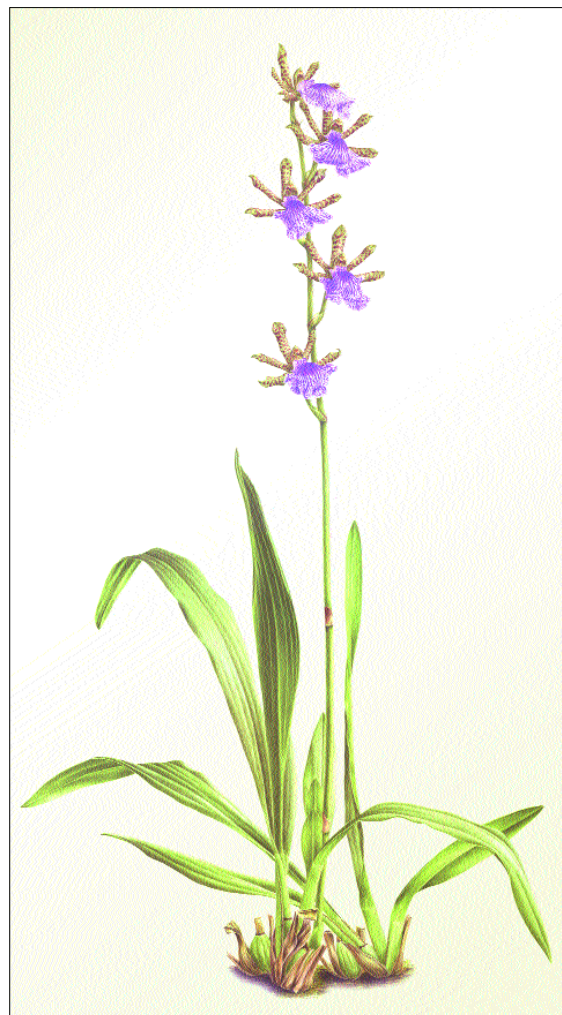


J. H. A. DUTILH

Lilium formosanum



Pseudobombax grandiflorum



Zygopetalum mackaii

Two thirds of the flora of Europe

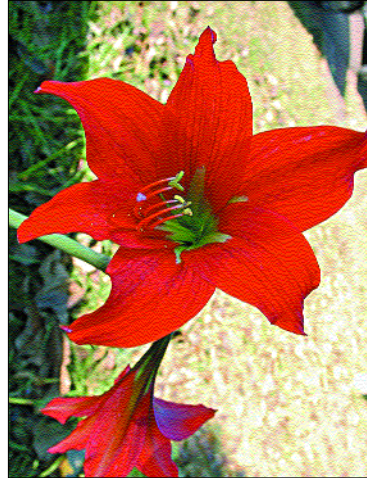
“In numbers of species”, estimated the Scottish botanist George Shepherd, professor in Campinas State University (Unicamp), when he introduced the fourth volume of the collection *Phanerogamic Flora in the State of São Paulo*, in June 2005, “São Paulo is home to two thirds of the flora of Europe”. Phanerogamic Flora is also the name of the most comprehensive mapping of native vegetation in the state. Prepared by around 250 botanists from eight research institutions in São Paulo, in other Brazilian states and abroad, it began in 1994 and then became a model for joint-working which, a few

years later, would serve as inspiration for the Biota-FAPESP program.

Based on almost 60 visits to collections maintained in herbaria and on around 20 thousand samples collected in more than 500 field trips, the botanists calculate that São Paulo, even though it has been fairly significantly cleared of forest, is home to around 1500 genera and 8000 species of phanerogams, as the flowering plants are called, which account for 80 per cent of the state's flora – excluded from this inventory are merely the cryptogamia, as flowerless plants are called, such as mosses and ferns. All throughout the survey, the Flora



V. BITTRICH

Nymphoides indica

J. H. A. DUTILH

Hippeastrum reginae

J. H. A. DUTILH

Nothoscordum gracilis

V. BITTRICH

Eichhornia azurea

G. J. SHEPHERD

Hypoxis decumbens

V. BITTRICH

Dichorisandra incurva

team rediscovered species which were presumed to be extinct, and identified at least another 50 unique to the state.

New species appear even in the region of Greater São Paulo, for example *Ocotea curucutuensis*, a cinnamon tree up to 10 meters in height, and a passion fruit with light pink petals, the *Passiflora ischnoclada*. Among the archives of historical collections of herbaria such as those of the Botanical Institute, the researchers also found records of dozens of plants which have never been seen again.

A brainchild of the botanist Hermógenes de Freitas Leitão Filho, who died in 1996 during a botanical field trip, the Phanerogamic

Flora project has served to update the list of species threatened with extinction in the state: in 2004 this numbered 1020 species, three times more than in the previous report, six years previously. Since it indicates the geographical distribution of the plants, it serves also as a guide for more effective environmental conservation policies, capable of protecting the natural environments and the most fragile species. "The work is far from over," says Maria das Graças Lapa Wanderley, a researcher from the São Paulo Botanical Institute which shares the coordination of the project with Shepherd. The fifteenth and final volume of the collection should appear in 2016.

■ Biota-FAPESP

Diving into biodiversity



JOSÉ CEZAR NOLASCOPEIXES DE RIACHOS DA MATA ATLÂNTICA

Male of the killifish (*Leptolebias aureoguttatus*)

The fruits of a bold proposal

On the morning of 25 March 1999, the Biota-FAPESP program was publicly launched as “the most ambitious biodiversity program ever developed in Brazil”. Years later, it can be seen that there was no folly or exaggeration in this description of the Research Program into the Conservation and Sustainable Use of the Biodiversity of the State of São Paulo – or Biota-FAPESP, the Virtual Institute of Biodiversity. Up until the beginning of 2006, biologists had found at least 500 new species of plants and animals which reveal a hidden biological wealth in the almost 250 thousand square kilometers of the State of São Paulo – an area slightly larger than the United Kingdom.

A team coordinated in the first five years by the botanist Carlos Alfredo Joly, from Campinas State University (Unicamp), proposed to collect, organize, complete and analyze the State of São Paulo’s fauna and flora, including microorganisms, invertebrates and vertebrates and plants, from the most insignificant to the most imposing, not forgetting marine creatures nor the interactions between animals and plants. The biologists determined also to study the mechanisms that generate, maintain or reduce biodiversity – in this case quantifying the losses of plant or animal species throughout the history of the most populated and industrialized state in Brazil.

The researchers, who on that Thursday morning occupied the FAPESP auditorium, witnessing the birth of a collective project that had begun to be planned three years earlier, knew that there was no model to follow: no other group had ever demonstrated the courage to embark on such a broad enterprise. But the mobilization was intense. Biota-FAPESP brought together specialists from every public university and from some private ones in the state, from state and federal research institutions, from non-governmental organizations and from international institutions. They were botanists, zoologists, ecologists, forestry engineers, economists and geographers who integrated their research activities



EDUARDO CESAR

and explored the São Paulo state territory in every possible direction, in search of plants, animals or biological phenomena hitherto unknown.

Five years later, boasting a coordinating team of six researchers and headed by Ricardo Ribeiro Rodrigues, from the University of São Paulo (USP), the team which had started out with 200 members now numbered around 1000 (of which 800 researchers and students in São Paulo, 80 from other states and around 50 from abroad). And it was yielding an intense academic production, which by the end of 2005 had reached 514 scientific papers and 112 masters or doctoral theses.



MIGUEL BOYAYAN



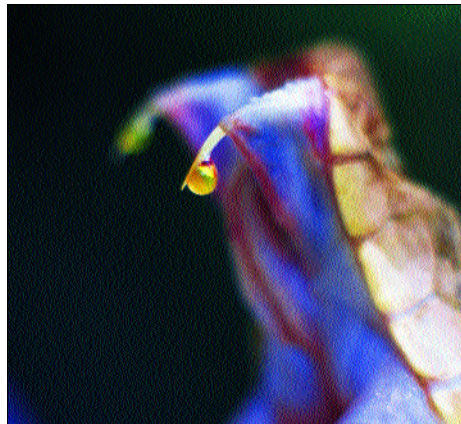
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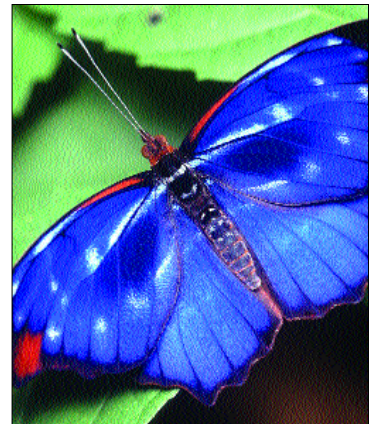
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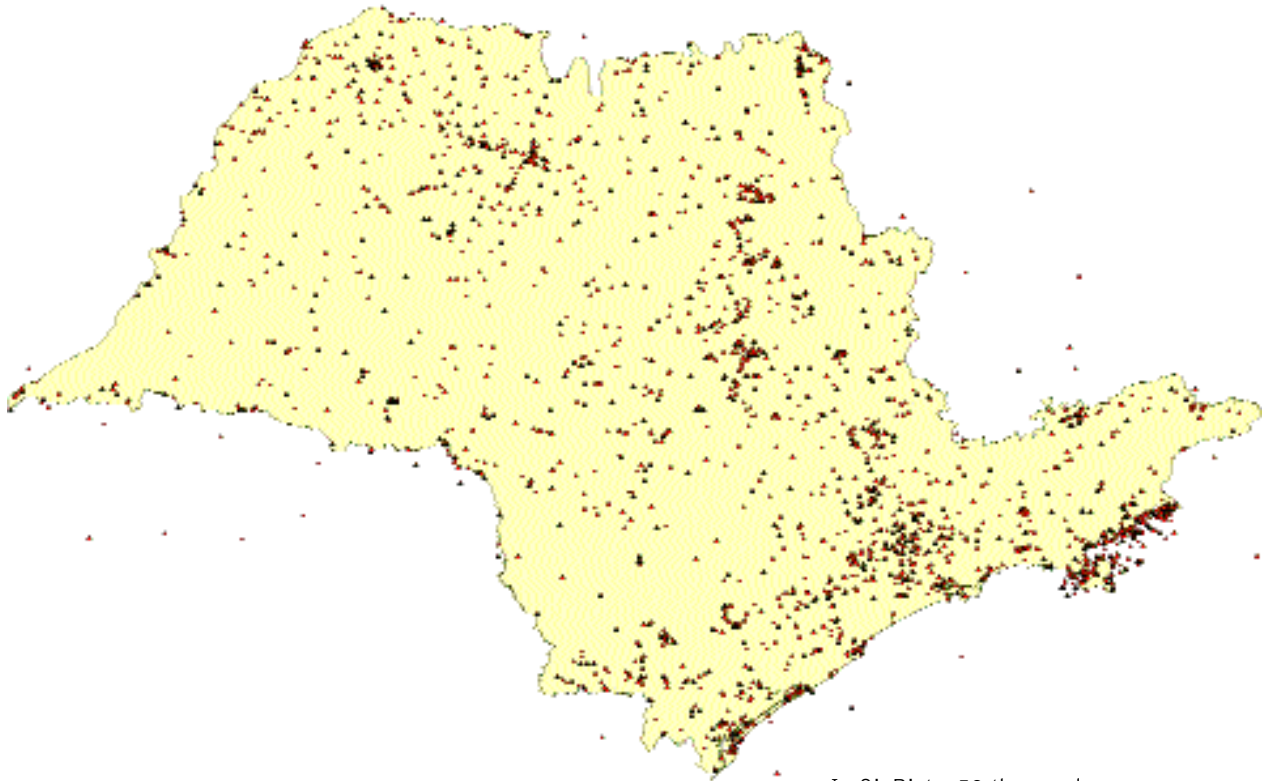
FABIO COLOMBINI

The discoveries attained even greater visibility thanks to a photographic exhibition *Biodiversity in the State of São Paulo – Colors and Shades*, seen by 75 thousand people in four cities across the state in commemoration of the program's first five years. Results are also circulated through the magazine *Biota Neotropica*, the program's medium for scientific dissemination.

It is not just scientific findings that are collected, because the researchers from FAPESP-Biota also seek applications which help to add value and to maintain biodiversity. It is for this purpose that they study microorganisms that may be exploited

industrially and they investigate plants and animals for chemical compounds which may lead to new pharmaceuticals. Dividends are beginning to emerge, through such projects as *BIOprospecTA*, one of the study areas outlined below which gives an indication of the very diversity in the program's research activities.

Biota/FAPESP has been an inspiration for surveys of flora and fauna in other states of the country and has supported public strategies for environmental planning and sustainable development, by indicating priority areas for the conservation and restoration of remnants of native vegetation in the state.



In SinBiota, 52 thousand precise records from collections of 6,000 plants and animals, in the state of São Paulo

Integrated discoveries

When studying the composition of plants of a forest or going out in search of new species of vegetation or animals, biologists in the state of São Paulo are apparently doing the same as French, Portuguese, German or Russian biologists who traveled throughout Brazil and created the roots of botanical research in the country. However, today's expeditionaries have at their disposal equipment which determines their exact location, as well as satellite images which provide a panoramic view of the region to be explored. Another difference is that information from

the data collected in the field, in the case of Biota-FAPESP, is incorporated to electronic databases. The results of the expeditions can thus be shared and analyzed also by other specialists, in addition to revealing the areas most under threat or the richest in animal and vegetal species.

The scientific records from Biota-FAPESP research activities are stored in two databases. The first is the Biota-FAPESP program's System for Environmental Information (SinBiota), established in 2001 for the purpose of recording surveys of plants or animals carried



Massuo Kato
of USP, collecting
apocynaceae leaves

out in the State of São Paulo. SinBiota holds around 52 thousand records with geographical coordinates of 6000 species, which can be consulted on the basis of the scientific name of the plant or animals, the name of the collector, the location or the date of collection. It is possible to see also the geographical distribution of the collection points for one or more species since SinBiota is constructed on a cartographic base representing remnants of native vegetation, reforested areas with exotic species (*Pinnus* and *Eucalyptus*), conservation units, and the network of rivers, roads and urban areas. This is the second database: the Biota-FAPESP program Atlas which incorporates the São Paulo Forest Inventory, a survey coordinated by the Forestry Institute. Created on the basis of surveys in the field, from aerial photos and satellite images, the Inventory monitors the area covered by remnants of native vegetation in the state, which presently amounts to 13 per cent of the state's territory. Each ecosystem presents situations that are even quite contrasting: while the Atlantic Rainforest recovered 2.86 per cent of its lost area in the last ten years, the Cerrado shrank drastically, progressively replaced with grazing lands and sugar plantations.

Recently, within SinBiota SpeciesLink was developed which is a gateway for information on more than 700 thousand collection records of microorganisms, plants and animals contained in the biological collections of museums and research institutions in São Paulo, in other Brazilian states and even abroad. Another way in which specialists – and even non-specialists – share discoveries about national biodiversity is the electronic magazine *Biota Neotropica*. Launched in 2001, it is now integrated in international databases of scientific journals such as *Zoological Record* and the *Directory of Open Access Journals*.

Links weakened between animals and plants

Interactions – between animals and plants, between species of animal, between plants or between human beings and natural spaces – provide Biota-FAPESP with a fertile field for study and discoveries. Between living creatures, there are intricate, subtle and inevitable relationships of dependence – which when broken, all lose out, as is demonstrated in the studies undertaken by the teams of Mauro Galetti, from the Biosciences Institute of the Paulista State University (Unesp) in Rio Claro, by Wesley Silva and by Thomas Lewinsohn, from the Biological Institute of Campinas State University (Unicamp), and by Jean Paul Metzger, from the University of São Paulo’s Biosciences Institute (USP).

Hunting, extractivism and principally the fragmentation of natural landscapes, caused by deforestation and by the expansion of cities and agriculture, break down the interaction between species in a manner which is difficult to put right, since millenary cycles of living alongside each other may be lost: birds, monkeys, rodents and bats feed on fruits from the forest trees and, inversely, the trees rely on the animals to spread their seeds in spaces where they may grow with less competition. In one study, the Unesp team confirmed that the majority (86 per cent) of the 2,500 species of trees in the Atlantic Rainforest adapted to dispersal by animals, mainly birds and mammals. Since they are small – on average, almost 2 centimeters –, the fruits, with their seeds, can be ingested and spread by a large number of animal species, even of small proportions, such as birds.

Biologists and ecologists examined ten remnants of continuous Atlantic Rainforest on the coast of the State of São Paulo and estimated the abundance and density of large birds such as the piping guan, the dusky-legged guan and the tinamou, and of mammals such as the woolly spider monkey, the red howler monkey, tapirs, pacas, squirrels, boars and the felines, that feed on fruits of the forest. The disappearance of these animals – and many of these species are considered to be under threat of extinction



MAURO GALETTI/UNESP



EDUARDO CESAR

The agouti, responsible for the dispersal of seeds from the jatoba tree, opposite

– could render the Atlantic Rainforest an *empty forest* – apparently complete but without pollinators and dispersers of seeds and, thus, under threat and lacking in the conditions to sustain itself in the long term.

“The high levels of deforestation have caused the marked decline of animal and plant species”, comments Galetti. “But the worst of the extinctions few people notice: it is the loss of the interactions between animals and plants, which are responsible for the maintenance of the forests.” The conclusions warn of the specific fragilities of each environment and may help in the monitoring and in the conservation plans – not just for the forests in the state of São Paulo, but also those of other ecosystems in Brazil which live under similar threats. In Amazonia chestnut trees age with a reduced chance of renewal because the extensive exploitation of the Brazil-nut tree (*Bertholletia excelsa*) threatens the survival of the agouti (*Dasyprocta spp*), the main disperser of chestnuts.



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Seeds of preservation

Researchers in the State of São Paulo have been working for years to better understand biodiversity and to propose new conservation strategies for the Cerrado. Native vegetation found in the dry areas in the interior of the state and the Western Central area of Brazil, only fragments of which remain between plantations and grazing lands, the Cerrado is also one of the four types of forest in the state of São Paulo which are part of the Parcelas Permanentes (Permanent Lots) project, which monitors the changes over time in the composition of the vegetation with the aim of studying the mechanisms which generate biodiversity.

One of Biota-FAPESP's first projects tackled precisely the viability of conservation of the remnants of the Cerrado, which at present covers merely 1 per cent of the state's territory – and only about half of this is protected by conservation bodies. Under the coordination of Marisa Dantas Bitencourt, from the University of São Paulo's Institute of Biosciences (USP), this study brought together biologists, forestry engineers, agronomists, economists and a geographer, who evaluated the state of conservation of the remnants and the socioeconomic profile of the neighboring communities.

“We discovered the hidden treasure in each of the areas which appear as dots on the state map”, reported in 2001 Giselda Durigan, a researcher from the Forestry Institute, and Marinez Ferreira de Siqueira, a biologist from the Reference Center for Environmental Information (Cria), who participated in the project and explored 86 fragments of the Cerrado. They also established that there no longer exists a culture of the Cerrado. “With rare exceptions, even the people who live alongside the remnants are unfamiliar with the plants. We saw pequi fruit rotting on the ground because few people knew it to be edible.”

Even so, as Marisa Bitencourt's team confirmed, the potential of the Cerrado is immense: around 80 common species offer economic potential and a further one hundred could have medicinal use. In another study, Marcos Buckeridge and his group from the Botanical Institute (IBt) demonstrated that the

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Commelina nudiflora



Ormosia arborea

PHOTOS MARINEZ FERREIRA DE SIQUEIRA

Dense woodland,
one of the features
of the Cerrado

seeds – at present thrown away – of a tree common to the Cerrado, the *Dimorphandra mollis*, are rich in galactoman, a type of complex sugar chemically identical to the guar gum used as a thickening agent in yoghurts and ice creams or as capsules for medicines – and almost all imported. “The yield of galactoman from the seeds of *Dimorphandra mollis* is among the highest ever found in nature”, says Buckeridge, who developed a method of extraction of this carbohydrate which results in a powder with 83.2 per cent purity. In the case of seeds from the *Hymenaea stigonocarpa* around 40 per cent of the dry weight is made up of a carbohydrate known as xyloglucan which affords greater mechanical resistance to paper.

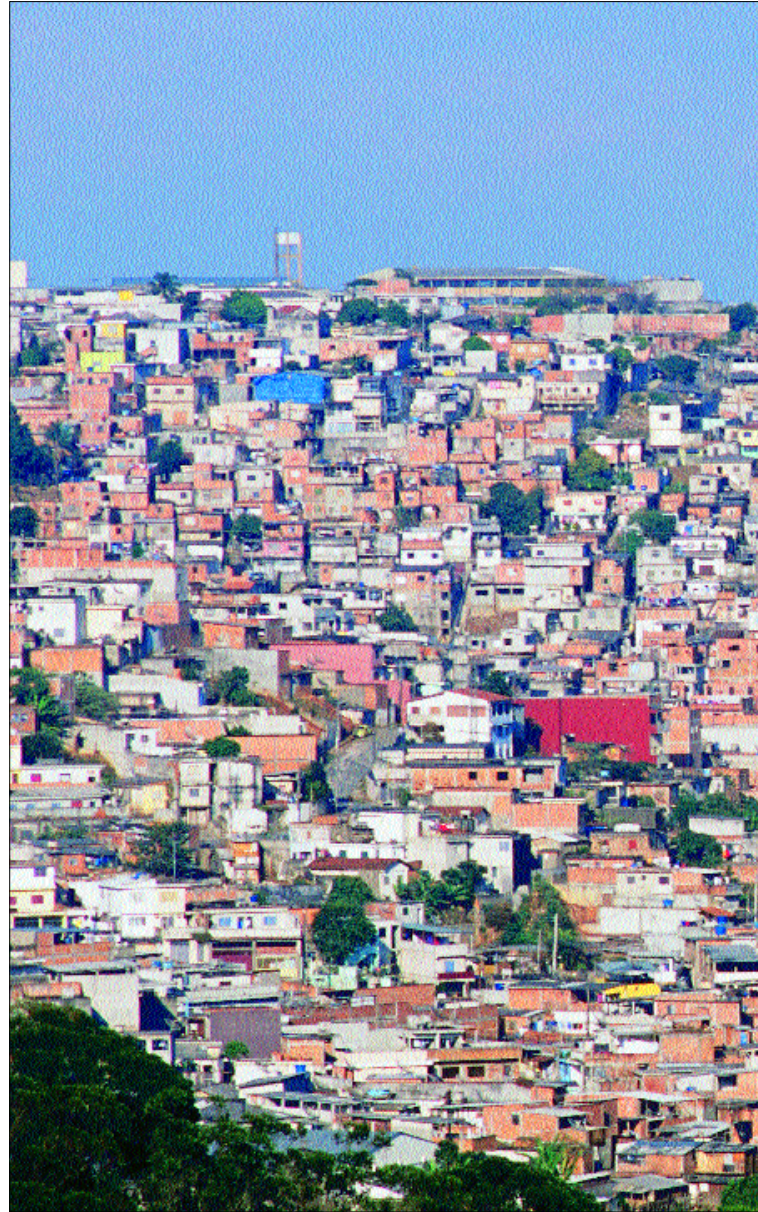
But the areas presently occupied by Cerrado in the State of São Paulo are insufficient to allow the rational exploitation of native species, concluded scientists, entrepreneurs and representatives of the government in a workshop coordinated by Marisa Bitencourt and Marcos Buckeridge in 2002 in the city of Atibaia, in the interior of the State: it is necessary in the first instance to implement a program of recuperation of that vegetation, piecing fragments together and promoting the planting of native species, in order later to implement the sustainable use of the trees. Conservation studies are proceeding in parallel with those dedicated to botany. In a more recent study, Silvia Rodrigues Machado’s team, from the Institute of Biosciences of the Paulista State University (Unesp) in Botucatu, is characterizing the astonishing variety of anatomical structures and the resourcefulness which permits the roots, stalks and leaves of the plants of the Cerrado to take maximum advantage of the scarce water.

The scarce green of the metropolis

Over almost 500 years of life, the city of São Paulo has gradually replaced its fields and woodlands with houses, high-rise blocks and industrial premises – between 1990 and 2000 alone, a fifth of its woodland was lost. At present, 200 square kilometers of untouched vegetation remain in the municipality, the equivalent of 13 per cent of its territory (1,512 square kilometers), according to the *Environmental Atlas of the Municipality of São Paulo*, a survey which did not restrict itself solely to the vegetative cover of the largest city in Brazil, which shelters 10 million inhabitants. The *Environmental Atlas* also recorded the fauna – it was never imagined that there would still be monkeys and so many birds in the parks of the metropolis – and the socioeconomic aspects of use and occupation of the soil.

Field surveys and analysis of satellites images showed that the green areas diminished throughout the municipality, but the loss was greater in the peripheral neighborhoods, in the Eastern zone and especially in two vital areas: the Cantareira range and the surroundings of the Guarapiranga reservoir. “These are two areas protecting water sources, close to the rural area, which suffer from the pressure of urban occupation without any planning”, commented the geologist Harmi Takiya, from the Secretariat for Green and the Environment, coordinator of this survey, carried out between 1999 and 2003. The results suggest actions which go beyond the mere recovery of the degraded areas. “The preservation of the vegetation is related to investments in education, health, housing and income distribution”, observes a teacher from the University of São Paulo’s Institute of Biosciences (USP), which collaborated on the project.

Also lost was a little of the lyrical character of the city which until the 60s was known as the Land of the Drizzle due to the fine persistent rain which contributed to a cooler climate than the present one: the mean temperature rose 1.3° Celsius in the last decades. There is also greater variation: in the city of 77 climates, the difference in temperature can reach ten degrees at the



same time between two close points, such as the Tietê Ecological Park and the Tietê Marginal, ten kilometers apart.

One of the main causes of the size of the variation is deforestation, associated with the creation of clandestine lots and favelas which propagate on the edges of the city. Added to this is the impermeabilization of the ground – São Paulo today has 60 thousand kilometers of asphalted roads, which retain heat and make the city hotter – and the strong influence of the daily circulation of 3 million motor



MIGUEL BOYAN

Serra da Cantareira: a natural vegetation reserve which loses space as the city of São Paulo expands

vehicles in the city, which generate heat through the burning of fuels and emit 2.6 million tons of pollutants into the air each year – and, the more smoke in the air, the greater the heat.

Trees are concentrated in 39 state and municipal parks and in a few neighborhoods – Jardins, Pinheiros and Morumbi, in the Western zone, and Moema, in the Southern zone closest to the Center. But as you head in the direction of Capão Redondo and Jardim Ângela, in the heart of the Southern zone, the

longest arm of the city, about 20 kilometers from the center, trees are few and far between. The space is taken by a horizontal completely urban landscape, with few high-rise blocks and striking complexes of precarious housing – and the temperature rises, slowly. Those who suffer are the inhabitants of the favelas and the tenements, continually pushed out to regions ever more distant from the center. Their homes, ill-equipped to cope with oscillations in temperature, are like ovens during the day and ice-boxes at night.



Rich and threatened rivers

The biodiversity of the São Paulo state fauna of freshwater fish is much greater than was imagined. In 2000, ten new species were found in only three kilometers of some streams and headwaters of the Alto Paraná basin, the largest in the state. 30 other stretches of river in the state revealed more than a dozen previously unknown species. One of the discoveries is that an abundant species, the yellow-tailed lambari, 8 centimeters in length, was, in fact, a new species, which was given the name *Astyanax altiparanae*.

“The yellow-tailed lambari is an omnivorous fish, which tends to feed on insects, but is capable of using practically all available foods,”



A new species of *Planaltina*

explains the coordinator of the survey, Ricardo Castro, a biologist from the University of São Paulo (USP). There are at least two dozen species exclusive to the state, found mainly in streams. However, there are reasons for concern, as was demonstrated in another study, headed by Lilian Casatti, from the Paulista State University (Unesp) in São José do Rio Preto. The construction of barriers, the intensive use of agricultural pesticides and fertilizers, the destruction of the natural vegetation and the introduction of exotic species have had a catastrophic impact on the number of species of fish in the rivers of the Alta Paraná basin, in the



FOTOS RICARDO M. CORREA E CASTRO/USP

Headwaters of the Alto Paraná basin, one of the largest in the state of São Paulo, Brazil



Another new species, of *Corydoras*



Yellow-tailed lambari

north-east region of the state, making actions of environmental recuperation a matter of urgency.

The study of algae in the State of São Paulo, also showed richness, a loss of species and environmental degradation. The biologist Carlos Bicudo, from the Botanical Institute (IBt), upon completing the mapping of algae in São Paulo state territory, increased from 2200 to around 5500 the number of species, the sizes of which vary from 0.002 millimeters of algae of the genus *Diogenes*, found in stagnant freshwater, up to 2 meters in the case of characeae. The study of algae also reveals the ever more frequent contamination of rivers,

lakes and reservoirs, because the very occurrence of one species or another indicates the state of environmental conservation: the *Cyanophyceae* (blue algae) and the *Euglenophyceae*, for example, grow more easily in environments polluted by sewers, rich in nitrogen and phosphorous, while the *Bacillariophyceae* or diatomaceae only live in clean waters. In another study, a team coordinated by Evaldo Espíndola and by José Galizia Tundisi, from the International Ecology Institute (IEE), shows how and to what extent contamination from residential and industrial waste harms the biological diversity of aquatic microorganisms.

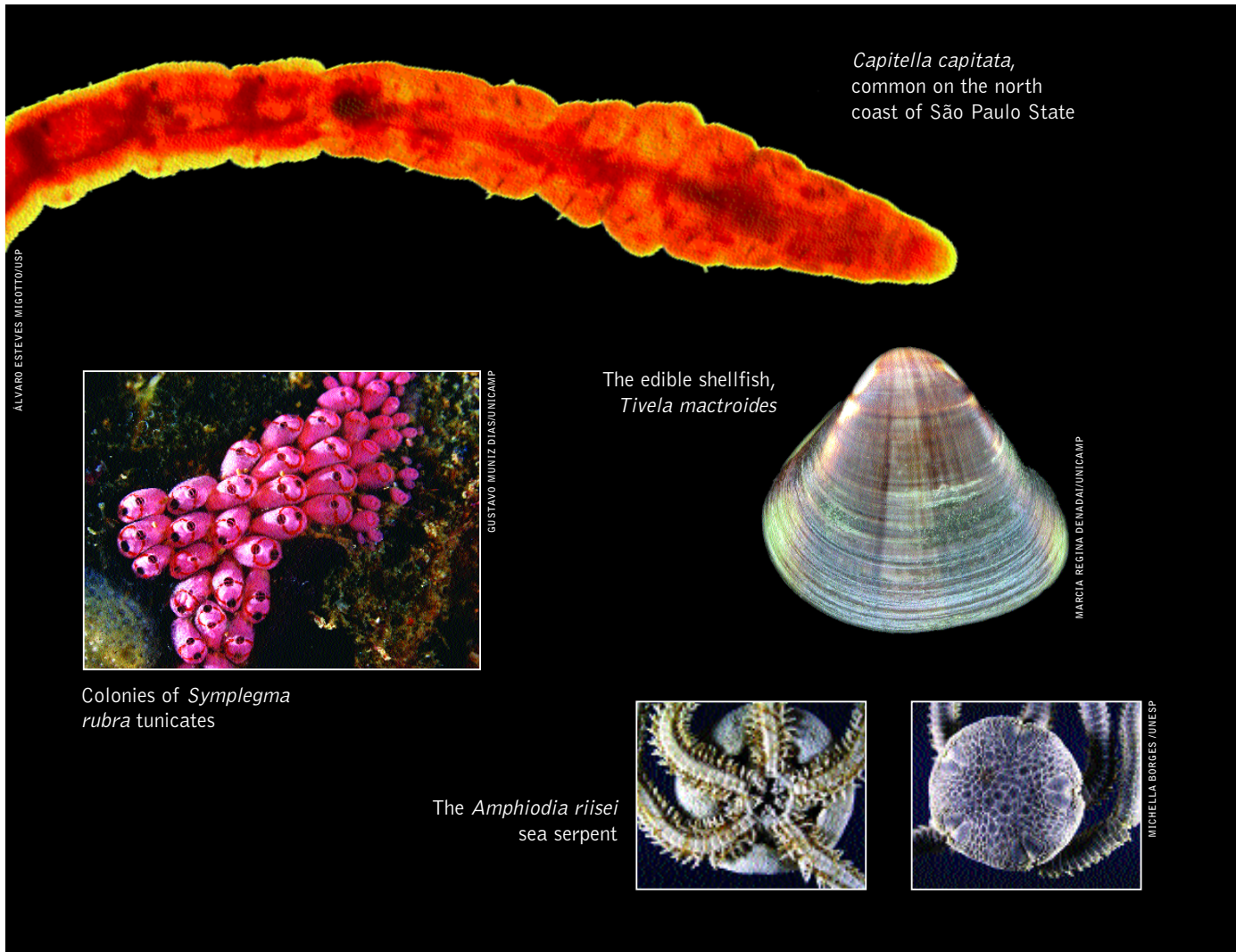
Inticing and surprising sea creatures

Many of the invertebrates animals that live concealed in the sand of beaches, incrusted on the rocks of wild coastlines or hidden in the depths of the sea, along the São Paulo shore, are new to science. They are such intriguing creatures as the reddish colonies of tunicates of *Symplegma rubra* or a sea serpent, the echinoderm *Amphiodia riisei*, which came to light on São Paulo's northern coast, as a result of a survey coordinated by the biologist Antonia Cecília Zacagnini Amaral, from Campinas State University (Unicamp).

To the discovery of such unexpected

diversity should be added an awareness of environmental imbalances. For example, the abundance of the reddish worm *Capitella capitata* in the Caraguatatuba inlet indicates intensive discharge of domestic sewage. Already the *Isognomon bicolor*, an exotic species of bivalve mollusk found along rocky coastlines which probably arrived by means of the ballast waters of ships, appears to be occupying the space of other species of commercial importance, such as the *Perna perna* mussel, a source of income for the local communities.

Not only exotic species, but also the



construction of houses and the extraction of sand and granite are impoverishing the diversity of animals that thrive on the rocky coastlines, environments which are biologically precious since they represent the transition between terrestrial and aquatic milieus. Seen as an extension of the ranges which occupy the sea floor, wild coastlines form micro-habitats rich in species of algae – green, red, dark brown or blue –, sponges, sea-urchins, cnidarians, mollusks, crustaceans and fish. Flávio Berchez, who with his team from the Institute of Biosciences of USP developed

a methodological approach for the mapping of rocky coastlines, described the communities of around 6 kilometers of coastline and found around 70 types of population, each one of them generally dominated by a single species. Currently, Maria Célia Villac and her group, from the University of Taubaté (Unitau), are investigating the ecology and the impact of potentially harmful micro-algae found on beaches of the northern shore of the State of São Paulo. This fieldwork has also contributed to the research undertaken by the Butantan Institute into micro-algae toxins and poisons.



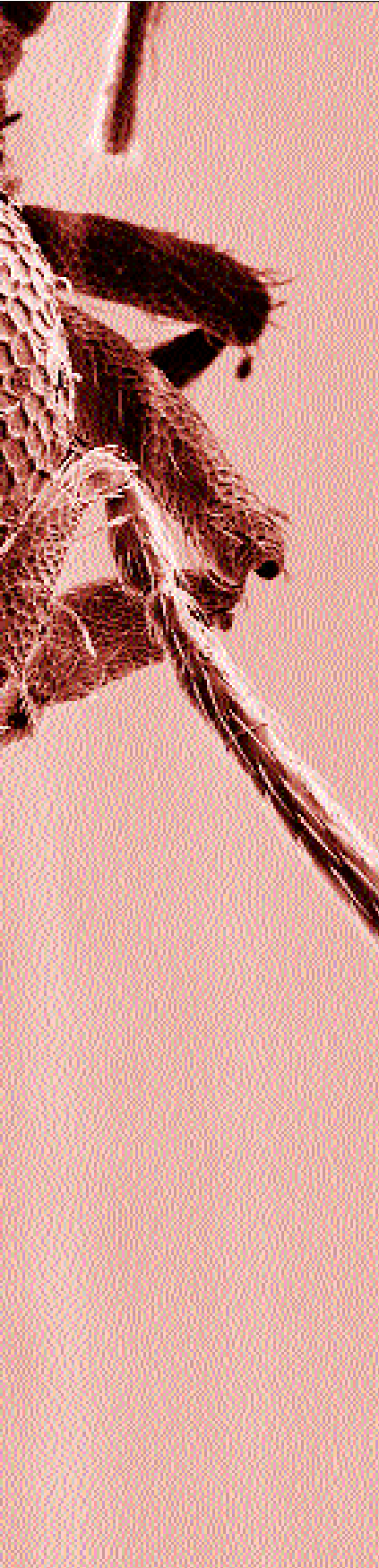
The *Diopatra cuprea* worm, that reaches up to 15 centimeters in length

Miniscule, hidden and essential

After four years of work, Antonio Domingos Brescovit and his team from the Butantan Institute added to biological collections around 15,000 spiders, 2000 scorpions, 8 thousand opilios, 1500 pseudo-scorpions, 5000 mites, and 1500 myriapods – and this was just a part of what they collected in the 30 expeditions to the Atlantic Rainforest and another 12 to the Cerrado, from where they brought back around 90 thousand adult arachnids, a group of animals which for the majority of people arouses little sympathy, though they carry out valuable ecological exercises, such as the control of insect populations. This was one of the largest data collection exercises ever carried out on arachnid and myriapod fauna in the state of São Paulo and in peripheral states, which will also contribute to the historical recordings of distribution of species, organized through the project with data dating back to 1767. Biologists believe they have found at least 85 probable new species, half of which in the state of São Paulo.

In parallel, a team coordinated by Carlos Roberto Brandão, a biologist from the Zoology Museum of the University of São Paulo (USP), examined 26 areas of preserved Atlantic Rainforest in 10 states – Santa Catarina, Paraná, São Paulo, Rio de Janeiro, Espírito Santo, Bahia, Sergipe, Pernambuco, Alagoas and Paraíba. The biologists collected 1400 samples from one square meter of the layer of soil closest to the surface and from the covering of dry leaves, the so-called *serapilheira* or undergrowth, in which are concentrated 60 per cent of the species known as ants. 410 species of ant have already been identified in the Atlantic Rainforest, but it is estimated that the coastal forest may harbor up to 1000 species – values which mark it out as one of the richest environments in ant species in the world. Two of the most common species of ant, which are also among the most common animals in the Atlantic Rainforest, are the *Pheidole flavens*, with workers of less than a millimeter in length, found in almost 2 out of 3 meters studied, and the *Pyramica denticulata*, also millimetric, with workers endowed with very long jaws and a heart-shaped head. These insects also prove to be one of the best indicators of biological





The *Pyramica denticulata*, one of the most common species in the Atlantic Rainforest



Jessica osoriana, common in São Paulo

diversity: in any place, the more there are of these species, the greater likelihood of other species of invertebrates and vertebrates.

Butterflies and moths

A team from Campinas State University (Unicamp) coordinated by Keith Brown Jr., worked with local butterfly and moth communities, which comprise the category of Lepidoptera – in six years, around 5000 species were recorded in 80 localities in the state of São Paulo. A study by Brown, Márcio Uehara-Prado and André Freitas demonstrated that each type of vegetation possessed its own Lepidoptera fauna, with greater richness – and higher than expected – in partially disturbed natural regions, such as in the surroundings of Paranapiacaba, Atibaia, Itirapina and Cotia, where the native vegetation was mixed with orchards, vegetable gardens, small farms and regenerated or reforested areas. One explanation for this phenomenon is that, as the original vegetation was being transformed, micro-environments were created which became home to species that would not normally live there, while the species more sensitive to variations in light and humidity disappeared.

The biologists in this group believe that it may be possible to recognize typical communities of Lepidoptera according to each place or vegetation and understand how they adapt to forests that are more humid or drier, at a higher or lower elevation, more preserved or disturbed in the state of São Paulo. In this way, it becomes easier to develop management plans for these fragile fauna and for the Atlantic Rainforest and the Cerrado themselves, defining the limits of human disturbance.



FABIO COLOMBINI

Hyla albomarginata

Amphibians from 1 to 30 centimeters

In 1998, in the State of São Paulo around 180 species of anurans had been identified – the most diversified and well-known group of amphibians, comprising toads, frogs and tree frogs. Seven years later, towards the end of the extensive survey carried out by the team coordinated by Celia Haddad, from the Biosciences Institute of the Paulista State University (Unesp), the diversity of anurans from areas within the State of São Paulo had reached 250 species, equivalent to a third of the species known in the whole of Brazil. Among these animals there is notable variation in size and habits – from the aqua-toad (*Bufo schneideri*), a toad from the lakes and creeks of the Cerrado and the Atlantic Rainforest of up to 30 centimeters in length, to the flea-frog (*Brachycephalus hermogenesi*), the adult of which attains around 1 centimeter and which lives among the dead leaves on the floor of the thickets of the Atlantic Rainforest. Another astonishing fact is that almost 20 per

cent of the species are endemic – they do not occur in any other place.

Such richness results from the variety of environments and micro-environments of the state, which all along the coast is home to dense and humid forest – ideal for these animals which spend a part of their life in water and are able to take advantage also of the isolation afforded by the mountainous terrain – while in the interior of the state the woodlands are drier and more open, with a lesser diversity of anurans. Yet, given their dependence on humidity, the anurans are also the group that most readily offers evidence, in the form of declining populations and extinction, of the environmental transformations which result from the loss of natural vegetation. Very rarely do species from enclosed forests manage to adapt to open environments. Biologists estimate that, on account of deforestation, there has been a considerable loss of diversity of species, even before they have come to be known.



Cerdocyon thous, bush dog



PHOTOS FABIO COLOMBINI

Callithrix penicillata, black tufted-ear marmoset



Blastocerus dichotomus, marsh deer

Under the influence of neighboring regions

Biologists from the Zoological Museum of the University of São Paulo (USP) worked hard trying to explain why elephants exist in Africa, while in South America the largest mammals are tapirs. Mário de Vivo, with his team, concluded that so-called mega-fauna became extinct here due to climate changes and their effect on the vegetation: the increase in rainfall reduced the area occupied by savanna vegetation. Although Africa was subject to the same climatic alterations, larger animals survived in areas such as the Sahara desert, which was transformed into savanna receiving more rain.

It is known that the forests in the State of São Paulo are home to almost 200 species of mammal – the majority are bats – and they are subject to influences from neighboring regions. São Paulo shelters monkeys which also live in states to the east, north or west, wild dogs found on the edges

of Amazonia and rodents in common with the south of the country. The team from USP demonstrated that the fauna of mammals from the Atlantic Rainforest is composed of an overlapping of different fauna that evolved in different ecosystems: an autochthonous fauna has been living in the Atlantic Rainforest for a long time, another fauna occupies the pockets of open vegetation, as though the expansion of the forest had captured it, a third, of temperate origin, displays relationships of common origin with the fauna of the south of the continent and, finally, animals that came from Amazonia and have yet to become differentiated. These discoveries formed the basis for a long-term program for monitoring mammal populations which will permit the evaluation of the real state of the conservation of the biota and the effect of human activity in the course of time.



José Santana, from Iporanga, making a basket with soapberry liana fiber

Among traditional communities

The inhabitants of so-called traditional communities are traditionally viewed in passive mode – or, at best, as secondary players – in environmental conservation plans. Frequently, their agricultural and extraction activities are considered to be the root cause of impact on conservation areas or close-lying areas. However, studies developed within the ambit of the Biota-FAPESP program suggest the opposite: in many cases, these groups of descendants from native indigenous populations and from Portuguese colonizers are essential players in the conservation of biological diversity and natural environments. For this reason, researchers consider it a matter of urgency that they be given greater autonomy and involvement in the use and conservation of natural resources. Since human societies and

nature are intimately linked, integrating approaches are sought in order to advance in the theory and practice of conservation.

The effects of urban migration

In one of the research projects, Alpina Begossi and her team from the Natural History Museum of Campinas State University (Unicamp) interviewed 449 fishermen based on river edges of the São Paulo Atlantic Rainforest and 116 inhabitants of communities on the banks of the Araguaia and Negro rivers, in Amazonia. They found that fishing and tourism, in the South-East, are replacing subsistence farming – as a result, local knowledge of cultivation tends to decrease. In the communities



ALPINA BEGOS/UNICAMP

Fishermen from Ponta de Almada, northern shore of São Paulo State



RODRIGO DE PROSPERO/UNESP

Sinésio Rodrigues gathers fiber-bark to make handicrafts



ROBERTA RIZZI/UNICAMP

Pedro Silveira helps João Moura gather plants

of Rio Negro, the abandonment of agriculture promotes loss of access to land on the part of native inhabitants and the expansion of large landowners. Technological innovations cause traditional techniques to be increasingly forgotten: the plants used for the dyeing of hammocks and as floats for fishing nets ceased to be used two decades ago, with the arrival of nylon hammocks and polystyrene nets.

Knowledge of plants – not just for cultivation, but also how to use them in the making of canoes, oars, baskets or houses – also dwindles with the migration of river-dwellers to the urban centers. However, researchers concluded, the use and the handling of natural resources by native populations contributes to the increase in biodiversity and the capacity for restoring the forests.

Shared knowledge

In Iporanga, a municipality in the south of the State of São Paulo which constituted another area of study, the creation in 1958 of the Alto Ribeiro State and Tourist Park (Petar), imposed restrictions on the use of forest resources by the local inhabitants, composed of mixed Indian-white race and descendants of escaped slave communities. Interviewing the local inhabitants in five areas of 2.000 square meters, Lin Chau Ming, from the Paulista State University (Unesp) in Botucatu, established that knowledge of how to make use of plants is similar amongst those of mixed white-Indian race and descendants of escaped slave communities and amongst the inhabitants inside and outside of the Petar, owing to the mobility of the communities and cultural exchange



CARLOS EDUARDO MARINELLI/UNICAMP

Main street of São Luiz do Paraitinga, with grazing land and remnants of native vegetation in the background

since the 17th century, when the region began to be inhabited. The results of this survey could help to consolidate conservation policies for natural resources and underline how traditional ways of life, in themselves, contribute to the preservation of natural landscapes: the Atlantic Rainforest is sustained in more than 85 per cent of the territory of traditional communities.

Integrating nature and society

In another study, in progress, Paulo Inácio Prado, of Unicamp, is examining with his team how the inhabitants of São Luiz do Paraitinga, a municipality in the Alto Vale do Paraíba, north-east of the state of São Paulo, interact with the landscape in the region, which consists of fragments of Atlantic

Rainforest, grazing lands, subsistence smallholdings (mainly corn and beans) and eucalyptus monocultures.

This research brings together not just biologists, but also sociologists and anthropologists, who set themselves the challenge of establishing a dialogue and finding common conceptual bases between biological sciences and social sciences: the concept of landscape has proved to be a point of convergence between the two important areas of knowledge, as it is recognized by both. The data collection on fauna and flora are conducted in conjunction with studies of anthropological and historical characterization of the inhabitants and of the process of landscape occupation. It thus highlights how social changes give rise to changes in the landscape and in biological diversity.



EDUARDO CESAR

Cassia leptophylla, an ornamental tree with yellow flowers from which an alkaloid of pharmaceutical interest is extracted

Medicines which emerge from the forests

In 2000, when Biota was less than a year old, good news was received from the only project in the program engaged in bio-prospection: the discovery of chemical compounds extracted from plants from the Atlantic Rainforest and from the Cerrado in the state of São Paulo which in preliminary laboratory tests had displayed antifungal, antibiotic, anti-malarial, and anti-tumor properties which cried out for further studies.

“Given that in bio-prospection research the expectation of finding species with biological action of real interest is merely 1 per cent, our results are pretty encouraging, because 3 per cent of the extracts from the plants collected display some action”, Vanderlan da Silva Bolzani

from the Chemistry Institute of the Paulista State University (Unesp) in Araraquara reported at the time: Vanderlan is the coordinator of a team of 45 researchers who explored forest remnants, collected plants and prepared and analyzed extracts.

In 2004, Vanderlan announced a further innovative result: a substance called spectaline, extracted from the spectacular cassia tree (*Senna spectabilis*), displayed analgesic and anti-inflammatory action. In animal laboratory tests, two semi-synthetic derivatives of spectaline inhibited the acetylcholinesterase enzyme, which regulates acetylcholine, a neurotransmitter important in the control of central nervous system disorders.

These studies open the perspective for the discovery of models of medicines for Alzheimer’s disease, for which there are few treatments. Researchers believe that it will be possible to



MIGUEL BOYAYAN



produce new medicines at lower costs than the present ones, based on plants from the Brazilian biodiversity and with national technology. From the ecological point of view, such research enriches the analysis of plants chemical profiles and yields more information on their processes of adaptation and interaction with other living creatures – data which is fundamental to the conservation and sustainable development plans for the forest remnants in São Paulo.

Against ulcers and tuberculosis

Another study which links the sustainable use of Brazilian biodiversity to prospection for pharmaceuticals in plants of the Atlantic Rainforest and the Cerrado is being coordinated by the teams of Wagner Vilegas, also from the Chemistry Institute of the Paulista State

University (Unesp) in Araraquara, along with Alba Brito's team from Campinas State University's Institute of Biology (Unicamp).

Specialists from this group have already identified chemical compounds known as alkaloids, obtained from a tree native to the Atlantic Rainforest, the *Alchornea*, which proved in the laboratory to be effective in combating *Helicobacter pylori* – the same bacteria, responsible for gastric ulcers, can be eliminated by means of other alkaloids, extracted from the leaves of a tree from the Cerrado, *Strychnos pseudoquina*. Already extracts from the leaves of the *Davilla elliptica* and some species of trees of the *Qualea* genus have displayed promising action against *Mycobacterium tuberculosis*, the bacterium which causes tuberculosis. The next steps in the study include the use of pure substances or fractions, in order to understand the mechanisms that explain these biological properties.



Guaçatonga leaves
with anti-ulcer action,
and the laboratory of
USP's Chemistry Institute

Botanist and chemists working in a network

Since 1999, a team from the Paulista State University's Chemistry Institute (Unesp) in Araraquara, coordinated by Vanderlan da Silva Bolzani, has collected almost 800 species of plants, prepared around 1,700 extracts and isolated more than 150 chemical compounds with promising pharmacological action. Such results motivated the creation, in 2003, of the Biota Network for Bioprospection and Biotrials – or *BIOprospecTA*, a subprogram of Biota-FAPESP which integrated research groups consisting of botanists, ecologists, chemists, pharmacists, pharmacologists and doctors

in search of chemical compounds of pharmacological or cosmetic interest obtained from a base in microorganisms, fungi, plants or animals.

The results were quick to emerge. Researchers from *BIOprospecTA* – a network coordinated by Vanderlan, Glaucius Oliva, from the University of São Paulo (USP), and Paulo Cesar Vieira, from the Federal University of São Carlos (UFSCar) – extracted from leaves of the guaçatonga tree (*Casearia sylvestris*) extracts and fractions with action against gastric ulcers and from the spectacular cassia tree (*Senna spectabilis*), isolated alkaloids that inhibit an enzyme of the central nervous system. From the coral tree (*Erythina mulungu*), three alkaloids with ansiolitic action were isolated, which together with those from the *Senna spectabilis*, progressed to the phase of pre-clinical studies, in partnership with a nationally financed pharmaceutical company. Already the mulato calycophyllum tree (*Calycophyllum spruceanum*) is the object of deeper studies since it contains antioxidant substances, which prevent cell death.

In the USP Chemical Institute, Paulo Moreno's team discovered four essential oils in plants from the Atlantic Rainforest with anti-inflammatory action, seven with antioxidant action and another four capable of detecting the *Escherichia coli* bacteria, which causes diarrhea. Already Jairo Kenupp Basto's group, from USP in Ribeirão Preto, has obtained around 70 substances from only six fungi – of this total, almost 40 display previously unknown chemical structures, which constitute a valuable source for the research into new pharmaceuticals. Studies are underway also with bacteria, insects and spiders.

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