Publicacions del
Centre de Recursos de Biodiversitat Animal
Volum 1, 2002

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E. Mateos, J.C. Guix, A. Serra & K. Pisciotta

Divisió de Ciències Experimentals i Matemàtiques
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CENTRE DE RECURSOS DE BIODIVERSITAT ANIMAL

UNIVERSITAT DE BARCELONA

ISBN 84-600-9653-X

Depósito legal: B.5.249-2002

February 2002

Published by
Centre de Recursos de Biodiversitat Animal
Divisió III, Universitat de Barcelona
Av. Diagonal 645
08028 Barcelona, Spain

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Printed and bound in Spain by
Romargraf, S.A., Barcelona

Cover: a juvenile Brown capuchin monkey, *Cebus apella* (photo: V. Pedrocchi)

To our late friends,
Carles L. Adzerias and Roberto Bürgi

PREFACE

The Brazilian Atlantic rainforest is a complex biome formed by a network of ecosystems that have no clear limits. It covers 3000 km along the Eastern coast of Brazil, which makes it one of the continental environments in the world that spreads across a widest range of latitudes. This geographical trait, as well as its changing relief and climate both nowadays and in the geological past, has enabled the existence of an extraordinary plant and animal diversity. The fact that it was the first South American biome that suffered the anthropic impacts derived from European colonisation has turned it into one of the most fragile macroregions in the planet from a conservational point of view.

The book that you are holding in your hands is not a consequence of chance. On the contrary, and as it happens with all significant works, there is a whole set of people and circumstances behind it that constitute, through their interactions, its cause.

To find the trigger that set off the facts that led to the publication of this book, we must head back to 1991. It was then when a group of researchers from the Universitat de Barcelona, the Fundação para a Conservação e a Produção Florestal do Estado de São Paulo (Fundação Florestal) and other Brazilian institutions organised an expedition through the most inaccessible areas of the Parque Estadual Intervales in the Brazilian Paranapiacaba mountain range. The main goals of this expedition was making a first scientific approach as well as checklists of vertebrate species in wide extensions of the Atlantic rainforest that had remained unknown to geographers and biologists up to then.

In 1994, J.C. Guix, E. Mateos and K. Pisciotta arranged a second expedition with the aim of carrying out density estimates of some animal species that were particularly interesting for the conservation of that portion of the Brazilian Atlantic rainforest.

The successful results achieved in those expeditions led to the organisation of a third one in 1998, with the objective of developing a pilot project to carry out density estimates of some reptile, bird and mammal populations in the Paranapiacaba ecological *continuum* (Parque Estadual Intervales, Parque Estadual Carlos Botelho, Parque Estadual Turístico do Alto Ribeira and Estação Ecológica de Xitué). The organisation and coordination of this third trip had a more institutional nature, and it was taken up jointly by the Centre de Recursos de Biodiversitat Animal of the Universitat de Barcelona and the Fundação Florestal and the Instituto Florestal do Estado de São Paulo. Nearly 40 researchers from the Universitat de Barcelona, the Fundação Florestal and several Brazilian universities made up the working teams that were distributed in the areas of the parks. The main tasks developed were the performance of censuses of frugivorous monkey (Cebidae) and bird (Cracidae, Ramphastidae and Psittacidae) populations and the survey of birds of prey (Cathartiformes and Accipitriformes) as well as reptile (Crocodylia) and mammal (Mustelidae) populations occurring in rivers and lagoons in the area.

It is with great pleasure that we present this book, which gathers the results from the work endeavoured in this third expedition to the Brazilian Atlantic rainforest. We are certain that this shall be a reference work for the scientific community as well as a useful tool for the Brazilian and international institutions watching for the correct conservation of the Brazilian Atlantic rainforest. The study of the fauna has a remarkable interest and it constitutes one of the basic aspects for the knowledge, management and conservation of the Paranapiacaba ecological *continuum*.

We must mention the participation in the expedition of a medical team that attended and solved the - fortunately slight - incidents that disturbed the researcher's health during the trip. Also, we must remark the decisive collaboration of the parks' staff, since their knowledge of the areas of work and their task of support were basic for the successful development of the research activities. Finally, we would like to thank the institutions, companies and people that are listed below. Without their understanding and support, this book would have never been a reality.

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Fundação para a Conservação e a Produção Florestal do Estado de São Paulo
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Parque Estadual Intervales, Parque Estadual Carlos Botelho, Parque Estadual Turístico do Alto Ribeira, Estação Ecológica de Xitué
Industrias Sport, S.A. (Inesca), Arpi Serra, S.A.
Nigel Bradbury, Cristiane Leonel, Núria López Mercader, Dalton Novaes, Wagner G. Portilho, Eleonora Trajano, Vera C. Stegun Vidigal, Edwin O. Willis and Carlos Yamashita.

To all of them, our most sincere acknowledgement.

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Chapter 1

INTRODUCTION AND OBJECTIVES

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THE BRAZILIAN ATLANTIC RAINFOREST IN THE STATE OF SÃO PAULO

Geology and Relief of Eastern São Paulo

The state of São Paulo occupies an area of 247320 km^2, 578 km^2 of which correspond to river systems (Cantão, 1974). Situated within 19º 46' 30" and 25º 16' 06" South and 44º 09' 24" and 53º 08' 54" West G in southeastern Brazil, it is geologically characterized by the eastern mountain range's crystalline relief and by the monotonous relief of the Brazilian Plateau. There are at least three distinct geographical zones (from East to West): the coastal plain of Quaternary origin, the Atlantic mountain range of Pre-Cambrian origin and the West orientated plateau (Cantão, 1974).

The coastal plain is a long fluvial and marine sedimentary stretch confined by the eastern slopes of the Atlantic range on the West and the Atlantic Ocean on the East. It is only a few meters above sea level, and widest at the rio Ribeira de Iguape Lowlands (approximately 80 km).

The eastern Atlantic mountain range, better known in Brazil as Serra do Mar, constitutes a group of mountain chains which extend parallel to the Atlantic coast line for over 900 km. Their Atlantic slopes rise to abrupt mountain peaks between 800 m and 1100 m high.

The Plateau can be subdivided into eastern plateau (or Atlantic), peripheral depressions and western plateau (Ab'Sáber, 1969). Gentle folds dominate the eastern plateau giving it the appearance of a sea of mounds ("mar de morros") (Ab'Sáber, 1977a, b). Parallel ridges also exist in the Plateau, and, near the State of Minas Gerais, there is an extensive escarpment, the Serra da Mantiqueira, which forms the limits of the state's southern plateau.

Serra do Mar and Serra da Mantiqueira were originated through a process of bending and fracturing of the Brazilian Shield, which had been originated by several orogenic episodes (Almeida et al., 1973). The rock formations of these mountain ranges are essentially of Pre-Cambrian origin, and granites, gneisses, migmatites and quartzites are frequent (Bigarella, 1978).

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

Climate

The Earth's tropical regions form a belt between 23º 27' latitude North and South from the equator (Prance & Lovejoy, 1985). Consequently, at a macro-scale level, the State of São Paulo is frequently included in the subtropical zone (see National Geographic Society, 1972; Sarmiento, 1990). However, the real limits between the tropical and subtropical zones vary greatly according to elevation (Prance & Lovejoy, *op. cit.*).

In general, the majority of the São Paulo's land west from the coastal mountain ranges between 400 and 700 m elevation presents subtropical characteristics, while the coastal stretch east from the Serra do Mar mountain range complex fits the tropical climate category.

The sharp temperature falls caused by the South Pole cold fronts in the winter do not cause vegetation damage on the coastal plains. This is not the case in areas of the Serra do Mar and Serra da Mantiqueira at elevations above 500 m, and less frequently in São Paulo's inland (e.g. Ribeirão Preto area), where frosts have great detrimental effects on vegetation.

Rainfall is generally abundant, specially on the eastern slopes of the Serra do Mar and Serra da Mantiqueira, where an annual precipitation of over 2000 mm frequently occurs. Local precipitation can reach 4000 mm (e.g. 4457 mm near Rio Itapanhau and 4949 mm and 5597 mm in the Serra de Cubatão; Hueck, 1972a; Cruz, 1974).

In addition, hillside Atlantic rainforest of the Serra do Mar and Serra da Mantiqueira function as strong water condensators, enabling the occurrence of continuous water dripping from the apices of leaves during days of intense fog. This phenomenon is known as "hidden precipitation," and can double or triple current precipitation values because conventional pluviometric stations are situated in clearings or completely deforested areas, collecting direct rainfall only (Pena *et al.*, 1990).

The Brazilian Atlantic rainforest

The Atlantic rainforest is situated on the East coast of Brazil. It originally stretched from the State of Rio Grande do Norte (Near Cabo de São Roque; 5º 45' S) to the State of Rio Grande do Sul (Osório; 29º 50' S), covering a distance of over 3000 km (Andrade-Lima, 1966 in Silva & Leitão Filho, 1982) (Figure 1). This biome is better known in Brazil as "Mata Atlântica" ("mata" in Brazil is synonymous with forest).

The distribution of the Atlantic rainforest is related to the humidity it receives from the Atlantic Ocean. The constant oceanic winds are barred by the coastal mountain chains, rising to colder air layers. The swift condensation of this moisture-laden air causes fog, drizzle and rainfall throughout most of the year, enabling the development of dense vegetation (Campos, 1912). In these areas, the annual precipitation is always higher than 2000 mm.

In areas where coastal mountains are absent, natural interruptions of this type of forest occur because of local climate conditions (Hueck, 1972a). In the Cabo Frio area (State of Rio de Janeiro) for example, due to little rainfall (less than 1000 mm per year), the Atlantic rainforest gives place to an extensive open formation, with cactuses and grasses (Hueck, *op. cit.*). Taking the vegetation break at Cabo Frio as a reference point, the Atlantic rainforest can be subdivided into two great domains: the northern domain, with a hot and more stable climate, and the southern domain, subject to great temperature fluctuations caused by South Pole cold fronts, particularly during the winter.

Hueck (1966, 1972a, 1972b) recognizes four distinct types of vegetation formations in the Atlantic rainforest. Of these, three occur in the State of São Paulo: a - Coastal plains Atlantic rainforest (up to approximately 50 m / 100 m elevation); b - South Hillside Atlantic rainforest, low elevation (between 50 m / 100 m and 1300 m / 1600 m); c - South Hillside Atlantic rainforest, high elevation (located in the eastern slopes of Serra da Mantiqueira, between 1200 m / 1600 m and 2100 m / 2500 m).

Above the rainforest superior limit, sub-alpine altitude fields can occur with grasses and Ciperaceae. In general, trees of the Coastal plains Atlantic rainforest reach greater heights (30 - 35 m or more) than the ones of the low elevation South Hillside Atlantic rainforest (20 - 30 m) and the ones of the high elevation Atlantic rainforest (8 - 15 m).

Figure 1. Estimated Atlantic rainforest distribution (*sensu* Hueck, 1966; 1972b) in the early 16th Century.

Forest succession stages in the Paranapiacaba fragment

Over the last few years, several authors have questioned the premise that there are stable states in forest plant and animal communities. According to this premise, dense and complex vegetal formations would naturally evolve to reach a peak developmental stage, known as “climax”, in which they would no longer experiment substantial changes.

Alternatively, the notion of dynamic equilibrium of forest communities has steadily been gaining weight. According to this notion, primary tropical forests – those which have not suffered direct human alterations - would be formed by mosaics of serial stages of different ages, in which elements of the beginning, intermediate and mature phases would mix in different proportions. For instance, natural clearings formed by the fall of great trees enable heliophyllous bushes and herbaceous vegetation to grow, and areas of very old vegetation allow the trive of a great number of ombrophilous species, etc. (see Cousens, 1965; Richards, 1972).

The term “climax” presents the inconvenience of being related to the idea of “static equilibrium” of plant communities. For this reason, the terms “maturity” and “mature” are adopted in the texts of this book to characterize the more advanced succession stages of tropical forests in the study area.

Consider the case of a primary forest which has been completely cleared or subject to intensive timber extraction (e.g. selective cut of hardwood or of palm trees), from which some trees and bushes regrowth capacity has not been seriously affected and in which the soil has not plowed or repeatedly burnt. The vegetation that has not been irreversibly affected by these anthropic activities will tend to regenerate through new outbreaks, and, if it is not subject to repeated clearing episodes, it will give place to a new forest formation. Given this sequence of events, taking into account regeneration time (from the last anthropic interference), vegetation structure and vegetation composition, it is possible to classify the Paranapiacaba fragment forests (see chapter 2) into the following categories:

- Mature forests. Generally, forests subject to a single episode of deforestation or intensive selective extraction and abandoned over 80-100 years ago.
- Late secondary forests. Same as Mature forests, but abandoned 50 to 80 years ago.
- Young secondary forests. Those existing 20 to 40 years after the last deforestation or selective extraction event occurred (one or more anthropic activity episodes).
- "Capoeiras" or shrublands. Forest areas deforested for the first time 5-15 years ago, or that have undergone several deforestation episodes.

Vertical stratification of the forest

Tropical wet forests are formed by very dense vegetation, which tends to be distributed in vertical strata because of strong light competition (Richards, 1972). Even though clear limits between these strata cannot always be recognized due to considerable superposition among them, efforts to distinguish them are useful for a better understanding of how diverse animal species partition and make use of these tridimensional structures.

In the mature and late secondary Atlantic rainforests of the study area, at least five vegetation vertical strata are recognizable: herbaceous stratum, understorey, subcanopy, canopy and emergent stratum. The herbaceous stratum, as its name indicates, is predominated by small sized herbaceous plants (generally between 0.01 and 0.80 m tall), as well as seedlings and plants in their earlier developmental stages. The understorey is characterized by the dominance of young woody plants between 0.80 and 2.00/3.00 m tall, while in the subcanopy woody plants ranging from 2.00/3.00 m to 12/15 m tall dominate. The canopy stratum is composed of the crowns of large sized trees, whose inferior level is at 12/15 m and superior level approximately between 18 and 20/25 m. Crowns of great size trees sporadically rise above this level. In some cases, these emergent trees can reach 30m or more (for example, next to coastal plains and in the depths of hillside valleys, where they are better protected from winds and the topsoil is usually deeper and more fertile).

Obviously, the strata's height limits are not rigid and vary according to the type of forest. Thus, while the canopy of the Lowlands Atlantic rainforest reaches 25 m in height, that of the hillside Atlantic rainforest rarely reaches 20 m. Some authors tend to unite the herbaceous and understorey strata in a single stratum (called undergrowth), and they do the same with the canopy and emergent strata (Silva & Leitão Filho, 1982).

Forests at similar elevations may also be somewhat structurally distinct. Strata height variation among different vegetation formations is evidenced by comparison of forests in Parque Estadual Turístico do Alto Ribeira (P.E.T. Alto Ribeira) and in Parque Estadual de Carlos Botelho (P.E. Carlos Botelho). In some zones of shallow calcareous soil in P.E.T. Alto Ribeira, mature or late secondary forests may present significantly lower stature than those of same succession stages in P.E. Carlos Botelho.

On the other hand, young secondary forests and cloud forests near mountain peaks lack some vegetation strata (including the emergent and sub-canopy). Because vertical structure can affect the distribution of arboreal animals and their population density, only relatively well preserved forests of similar structures, namely mature and secondary late forests, were chosen for the density estimates.

Other types of forests in the State of São Paulo

To the West of the Brazilian coast ranges, a large assemblage of forests physiognomically and floristically distinct from Atlantic rainforest occurs. These forests were designated “East and South Brazilian subtropical forests” (Hueck, 1966, 1972a) or “oriental and meridional Brazilian deciduous and mesophytic subtropical forests” (Hueck, 1972b) for their unique characteristics and geographical distribution.

Between the end of the 19th century and the beginning of the 20th century, some botanists and naturalists began to give emphasis to a series of differences between the Atlantic rainforest and the western subtropical forests. Martius (1840-1906) was the first naturalist to separate the Atlantic rainforest and the western subtropical forests into two distinct units (see Martius in Hueck, 1972a). From then on, other naturalists and botanists made efforts to distinguish these two forests and describe them in more detail (Löfgren, 1898; Campos, 1912; Sampaio, 1945; Hueck, 1956; Coutinho, 1962; Rizzini, 1963; 1979; Andrade-Lima, 1966; Eiten, 1970; 1983; Joly, 1970).

Yet, Kurt Hueck's precise delimitation and characterisation of them in 1966 (Hueck, 1966; 1972a, 1972b) laid the groundwork for several publications on biogeography (see Hershkovitz, 1969 in Blake, 1977; Cabrera & Willink, 1973; UNESCO, 1981; Thomas *et al.*, 1998). It is currently recognized enough significant physiognomic, floristic and phytosociological differences between both forest masses to justify their separation (see Hueck, 1972a; Rizzini, 1981; Assumpção *et al.*, 1982; Silva & Leitão-Filho, 1982; Leitão-Filho, 1992, 1995).

Another very characteristic forest formations are the Araucaria forests. These forests are named after the conifer species that dominates their high arboreal stratum: *Araucaria angustifolia* (Araucariaceae), while species typical of subtropical forests dominate in the subcanopy and understorey. The original distribution of Araucaria forests comprises mainly the South region of Brazil (States of Paraná, Santa Catarina and Rio Grande do Sul), with isolated occurrences in the States of São Paulo, Rio de Janeiro and Minas Gerais. They also reach the Northeast edge of Argentina (Hueck, 1972a).

In the State of São Paulo, the last large remnant for Araucaria forests is in Campos de Jordão, including some testimonial specimens in some farms bordering the high altitude limits of Parque Estadual de Carlos Botelho (São Miguel Arcanjo County) and Parque Estadual Intervales (Ribeirão Grande and Capão Bonito Counties).

In addition to the remaining subtropical and Araucaria forests, other significant vegetation formations are the western State of São Paulo's riparian forests (better known as gallery forests or “matas ciliares”), coastal arboreal restinga (or "matas de restinga") and mangroves.

In the State of São Paulo, riparian forests – forests that grow by river margins – stand out specially in remaining inland cerrado areas, presenting various components typical from the nearest Subtropical forests. Before the expansion of coffee and sugar-cane plantations, extensive zones contiguous to the Paraná, Tietê, Paranapanema, Mogi-Guaçu and other smaller rivers were covered by floristically very rich riparian forests, where palmito palm (*Euterpe edulis*) and the Black-fronted piping-guan (*Pipile jacutinga*) occurred at hundreds of kilometers from the coast (Guix, 1997).

The arboreal restinga is a forest formation that grows in Quaternary sandy soils on coastal plains near the ocean. Mature restinga forests can reach over 20 m in height, its secondary stages usually varying between 8 and 15 m. Frequently, components of adjacent Atlantic rainforests occur mixed with those of the restinga (e.g. *Euterpe edulis*).

Floristic and faunistic diversity of the Atlantic rainforest

During the Pleistocene epoch (between 1.6 and 0.01 million years ago) and during great portion of the Tertiary period, significant variation in temperature and pluviometric patterns occurred in South America because of the cold dry air masses that swept the continent during glaciations. The climatic changes that happened during this geological time determined a series of alternating episodes of rainforest expansion and retraction relative to the open vegetation formations (e.g. Cerrados and Caatinga) (Haffer, 1969; 1974; Ab'Sáber, 1977a). These fluctuations would have caused fragmentation of the geographical range of some species and the isolation of populations in ecological refuges. During the longest periods of isolation, some of these populations probably differentiated at a species level.

Thus, a Pleistocene refuge would have been a restricted area where the forest was sheltered during those episodes of changes in vegetation, establishing a survival zone to some plant and animal populations (Haffer, 1974, 1985). Currently, those refugia may be identified by a high rate of plant and animal species endemicity in a particular forested region.

In periods of forest expansion, some currently isolated South American forests probably experienced brief contacts among themselves, either directly through an overlap in particular zones of their areas of distribution or through dispersal corridors formed by riparian forests (Smith, 1962). Thus, plant and animal populations from a forest type would have invaded and colonized regions dominated by a different forest type and then, when in isolation during another retraction episode, they would have differentiated at a subspecies or species level.

Apparently, the northern portion of the Atlantic Rainforest was subject to penetration of Amazonian floral and faunal components (see Haffer, 1974; Sick, 1985a). Its southern portion, despite Serra do Mar and Serra da Mantiqueira's relatively greater isolation from other regions, would have received faunal components originated in the Andes, which in general remained confined to high elevations (Sick, 1985a; 1985b).

Among Amazonian components in the Atlantic rainforest are plants that produce fleshy fruit, like *Euterpe oleracea* (Arecaceae), and frugivorous birds such as *Tinamus solitarius pernambucensis* (Tinamidae), *Crax blumenbachii* (Cracidae), *Cotinga maculata*, *Lipaugus vociferans* and *Xipholena atropurpurea* (Cotingidae) (Sick, 1985a). Sick (1985b) considers some insectivorous birds of the Families Caprimulgidae, Furnariidae and Rhinocryptidae elements of Andean origin in the Atlantic rainforest, while the Brazilian araucaria tree (*Araucaria angustifolia*) would be an example of an originally Andean component in subtropical forest areas (Rambo, 1951).

Within the geographical distribution of the original Atlantic rainforest, the region corresponding to the Serra do Mar and Serra da Mantiqueira mountains and part of the coastal plain is one of the zones of greatest plant and animal species diversity in South America (Silva & Leitão Filho, 1982; Sick, 1985a), and it presents high levels of endemicity (Haffer, 1974, 1985; Heyer & Maxson, 1983; Terborgh & Winter, 1983; Brown, 1987; Collar et al., 1987; Prance, 1989; Ridgely & Tudor, 1989; Gentry, 1992; Thomas et al., 1998). This zone – possibly a Pleistocene refuge – is at the limits of one of the main centres of endemism in South America (Figure 2). From the perspective of conservation of a Tropical rainforest biological diversity, the entire extension is considered a world priority, from the north of the State of Rio de Janeiro to the south of the State of Santa Catarina (see Terborgh & Winter, 1983; Fitter, 1988; Myers, 1988; Conservation International, 1991; Gentry, 1992; Viana & Tabanez, 1996; Thomas *et al.*, 1998; Myers *et al.*, 2000).

Over the last few years, several authors have proposed alternative models to explain the high species richness of the Neotropical Region's rainforests (see Haffer, 1997 and Nores, 1999 for a recent review). Nevertheless, the Pleistocene refugia model remains the most complete and inclusive model, and, despite being proposed 80 years ago, it could not be rejected in its essence.

Taking as a premise that the Tertiary and Quaternary vegetation fluctuations would have fragmented the distribution of several plant and animal forest species, it becomes difficult to conceive that many of the populations that remained isolated for long periods of time would not differentiate at a species level. Therefore, even though repeated climatic and ecological fluctuations can not be universally used to explain the origin of all of the most recent species, it is probable that forest paleorefugia significantly contributed to generate diversity.

Figure 2. Centres of endemism of Atlantic rainforest plant species postulated by Thomas *et al.* (1998).

Biome fragmentation

Rife European extractivism and colonisation from the Brazilian coast inland gave rise to a progressive process of loss of floral and faunal richness and diversity. The almost continuous spoliation of Brazilwood ("pau-brasil," *Caesalpinia* spp.), the valuable red wood trees used to dye clothes from the 16th to the 19th centuries is a good example of what this period of time represented. However, not only pau-brasil was being exploited: minerals, seeds, skins and a great number of live animals also overloaded ships to Europe (see Table 1).

In the midst of extensive extractivism and a still incipient colonisation of the Atlantic rainforest, several settlements, villages and cities appeared, some of which would become important economic and human population centers. This is how cities like São Paulo, Rio de Janeiro, Salvador and Recife appeared and grew. With the gradual human contingent growth in and near these centers, human settlements progressively deforested and occuppied new areas for agriculture and cattle raising.

At the end of the 19th century, extractivism and plundering of natural resources grew rampantly. This type of extractivism, similar to that currently in practice in many parts of the Amazon, lasted until the end of the 1960’s decade. During the 50’s, for example, palmito palm extraction for street markets and preserves factories, and "caixeta" extraction (mainly *Tabebuia cassinoides*) for pencil industry and other derivatives constituted some of the main activities of the rural settlements in the Cananéia region (Hueck, 1972; São Paulo, 1998).

Table 1. Freight list of the French ship "Pèlerine". The ship was seized by a Portuguese fleet around 1531, while returning to Marseilles from Recife (Johnson, 1992). One quintal (quintais in plural) is about 60 kg.

PRODUCTS	QUANTITIES	VALUES (ducados)
Pau-brasil (Brazilwood)	5000 quintais	40000
“Leopardo” skins (= Jaguar, Ocelot ...)	3000 units	9000
“Papagaios” (=several parrot species)	600 specimens	3600
“Macacas” (= several Cebid and Calitricid species)	300 specimens	1800
Minerals (including gold)	?	3000
Native cotton	300 quintais	3000
Native cotton seeds	300 quintais	900
Medicinal oils	?	1000

The unrestrained use of wood and vegetal coal and the cocoa, banana and tea plantations caused a remarkable retrocession of the Lowland Atlantic rainforest. Little by little, an extensive forest biome became fragmented in areas ever so small and isolated among themselves. The northern portion of the Atlantic rainforest – from south of Espírito Santo to Rio Grande do Norte – suffered the greatest amount of deforestation. Of 1839 woodlots southeast from the State of Pernambuco monitored by satellites between 1974 and 1997, only 7% were larger than 100 hectares and almost half of them (48%) were smaller than 10 hectares (Ranta *et al.*, 1998).

Currently, the most extensive and best preserved remaining areas of Atlantic rainforest are situated near the southern mountain ranges (e.g. Serras do Mar and da Mantiqueira, parallel to the coast). Less than 8% of Atlantic rainforests are left today and, even though deforestation rates have diminished, deforestation continues almost in a ceaseless manner. The spoliation process also persists. Ferns, fern trunks, *Heliconia* spp., epiphyitic and terrestrial bromeliads and palms are currently some of the main targets. Consequently, a process of habitat simplification was generated, and one of the most evident examples of this situation is the absence of palmito palm in many southern Brazilian rainforests.

Seventy endemic birds species occur in the Atlantic rainforest (*sensu stricto*), 38 of which are threatened. According to estimates by Brooks & Balmford (1996), 32 of these species will be extinct in the next decades if the current deforestation and poaching rhythm is kept up.

Frequent extinctions produce negative effects on the habitat beyond the scope of directly affected species. Many frugivorous bird and mammal species of the eastern Brazilian forests establish mutualistic relationships with plants: the latter produce “food packages” in the form of fleshy fruits and the former disperse their seeds (Herrera, 1985). Several tree species of the genus *Eugenia* (Myrtaceae) and *Cryptocaria* (Lauraceae), for example, are only disseminated by large-sized frugivores like the Wooly spider monkey (*Brachyteles arachnoides*), the Dusky-legged guan (*Penelope obscura bronzina*) and the Black-fronted piping-guan (*Pipile jacutinga*) (Guix, 1995). When illegal hunting causes local extinction of large-sized frugivores, many mutualistic relationships are broken, yielding indirect consequences to those plant species and to the floral diversity of the remaining forests.

The earliest zoological expeditions in the study area

The first zoological expedition known in the Paranapiacaba fragment took place between 26 August and 5 September 1929. It was carried out by the ornithologist Olivério Pinto from the former Museu Paulista (currently Museu de Zoologia da Universidade de São Paulo), João Leonardo Lima (naturalist and former taxidermist of that same museum) and the mammalogist Glover Allen, from the Museum of Comparative Zoology (U.S.A.). These researchers collected in the area which now corresponds to the P.E. Carlos Botelho (Serra dos Agudos Grandes), while the road later connecting São Miguel Arcanjo and Sete Barras was being opened through the park's pristine forests (Pinto, 1945). Part of the material collected was deposited in the Museu de Zoologia - USP, having then the closest settlement, São Miguel Arcanjo, designated as the collection locality.

The Museu Paulista conducted another expedition near the Paranapiacaba fragment from 12 to 21 May 1940. This ornithological expedition took place in the former Fazenda Poço Grande, near the Juquiá river (tributary of Ribeira de Iguape river), approximately 20 km from the P.E. Carlos Botelho in a straight line (Pinto, 1945). In only 10 days, the ornithologist Olivério Pinto and the taxidermist Alfonso Olalla collected 473 bird specimens, among which species as rare as *Psilorhamphus guttatus* (Family Rhinocryptidae). In the Museu de Zoologia - USP, there is also material collected by Adolfo Hempel at the beginning of the 20th century and by João Lima in 1925.

In addition to these zoological expeditions, in the early 19th century the caves of the P.E.T. Alto Ribeira were also hosts to several geological expeditions organised by the Brazilian Government.

Background information on density estimates in the area

The protected areas currently composing the Paranapiacaba fragment were set aside from 1958 on, when P.E.T. Alto Ribeira was established. P.E. Carlos Botelho was created in 1982, then Estação Ecológica de Xitué in 1987 and the Parque Estadual de Intervales in 1995. Even though Intervales only gained State Park status later on, the area (previously "Fazenda Intervales") was under custody of the State of São Paulo´s government since 1987, through Fundação Florestal (see chapters 2 and 3). Fazenda Intervales's incorporation as a conservation area was of crucial importance to the Paranapiacaba fragment, since it constitutes the central plot that allows communication between the three other parks, which, until 1987, were in danger of being dismembered by deforestation.

When these areas were consolidated as conservation units, and even before that (see Willis, 1989), some researchers became interested in compiling plant and vertebrate species lists. These preliminary floral and faunal check lists, many of which remained in unpublished report format for several years, laid the groundwork that enabled Instituto Florestal and Fundação Florestal's technicians to grasp the enormous potential of these forest areas as biological patrimony stocks of the Atlantic rainforest.

From the middle 1980’s, several researchers started faunistic studies, especially of vertebrates (see for example Leonel, 2001). Despite considerable efforts, often without any public or private funding, large Paranapiacaba fragment zones (mainly in Intervales) remained scientifically unexplored.

Even though plants and vertebrates are relatively conspicuous biological groups, species lists are still far from being complete, and certainly many new species are yet to be detected and/or described within these two large biological groups (especially among plants of the Family Myrtaceae, amphibians, marsupials and rodents). Regarding the fungi and invertebrates, the Paranapiacaba fragment is still an almost entirely unknown world.

With the aim of gaining knowledge on the biological heritage of the Paranapiacaba fragment's unprospected areas, a group of technicians and researchers from the Fundação Florestal, the University of Barcelona, and the Brazilian universities UNESP-Rio Claro and USP-Piracicaba conducted a recognition expedition in Intervales between 4-16 October 1991 (Guix *et al*., 1992). During this trip, 110 km of trails were examined on foot, crossing the slopes of the Paranapiacaba mountain range from the park's headquarters to Saibadela base. During the first contact with Intervales' most inaccessible zones, plant and vertebrate species were listed, enabling the research group to recognize and map areas of special interest for research and conservation (e.g. São Pedro Valley, between Base São Pedro and Guapuruvu).

Between 31 July and 14 August 1994, a second expedition organised by researchers from the University of Barcelona and the Fundação Florestal (Mateos & Mañosa, 1996), targeted three isolated localities in Intervales (Alecrim, São Pedro and Funil). The main objective was obtaining density estimates of threatened vertebrate species, especially birds of prey, birds of the Family Cracidae and primates of the Family Cebidae, in addition to the *Caiman latirostris* population found in 1991 near the Base Funil. During this inventory, research teams performed 68 transects totalling up 290 km. It was also possible studying the Alecrim area, which led to the discovery of a second *C. latirostris* population in the Paranapiacaba fragment.

Aiming to performe new density estimates of threatened species and to increase the sampled areas, in 1998 the University of Barcelona, the Fundação Florestal and the Instituto Florestal funded a third expedition, carried out in seven zones distributed over the four protected areas of the fragment. Several researchers and students from Brazilian universities and the University of Barcelona, as well as a technical support team from the Fundação Florestal, participated in this expedition.

OBJECTIVES

Why performing density estimates?

How many individuals of each species are there in a certain place? This question, which is relatively simple, is not often easy to answer.

Censuses consist of estimating the number of individuals belonging to a certain animal or plant species which inhabit an area, that is, its populational density. When that area is too big to count all the individuals, an estimate is performed: counts take place in fractions of the area which, if representative enough, allow an extrapolation to the total of the area. In some cases, this extrapolation yields a rather good estimate of a species total abundance.

Density estimates are just the first step to value the degree of conservation of a species. A species management guidelines shall be based on those density estimates together with data regarding genetic variability of the populations, the degree of isolation between them and the whole of environmental resources on which they will be able to count for their recovery.

Censuses carried out in tropical forests are particularly complicated considering access and visibility conditions in the areas. It is known that species richness in that sort of environment is very high, but densities of medium and large size animals tend to be quite low when compared to those in other sorts of environments. Large areas need to be surveyed in order to obtain a representative sample of those populations. Networks of paths become essential in very dense forests such as the Atlantic rainforest to allow census takers to move and detect animals and therefore to make census feasible.

All this effort and resource expense, what for? why are census of rare or threatened species necessary?. Some of the species which are currently endangered in a certain area often constitute the best indicators of the maturity degree of the ecosystem. Large size frugivores such as the Black-fronted piping-guan (*Pipile jacutinga*), predators placed at the top levels of food chains such as the Southern river otter (*Lontra longicaudis*), the Mantled hawk (*Leucopternis polionota*) or the Broad-snouted caiman (*Caiman latirostris*) are some of the indicator species in the Atlantic rainforest. The environment capability to sustain those populations is indirectly being valued by estimating their sizes.

On the other hand, periodical censuses are one of the most objective ways to keep numerical control of those animal populations. When that control does not exist, there is a high risk of losing a species for good. The aim of the Centre de Recursos de Biodiversitat Animal of the Universitat de Barcelona, the Fundação Florestal and the Instituto Florestal of the State of São Paulo is continuing with the work started in 1994 by carrying out periodical censuses. The areas selected in the 1998 expedition were chosen because of their complicated access and the good conservation degree of their forests; they can be considered as representative of what the Atlantic rainforest looked like before anthropic actions set off by european colonisation started.

We believe that these data will become a comparative reference for future considerations of human impacts in the Brazilian Atlantic rainforest.

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Chapter 2

THE PARANAPIACABA FOREST FRAGMENT

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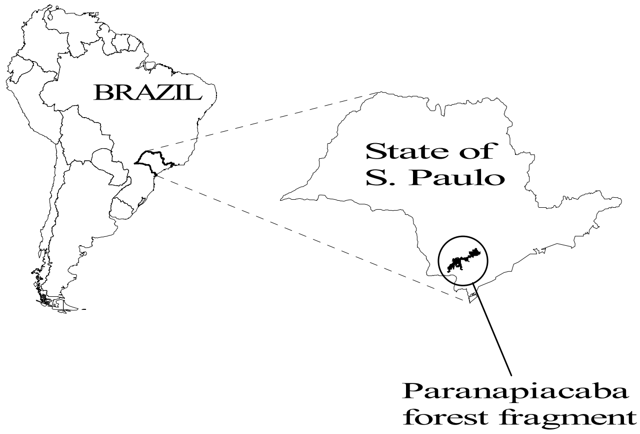
PROTECTED AREAS IN THE PARANAPIACABA FRAGMENT: AN ECOLOGICAL *CONTINUUM*

The Paranapiacaba forest fragment (Figure 1) consists of four legally protected reserves (125783 ha) and some contiguous forest private areas. Together, they comprise approximately 140000 ha of forests in several ecological succession stages. The fragment's protected areas constitute the Paranapiacaba ecological *continuum* (Figure 2).

Figure 1. Location of the Paranapiacaba forest fragment.



The ecological *continuum* concept has been gaining acceptance among technicians, scientists and governmental authorities. The Brazilian government and many international institutions have been working towards the viability and legal protection of bioregions and large corridors connecting conservation units throughout Brazil and South America. The reason for this effort is that contiguous areas shelter greater numbers and larger populations of species, enabling these to be more resistant to external impacts such as natural or human caused catastrophes. The maintenance of large extensions of natural habitats with free flows of matter and energy is basic to biodiversity conservation.

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Figure 2. The Paranapiacaba forest fragment showing the protected areas (i.e. ecological *continuum* in white. A: Parque Estadual Turístico do Alto Ribeira; B: Parque Estadual Intervales; C: Parque Estadual Carlos Botelho, D: Estação Ecológica de Xitué) and the surrounding private lands (in grey).

Several authors have pointed towards habitat fragmentation as one of the main causes for the current erosion of biological diversity (Metzger, 1995). Conservation biology studies have shown that only a few species can be protected in small reserves, thus small fragments are incapable of maintaining genetic diversity for long periods of time (Soulé & Wilcox, 1980).

MacArthur & Wilson (1967) investigated the effects of habitat fragmentation based on the theory of island biogeography (Metzger, 1995). The relationship between island area and the number of species able to persist in them allows for inferences on species richness reduction in tropical forests, as these are isolated by deforestation (Wilson, 1997). Tropical and temperate forest fragments studies across continents provide evidence that the rate of local extinction is inversely proportional to a fragment's surface area. The number of extinct species in small and isolated fragments is proportionally larger than that in large fragments, with extinction rates increasing significantly in fragments smaller than 1 km^2. It was estimated that in forest fragments between 1 and 25 km^2 - size of most parks and reserves -, the extinction rate of bird species is of 10% to 50% in the first 100 years (see Willis, 1979; Wilson, 1997). Even the rupture of narrow natural habitat corridors between large extensions of natural habitats can lead to species loss (Murphy, 1997).

Other more subtle effects accompany local biological diversity reduction resultant from habitat loss and from isolation of remaining forest ecosystems. Some species or species groups are more sensitive than others are to the loss of unique and specific microhabitats within an ecosystem. For example, some authors found that, in some forest fragments smaller than 250 ha in the State of São Paulo, large predatory birds (Accipitridae and Falconiformes), canopy frugivores (Psittacidae, Cotingidae and Ramphastidae), predators of large insects (Picidae and Formicariidae) and small insectivorous birds (Formicariidae) dependent on bamboo species locally called "taquaras" (*Merostachys* spp.; *Chusquea* spp.) are especially susceptible to local extinction. Conversely, omnivorous/insectivorous generalist bird species colonize these fragments. As a consequence of the local extinction of species and species groups, mainly among canopy frugivores and hummingbirds, forest plant species coadapted to these avian species can also be lost (Willis, 1979; Martuscelli, 1996).

CONSERVATION UNITS OF THE PARANAPIACABA ECOLOGICAL *CONTINUUM*

The concept of area continuity is included in most of the current natural environment protection strategies. To qualify for designation as a Biosphere Reserve, an area must include landscapes, ecosystems and animal or plant species or varieties in need of conservation. It must be large enough to guarantee the three basic functions of Biosphere Reserves: biodiversity conservation, sustainable development (that is, economic development that guarantees the maintenance of cultural, social and environmental values) and logistic function (scientific research, monitoring, education and information exchange).

Another UNESCO program for the protection of nature is the World Heritage Convention. A natural property can be declared World Heritage Site, that is, an area that must be preserved at all costs, when it contains, among other characteristics, representative habitats inhabited by threatened animal and/or plant species of outstanding scientific and conservation value.

The conservation units comprised in the Paranapiacaba ecological *continuum* were declared Upper Ribeira Pilot Areas of the Atlantic rainforest Biosphere Reserve in 1991. In 1998, the Upper Ribeira region as well as the Iguape-Paranaguá region of estuaries and lagoons was declared World Natural Heritage Site, which stressed again the importance of this *continuum*.

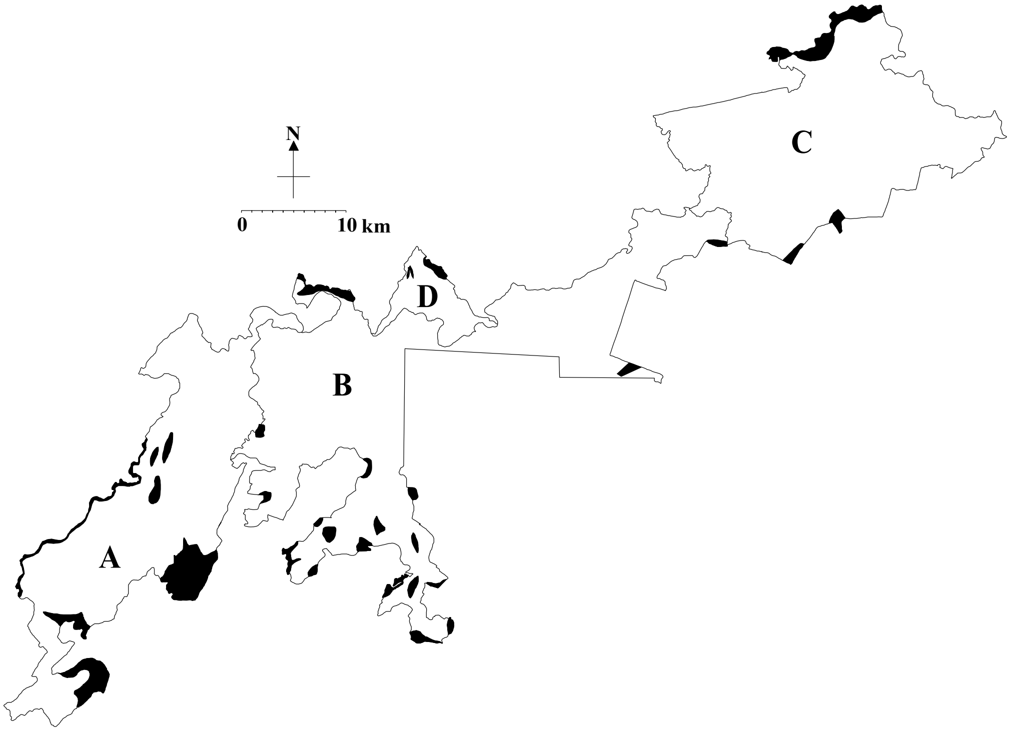
Areas currently protecting Atlantic rainforest formations and associated ecosystems in the northern and southern coasts of the State of São Paulo and Ribeira Valley, in the north of the State of Paraná and in the south of the State of Rio de Janeiro, comprise the largest expanse of preserved Atlantic rainforest in Brazil. Its importance is internationally recognized because it provides resting and feeding sites for migratory birds. It shelters also rural neighbourhoods and extractor communities ("caiçaras" and "quilombolas") that keep their traditional ways of living and depend on the maintenance of forest resources for their own survival (Allegrini, 1999).

The Paranapiacaba ecological *continuum* represents one of the best preserved areas remaining in the region. Composed by three contiguous State Parks (Parque Estadual Intervales, Parque Estadual Carlos Botelho and Parque Estadual Turístico do Alto Ribeira) and one Ecological Station (Estação Ecológica de Xitué) (Figures 2 and 3; see chapter 3).

This large remnant is located in the State of São Paulo, in the counties of São Miguel Arcanjo, Capão Bonito, Ribeirão Grande, Guapiara, Tapiraí, Iporanga, Sete Barras, Apiaí and Eldorado. It covers an altitudinal gradient ranging from 20 to 1095 m, including small portions of the Ribeira de Iguape river plain, extending to the Atlantic slopes of the Paranapiacaba mountains, reaching the divide between the Ribeira de Iguape and the Paranapanema river basins.

Most of the fragment is covered by mature and secondary Atlantic rainforest. Some surrounding and marginal areas in the fragment (near 10% of the total area) is composed by planted forests of *Araucaria angustifolia*, *Pinus* sp. and *Eucalyptus* sp., banana plantations and pastures (Figure 3).

Figure 3. Protected areas of the Paranapiacaba fragment (A: Parque Estadual Turístico do Alto Ribeira; B: Parque Estadual Intervales; C: Parque Estadual Carlos Botelho, D: Estação Ecológica de Xitué), showing the areas covered by mature and secondary Atlantic rainforest (in white) and the surrounding and marginal areas (near 10% of the total area) composed by planted forests of *Araucaria angustifolia*, *Pinus* sp. and *Eucalyptus* sp., banana plantations and pastures (in black).



Floristic composition as well as population structure and dynamics are only partially known because of the lack of interdisciplinary and integrated studies caused by infrastructure problems and the size of the parks.

Its large species richness and high levels of endemism characterize the fauna. Faunistic richness is representative of primary Brazilian southeastern Atlantic rainforest. Large numbers of bird, small mammal, reptile, amphibian and insect species are present while large mammals, birds of prey and fish exist in smaller quantities (São Paulo, 1998).

A large number of bat and troglobitic species are representative of the significant cave fauna in the area. In fact, this region is home to one of the largest cavities concentration in the country, such that over 300 caves have been registered in P.E.T. Alto Ribeira and approximately 50 in P.E. Intervales.

The P.E. Intervales, P.E. Carlos Botelho and P.E.T. Alto Ribeira and the E.E. Xitué are administrated by the State of São Paulo's Environmental Office (Secretaria do Meio Ambiente), through the Fundação Florestal and the Instituto Florestal. Activities carried out in the park are mainly orientated towards public recreation, scientific research, park maintenance, and monitoring of biodiversity and built structures protection.

Currently, the conservation of animals that need large forest areas is unviable in most of the forest fragments in the State of São Paulo. Martuscelli (1996) indicated that out of the 78 State Conservation Units, 45.9% are smaller than 500 ha, 12.9% are between 500 and 1000 ha, 19.4% are between 1000 and 5000 ha, 9 % between 5000 and 10000 ha and only 3.8 % are larger than 40000 ha.

SOCIO-ECONOMIC REGIONAL ASPECTS

Ribeira Valley is the poorest region in the State of São Paulo (São Paulo, 1998). Several initiatives to strengthen regional development have failed in the past. Public policies encouraging development in Ribeira Valley have not led to significant socio-economic improvements. The region's privileged environmental heritage is not regarded as a source of increase in the region’s value but as an obstacle to development (Ferraz & Varjabedian, 1999).

Ribeira Valley is close to two important urban and industrial centres, São Paulo and Curitiba. Recent investments and infrastructure build up include the duplication of Highway Regis Bittencourt (BR-116) and proposals to build hydroelectric dams in the Ribeira de Iguape River and transposing river basins in order to divert water towards São Paulo and Curitiba. These initiatives are threatening to turn Ribeira Valley into a supplier of low cost natural resources to be exploited rampantly without taking into account environmental or cultural heritages, with no benefits for the region's traditional residents (Ferraz & Varjabedian, 1999).

PRESSURES OVER THE ENVIRONMENT AND CHIEF CONFLICTS IN THE PARANAPIACABA ECOLOGICAL *CONTINUUM*

Geological resources in the P.E.T. Alto Ribeira consist of natural deposits of plumb, zinc, silver and gold, as well as significant deposits of non-metallic minerals like calcareous rocks, dolomites and ornamental granite (Shimada & Lemos, 1999).

The region's mining history can be divided into three distinct stages: gold, plumb-silver, and non-metallic minerals (mainly calcareous rocks and dolomite). The first lasted from the beginning of the 16th century to the beginning of the 18th century, being reactivated at the end of the 19th century. The plumb-silver cycle began in the mid 1800s, it reached its greatest intensity in the 1900s, and ended in 1992. The last cycle partially overlapped the second one; it started in the 1950s and increased its intensity until now (Shimada & Lemos, 1999).

During the 1970s, 1980s and beginning of the 1990s, several companies made intensive mineral prospects in the Upper Ribeira Valley, competing especially for metacarbonatic rock deposits, and pressing for new undertakings permit approvals. These deposits occur in the form of large rock formations, yielding between ten and a hundred million tons of extracted rock annually.

P.E.T. Alto Ribeira and neighbouring areas contain the largest carbonatic rock reserves in the State of São Paulo, particularly of metacalcareous and metadolomite rocks. They are the raw materials for the manufacturing of cement, concrete, lime, soil correctives, metal alloys, paints and varnishes, glass, animal food, ceramic, plastic and other materials. There are many industries using calcareous rocks and clay as raw materials near P.E.T. Alto Ribeira and P.E Intervales.

Accessibility is another complex issue for the Paranapiacaba Conservation Units. Accessibility to the areas is important but, on the other hand, roads have a significant impact over conservation because they act as real barriers to the free movement of fauna through the forest, cutting off canopy passageways and threatening animals with traffic accidents. P.E. Carlos Botelho is particularly affected by these problems. A highway, built in 1929 to improve the region's traffic, cuts through the park.

Highway SP-139 is 112 km long, of which 52 km are paved. P.E. Carlos Botelho is cut by 33 km of unpaved road. Highway SP-139 connects the plateau with the coastal plains, cutting through the Paranapiacaba mountain range with a 760 m altitudinal gradient. It is used mainly for transporting products, and transit has been diminishing gradually over the years because of the bad state of the road (Ferraz & Varjabedian, 1999).

São Paulo's government 1988 initiative to pave Highway SP-139 caused big high impact discussions. Environmentalists' movement against its pavement reached the national and international public, and the development of their campaign gained big press coverage. However, residents of the areas neighbouring the park continued demanding an improvement in traffic conditions. With time, the idea of a "park-highway" have been consolidated as an alternative to increasing park visitation and environmental education opportunities, in addition to improving the standard of living of the local population. Currently in progress, a proceeding of the Environmental Secretary of the State of São Paulo addresses road maintenance, identification and monitoring of environmental impacts, and inspection and control of the area affected by the road (Ferraz & Varjabedian, 1999).

Managing intensive pressures over natural resources requires a rigid control program. Each park has its own program, but cooperation among staff teams is already well defined, working together with the forest guard. The main concern is to guarantee the integrity of the area, avoiding invasions, illegal settlement, deforestation and mining. Illegal palmito palm extraction is one of the worst problems in the three conservation units, characterized as a conflict in P.E. Intervales during the development of the Environmental Management Plan - Phase I (see São Paulo, 1998).

The deaths of an illegal palm extractor in 1997 (P.E. Carlos Botelho) and another one in 2001 (P.E. Intervales) and that of a park ranger in 1998 (P.E. Carlos Botelho) had a great repercussion. They led towards an even greater concern and action towards this problem.

Environmental Management Plan in the P.E. Intervales included the characterization of conflicts involving mining pressures within and near the park and regulation of land involving remnant quilombo communities (hidden settlements used as shelter by fugitive slaves). P.E.T. Alto Ribeira has some unresolved disputes of this kind.

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Chapter 3

DESCRIPTION OF THE STUDY AREAS

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INTRODUCTION

Geography of the Paranapiacaba fragment is scarcely known. The available maps (1:50000), published by the Instituto Brasileiro de Geografia e Estatística (IBGE) in 1974 and 1987, are based on aerial photographs that were taken in 1966. A level map (1:50000) of P.E. Intervales made for the Fundação Florestal in 1989 is also available. Nevertheless, since 1991 it has been pointed out that the hydrographical cartography available is very deficient: there are rivers, streams and brooks that share the same names and several others that have not been named yet (Guix *et al.*, 1992).

Based on this fragmented and sometimes insufficient information, during the 1998 census an effort has been made to describe in more detail the main paths and water courses networks in the study areas (Figure 1), especially those that are less accessible to researchers such as Alecrim and São Pedro (P.E. Intervales).

This chapter presents general data about each one of the protected areas of the Paranapiacaba forest fragment. For each one of those regions, the study areas where different studies were performed are described (i.e. check list of vertebrates and frugivores, top predators, Broad-snouted caiman and Southern river otter censuses; Table 1).

These study areas had path networks that were enlarged some weeks before the study was started in order to increase the potential sampling area. The result was a complex network of paths in some areas, including junctions and connections between them.

Transects performed for the collection of data related to the frugivores census (see chapter 4) do not necesarily overlap the paths described in this chapter. Sometimes the transect consists of a path fragment or of two or more fragments interconnected from different paths.

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Figure 1. Protected areas of the Paranapiacaba fragment. A: Parque Estadual Turístico do Alto Ribeira, B: Parque Estadual Intervales, C: Parque Eestadual Carlos Botelho, D: Estação Ecológica Xitué.

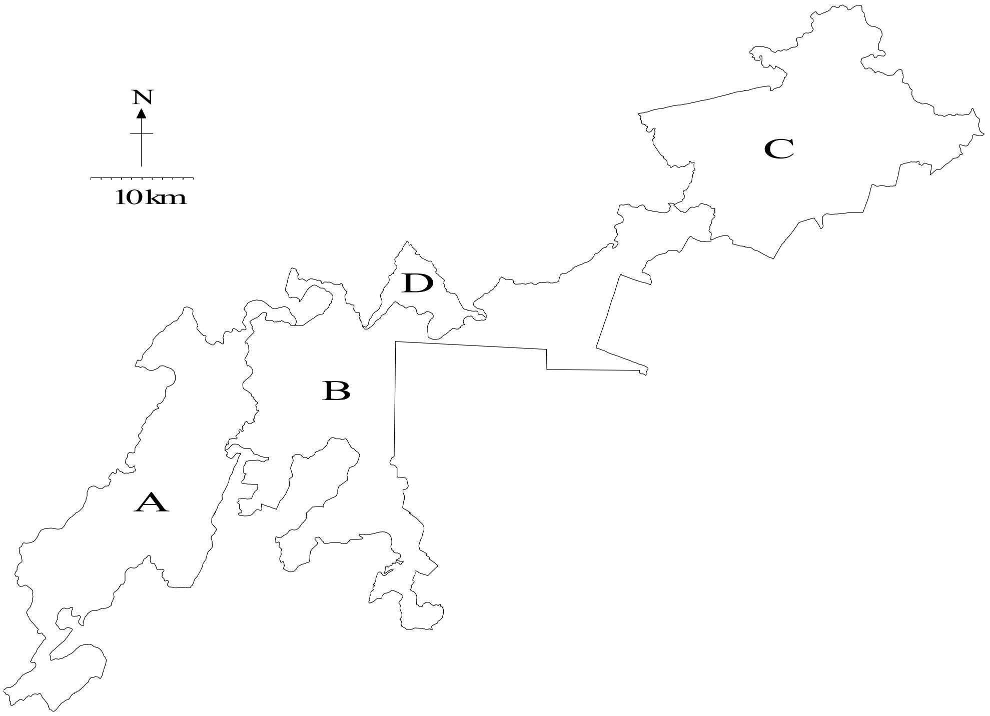
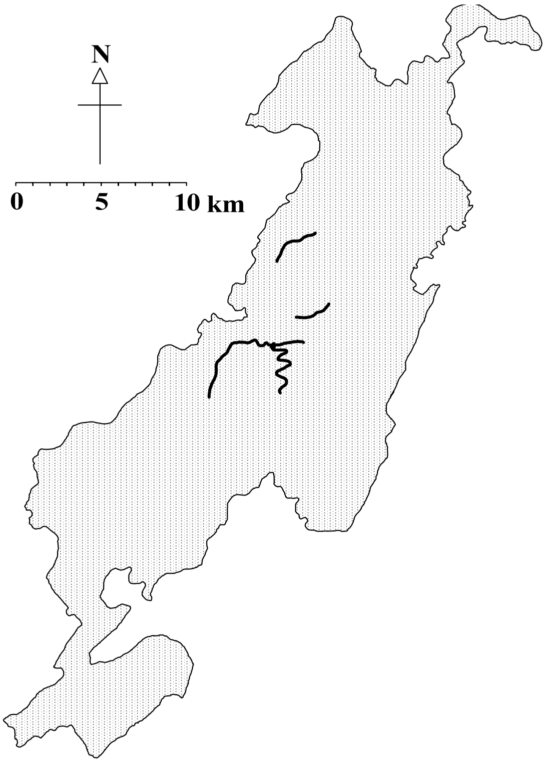


Table 1. Study areas where different studies were conducted. frugivores = censuses of frugivores; Caiman = evaluation of the population status of *Caiman latirostris*; Otter = observations of *Lontra longicaudis*; birds of prey = birds of prey survey; check list = check list of birds and mammals.

Study areas	frugivores	Caiman	Otter	birds of prey	check list
P.E.T. ALTO RIBEIRA					
Núcleo Caboclos	X		X	X	X
P.E.INTERVALES					
Alecrim	X	X	X	X	X
Carmo	X		X	X	X
Barra Grande	X		X		X
São Pedro	X		X		X
Saibadela	X		X		X
Sede Intervales					X
P.E.CARLOS BOTELHO					
Sede Carlos Botelho	X		X		X

PARQUE ESTADUAL TURÍSTICO DO ALTO RIBEIRA

Figure 2. Parque Estadual Turístico do Alto Ribeira showing the Núcleo Caboclos area.



Area: 35156 ha

Administration: Instituto Florestal

History: According to anthropologists, the history of human occupation in the region is 10000 years old. This is supported by the findings of fluvial *sambaquis* (accumulations of bivalve shells made by indigenous communities between 3000 and 10000 years ago) and more recent (2000 years old) ceramic sites. It is possible that the region was included in the migratory route of pre-colonial indigenous populations. The history of the Parque Estadual Turístico do Alto Ribeira blends with the region's colonisation history. It was officially created in 1958, but the objective of conserving the area was first established in the early 19th century. At that time, during a naturalist expedition to the region, scientists registered caves and they asked for the creation of a scientific reserve for paleontological and speleological studies.

Location: Between the Ribeira Valley and Southwestern São Paulo, including part of the Paranapiacaba mountain range, between Apiaí and Iporanga Counties. Between 24º 20’ - 24º 37’ S and 48º 24’ - 48º 43’ W.

Legal protection: The Parque Estadual Turístico do Alto Ribeira was created on 19 September 1958 by Decree nº 32283. It was ratified as P.E.T. Alto Ribeira on 28 November 1960 by Law nº 5973.

Altitude: 80 to 980 m.

Staff: Approximately 55 people working on administration, guarding and general services.

Infrastructure: There are several logistic areas (called “núcleos”) that are used for protection and scientific purposes: Santana, Caboclos, Ouro Grosso and Casa de Pedra. Data on frugivores censuses, birds of prey survey, check list of birds and mammals and the Southern river otter observations were collected only in Núcleo Caboclos. Most tourist activities are concentrated around these areas, including cave exploration, camping, short and long hikes, rappel, canyoning and river rafting. Some areas are used for recreation purposes only, some areas are orientated towards environmental education and some areas support research:

Núcleo Santana
- Tourist control station.
- Two camping areas, maximum capacity: 100 tents. Include three bathroom facilities.
- Trails and caves.

Núcleo Caboclos
- Control station and park ranger lodge.
- Camping area, maximum capacity: 40 tents.
- Environmental sducation lodge, maximum capacity: 20 people.
- Trails and caves.

Núcleo Ouro Grosso
- Visitor centre, including lodging, recreation room and kitchen. Maximum capacity: 50 people.
- Traditional culture museum.
- Trails, caves and the Ouro Grosso Lake.

Núcleo Casa de Pedra
Control station and park ranger lodge. Trails and caves.

NÚCLEO CABOCLOS AREA

Situation

The Núcleo can be accessed through a 17 km dirt track that starts on the road SP-250, km 294. Mining and research activities have been reported in the Alto do Ribeira region since the 19th century. Some companies tried to develop those activities up to the 1940’s, when the Instituto Geográfico e Geológico (IGG) proposed the creation of a protected area through a research for the prospecting of lead and silver.

In the Núcleo Caboclos region, right in the central area of P.E.T. Alto Ribeira, there are old and modern mining sites. The ancient ones correspond to attempts to find lead and silver. The current ones correspond to the extraction of calcareous material for the obtaining of lime.

One of the operational bases of the park is set in the Núcleo since 1958. It is funded by the IG (Instituto Geológico), and it develops activities related to public visits, planning of tourist routes, scientific research and investments on human resources and buildings. The IF (Instituto Florestal) collaborates with these tasks since 1984 by administrating other regions in the park.

Geographical characteristics

The region's relief is quite abrupt. It includes ridges and slopes, quartz outcrops and wide calcareous areas, some of them including karstic relieves.

Vegetation

The Núcleo is 600 m above sea level and it shows a typical hillside Atlantic rainforest vegetation with a high diversity. This diversity is increased by the existence of calcareous sediments that enhance the growth of forests with a slightly different floristic composition.

Secondary vegetation grows in the margins of dirt tracks and trails; it is characterised by taquarais (*Merostachys* sp.) and shrublands. The colonisation and extraction processes that started in the 18th century used these roads and some trails that are accessible nowadays.

Logistic conditions of the base

The infrastructure includes 1 lodging area for guides, 1 lodging and administrative area for technicians, 2 lodging areas for technicians and researchers, 1 house used as visitor's centre plus a camping area. There is no electricity available. Light is produced through photovoltaic cells and batteries that also allow the use of a VHF and SSB radio.

Description of the trails (*trilhas*)

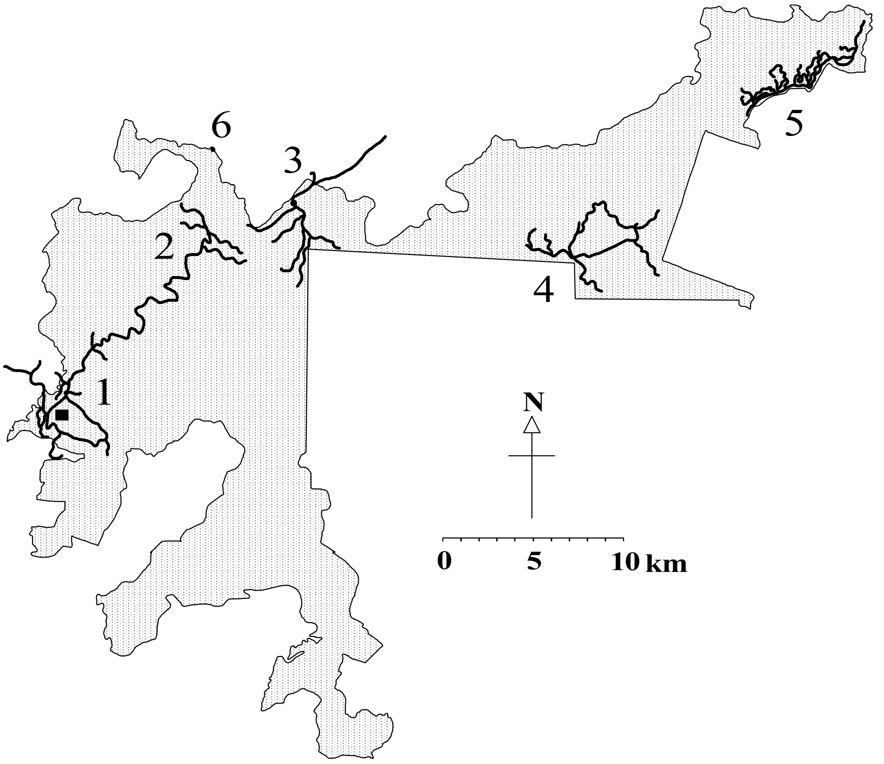
The region includes a large amount of trails, six of which were used:

- **Dirt track between Núcleo Caboclos and Espírito Santo.** It is a section of dirt track (4 km long) that starts in Núcleo Caboclos and ends in the Bairro Espírito Santo. The first section goes across several inhabited areas in wide open regions. All along the way, the forest around it is secondary. The track goes across several narrow watercourses.

- **Trilha Caboclos.** It is a short trail (1.5 km) that starts in Núcleo Caboclos heading East. It is considerably steep.
- **Trilha da Casa de Pedra.** It is 7.5 km long, but only the first 6 km were censused. It starts in the Núcleo Caboclos base and reaches a cave called Casa da Pedra. The first section goes across several inhabited areas surrounded by deforested lands that host farming and domestic animals. The second section goes across a steep secondary forest.
- **Trilha da Gruta da Temimina.** It is almost 5 km long and runs through a variable relief. In the areas that are closest to the road, there are slight slopes. In the surroundings of Gruta da Temimina, where the trail ends, the relief turns far more abrupt. At the beginning of the trail, the vegetation shows noticeable anthropic modifications (constructions, fruit tree plantations). Vegetation closes as the trail goes into the forest. One of the narrowest sections is in the middle of a banana plantation. Further down, there are a few difficult sections across taquarais areas. The trail requests a lot of attention due to the danger of falls on a wet and slippery ground. Although it includes large trees, the forest is typically secondary. There are imbaúbas (*Cecropia* spp.), young palmito palms and plenty of taquarais.
- **Trilha do Espírito Santo.** It is about 2 km long. The relief is variable. It includes closed forest areas and sections where the trail is perfectly marked. The trail starts near a set of houses called Espírito Santo and therefore anthropic influence is remarkable at the beginning.The area hosts caves, brooks and three quarries. One of those three quarries, the Pedreira de Petris has a low activity (one lorry per week). It started before the P.E.T. Alto Ribeira was turned into a conservation unit through the Decreto nº 32.283/58. The other two quarries were legally closed because they were started after the decree that protected the P.E.T. Alto Ribeira and they are placed within its limits. The vegetation is composed of secondary forests.
- **Trilha da Pescaria.** It is 3 km long. It leads to different points of the park such as the Caverna da Pescaria, Caverna Desmoronada and the Vale das Ilusões. Its relief is extremely abrupt, since it follows a mountain slope. Time ago, this trail was used to access a village called Paiol da Tábua. Nowadays, some inhabitants of the area still use this trail. Although people have been using it, large trees and not many bushes surround the trail. It crosses some mature forests but it mainly goes across old secondary forests.

PARQUE ESTADUAL INTERVALES

Figure 3. Parque Estadual Intervales. 1: Alecrim area; 2: Carmo area; 3: Barra Grande area; 4: São Pedro area; 5: Saibadela area; 6: Sede area. The black square shows the location of the Lagoa dos jacarés (Caiman lagoon).



Area: 49888 ha*

* Map standard measurements used in this chapter correspond to the park's total area as of 1998, when faunistic censuses were conducted.

Administration: Fundação Florestal

History: The area was first settled for farming in the 1950's, but the São Paulo State Bank (BANESPA) because of their ill success incorporated it to the park. From 1960 on, several properties and settlements were appended to the initial nucleus, adding up to the 38000 ha of Fazenda Intervales. Fundação Florestal took over the area in 1987, adding it to São Paulo State protected areas. Fazenda Intervales, with 38356 ha, and the returned properties Xiririca A and B, with 11532 ha, were together decreed a State Park in 1995, totalling 49888 ha. In October 1999, areas declared and recognized as remnant *quilombo* communities land were excluded from the park's territory, thus P.E. Intervales current area is approximately 42000 ha.

Location: Between the Ribeira Valley and Southwestern São Paulo, including part of the Paranapiacaba mountain range, in Ribeirão Grande, Guapiara, Iporanga, Eldorado and Sete Barras Counties. Between 24º 12' - 24º 25' S and 48º 03' - 48º 30' W.

Legal protection: Declared Serra do Mar APA's ("Área de Proteção Ambiental") Wildlife Zone since 1984 and part of the Atlantic Forest Biosphere Reserve since 1992. Decreed a State Park by State Decree nº 40135 of 8 June 1995, modified by State Decree nº 44293 of 4 October 1999.

Altitude: 60 to 1095 m.

Staff: Approximately 60 people are working on monitoring activities, guarding, providing public services and lodging.

Infrastructure: There are several logistic areas (called "bases") that are used for protection and scientific purposes. During the 1998 study we used six of these areas: Alecrim, Carmo, Barra Grande, São Pedro, Saibadela and Sede. Ten beds are available at base Barra Grande. It had originally been a guard base, but a house was readapted for non-concomitant tourists or researcher's accommodation. There are 8 beds at base Carmo and 10 at base Saibadela, both for researchers only. Administration, paths and tourist accommodations are concentrated in the Sede area (the park's headquarters).

1. ALECRIM AREA

Situation

The base Alecrim is placed South from the Sede of the P.E. Intervales, at 29 km from the track that joins both centres. It is only 6 km away from the limit of the P.E.T. Alto Ribeira. The base can be accessed on a vehicle from the Sede through the track. It can also be reached on foot or on a mule through a trail (*trilha*) from P.E.T. Alto Ribeira, although this way is much longer and complicated.

Geographical characteristics

The base is placed at 250 m of height, in the Pilões or Formoso river valley. The maximum altitude that can be reached from there is 700 m, and the minimum one is 150 m. The river Pilões (known also as river Formoso) flows 200 m away from the base. It is about 20 m wide and it collects waters from several streams and brooks that bring water from the top of the mountains through little valleys that are perpendicular to that of the river Pilões. There is an artificial lagoon about 1.5 km away from the base – when the road was built, it stopped the course of a brook and a little reservoir appeared. Approximately 18 km away from the base, in P.E.T. Alto Ribeira, there is another lagoon: the Lagoa Vermelha.

Vegetation

Settlers that modified the original forest have inhabited the surroundings of base Alecrim for centuries. Little banana plantations can still be found nowadays spread across the forest. The general state of the area is that of a late secondary forest, mature in some sections. Near the base there are taquaral areas (*Merostachys* sp.), the starting stage of a slow succession, indicating the remains of opened areas that were used for subsistence farming about 15 or 25 years ago. The Atlantic rainforest is generally healthy, with an average height of 18 m and emergent trees reaching 24-30 m. The palmito is quite abundant but it becomes scarce at the bottom of the valley, where the taquara is widespread. On mountain sides and summits and facing N and NW, the Atlantic rainforest is at its best and there is hardly any taquaral left.

Logistic conditions of the base Alecrim

Alecrim is a base of logistic support for forest rangers that can be accessed through a 29 km track in a bad state due to collapses during rain periods. The base has two empty buildings, two more which are sometimes used by rangers to stay and little one that used to be a school.

Description of the trails (*trilhas*)

A total of 14 trails were covered from the base. Some of those trails can be divided into sections due to their length and extension – overall, there are 17 sections. There are only two trails starting at the base: trilha da jacutinga and trilha do rio Pilões, and the track to access the base that goes on South and ends at the lagoa dos jacarés, 2 km away:

- **Leite 1.** Distance covered: 7.7 km. The trails starts 1.7 km SE from the base, beyond the lagoa dos jacarés. The starting height is 250 m and the final one is 650 m, after a constant ascending slope. The Atlantic rainforest can be considered as mature forest along the whole trail (medium width: 2-3 m) and there is only a little section (50 m) where taquara occurs.
- **Leite 2.** Distance covered: 4.9 km. The trail starts 0.5 km ESE from the base, before the lagoa dos jacarés. The starting height is 260 m and the final one is 650 m. The first section (approximately 1 km) is steep and covered with taquara, which makes sightings quite difficult. After that, the trail becomes narrower (0.8-1 m) and it lays across a mature forest. The trail crosses several brooks that go down both slopes to reach the river Pilões or the river Claro, tributary of the Pilões.
- **"Caminho da Pinha".** Distance covered: 1 km. the trail starts 5.5 km away from the base, where Leite 1 and Leite 2 join. It descends towards the river Leite. The starting height is 650 m, and the final one is 550 m.
- **Rio Claro Acima.** Distance covered: 3.1 km. The trail starts 3.2 km S from the base. It corresponds to an ascending branch of the trail Leite 1 that is placed at 1.7 km from its starting point and that leads to the river Claro. The starting height is 490 m and the final one is 350 m.
- **Rio Claro Abaixo.** Distance covered: 3.4 km. The trail starts at the same point as the Rio Claro Acima trail and goes down to the river Claro. The staring height is 300 m and the final one is 200 m. This trail descends slowly and continuously and it has an average width of 1-2 m. It includes some taquaral areas but it generally goes across secondary forests.

- **Ribeirão Grande.** Distance covered: 2.1 km. This trail starts 1.5 km NNW from the starting point of the Rio Claro Abaixo trail and it ends at the river Pilões. The starting height is 215 m and the final one is 195 m. The trail goes across mature Atlantic rainforest areas covering light descending slopes and flat sections.
- **Trilha da Divisa.** Distance covered: 3.7 km. This trail starts 50 m from the starting point of the Rio Claro Abaixo trail, it descends WNW, crosses the river Pilões and ends at the border with P.E.T. Alto Ribeira. From this point, the trail continues to the NE up to the Caminho do Carrapato. The starting height is 290 m and the final one is 550 m. The trail, which is 0.8-1 m wide, shows a continuous ascension, including some steep sections, and it generally goes across mature and secondary forests.
- **Trilha da Lagoa Vermelha.** Distance covered: 2.3 km. The trail starts about 3 km W from the starting point of Trilha da Divisa, it goes into with P.E.T. Alto Ribeira and leads to the Lagoa Vermelha. The starting height is 400 m and the final one is 510 m.
- **Trilha da Jacutinga.** Distance covered: 1 km. The trail starts at the base and it heads E. The starting height is 250 m and the final one is 400 m. The trail is steep and it goes across taquaral areas. It is not a good trail for censusing purposes.
- **Caminho do Rio Formoso.** Distance covered: 1.1 km. The trail starts at the base and it heads SW along the river Pilões margin. It is almost flat, the starting and final heights being both 240 m.
- **Caminho do Carrapato.** Distance covered: 1.3 km. The trail starts 1.3 km away from the base following the track towards the Sede and it heads NW. The starting height is 270 m and the final one is 390 m. It is a steep trail crossing taquaral areas, which does not make it advisable for censusing purposes.
- **Trilha do km 29.** Distance covered: 1.4 km. The trail starts at the track that leads to the Sede, 5 km away from the base and heading SSE. The starting height is 300 m and the final one is 500 m.
- **Trilha da Vargem Grande.** Distance covered: 0.9 km. The trail starts at the track that leads to the Sede, 5 km away from the base and heading N towards the river Pilões. The starting height is 300 m and the final one is 340 m.
- **Caminho Alecrim – Sede.** Distance covered: 19.5 km. The track starts at the base Alecrim heading NE and it ends 5 km away from the base do Carmo. The starting height is 250 m and the final one is 480 m. The track goes across a secondary forest that has plenty of emergent trees.

2. CARMO AREA

Situation

The base do Carmo is placed 10 km away from the Sede of the P.E. Intervales.

Geographical characteristics

The base do Carmo is in the northwestern area of the park, between 600 and 900 m above sea level. The river Lageado crosses the road between the Sede and the base do Carmo, and so does the river Carmo near the base. The relief in the area is quite abrupt. On the way between the base do Carmo and the Sede, as well as between the base and Alecrim, there are excellent observation points that offer wide views of the valley.

Vegetation

There are areas in the region where human influence was minimal or inexistent as well as areas in advanced successional stages. Generally, mature or old secondary forests cover the region. The lowest forests, locally known as "capoeiras", occur in the margins of tracks and trails due to the extraction of palmito palms and wood.

Logistic conditions of the base do Carmo

The Carmo region is an area of the P.E. Intervales that is dedicated to research activities only. The base do Carmo includes a two-bedroom house that can host up to eight people. There is no electricity available but a system allows the obtaining of hot water.

Description of the trails (*trilhas*)

Several trails were opened for surveillance and research purposes. Among them, the ones that were used in the census were:

- **Caminho Sede - Carmo.** Up to the research station of the Sede (sede de pesquisa) the track runs almost flat and it shows human impact in its sides. After the research station the forest adopts the appearance of a secondary forest in an advanced successional stage. Up to mark 8 (a mark on the side of the track) the track is in a good state for traffic. After that point, there are many complicated sections, steep and slippery. There are three critical sections. In the first one, erosion took away half of the track. In the second one, a river cuts the track. The third one is a wide mudflat that requires driving a four-wheel drive vehicle and a lot of experience. On the sides of the track, there are many taquarais (*Merostachys* spp.) and imbaúbas (*Cecropia* sp.). The closer to the base, the larger the trees near the track, such as figueiras bravas, guapuruvus and paus-sangue.
- **Caminho Carmo - Alecrim.** The track descends on to the base Alecrim along the mountainous edges of the valley. Plenty of sighting points along the way offer a wide vision of the valley. The track is humid and slippery and it has several critical points, particularly across mudflats. Sometimes the track gets narrow due to the intrusion of vegetation. Temperature increases considerably in the valley. Young and old secondary forests and mature forests compose the vegetation. Along the narrowest sections of the track, the canopy in both sides gets together and shadows the way.
- **Trilha do Carmo Acima.** The trail is almost flat. The vegetation around is diverse and it includes, amongst other species, palmito palms (*Euterpe edulis*), imbaúbas and taquaras in some sections. It is a long trail, approximately 4 km long. There are three sighting points along the way and it finishes at the river Três Corvos.
- **Trilha do Mono (=Rancho queimado).** It was opened for the behavioural study of the Woolly spider monkey (*Brachyteles arachnoides*). It starts approximately in the km 1.5 of the Trilha

do Carmo Acima. The trail is abrupt and quite narrow. Mature forests generally compose the vegetation in the area, although some young palmito palms can be found too.

- **Trilha das Figueiras.** The trail is almost flat. Due to big barriers of taquarais, it could not be used during our work. According to field guides, it is 12 km long and there is a surveillance base (no longer used) just after 6 km.

3. BARRA GRANDE AREA

Situation

The base Barra Grande is placed about 6 km away from the Sede of the P.E. Intervales, by the dirt track that goes from the Sede to the base São Pedro. The trip from the Sede to Barra Grande can be covered in 30 minutes on a four-wheel drive, but its accessibility depends on the rains.

Geographical characteristics

The base Barra Grande is placed in one of the highest regions of the Paranapiacaba mountain range, in an abrupt area. The base is on a steep mountain slope, at about 800 m of altitude. Several rivers and streams cross the area, but most of them do not carry much water: they have an average depth of 50 m and their average width is around 4 m.

Vegetation

The vegetation in the region corresponds to hillside Atlantic rainforest. Nevertheless, the Barra Grande area shows a strong human influence and obvious signs of exploitation activities that were developed in the past. One of those signs is the absence of adult palmito palms. Generally, there are few palms and a lot of taquaras (*Merostachys* sp.) and some other secondary forest species. The vegetation in the Barra Grande area is a patchwork of different successional stages: from areas covered by early species to late secondary and mature forest areas.

Logistic conditions of the base Barra Grande

The base Barra Grande is a two-bedroom house that includes a toilet and a kitchen. It has running water but no electricity and therefore there is no radio in it.

Description of the trails (*trilhas*)

The track between the base Barra Grande and the base São Pedro plus six trails were used to carry out the censuses. The average length of the trails is 5 km. A total of 43.7 km were censused, covering a range of altitudes between 550 m and 1030 m:

- **Caminho Barra Grande - São Pedro.** Distance covered: 10 km. It is a wide track that represents an important discontinuity in the rainforest canopy. Its starting altitude is 825 m and the final one is 790 m, including ascents and descents along the way. The vegetation is not homogeneous and it combines well preserved forest areas and semi-opened zones with starting species. Taquaral is relatively abundant in some sections.

- **Trilha das Pedrinhas.** The trail is 3.3 km long and it descends from 800 m to 665 m. The starting point of the trail is on the track between Barra Grande and São Pedro, approximately 2 km away from Barra Grande. This trail crosses one of the best-preserved rainforests in the region: a closed secondary rainforest area full of epiphytic species and young palmito palms. There are a few areas of taquara, but it is not a very common species.
- **Trilha da Macaca.** Distance covered: 4.5 km. It starts 4 km away from Barra Grande, in the track that joins the base and São Pedro. It goes down from 800 m to 755 m. The trail crosses late secondary rainforest areas as well as disturbed zones, opened and colonised by taquara. In the secondary rainforest areas there are a lot of epiphytic plants and palms and very few lianas. A good percentage of the trail runs along a brook.
- **Trilha ao Xitué.** Distance covered: 10 km. The trail starts in the Pano Amarelo path, in a crossing towards Mirante or Xitué. The starting height is 855 m and the final one is 750 m, but there are a lot of ascents and descents (550 m) along the trail. To start with, the trail crosses several stream and brooks and vegetation around is mainly riparian Atlantic rainforest with very few, and very young, palmito palms. Along most of the trail, the average height of the canopy is 15 m. Taquaras appear along most of the trail and it even becomes a dominant species in some areas, but every now and then there are well preserved rainforest sections.
- **Trilha Pano Amarelo & Trilha do Mirante.** Distance covered: 3.8 km. This trail starts in the track between Barra Grande and the Sede, a few meters away from the base. This trail is extremely steep, especially at the end, and it goes from 825 m to 1030 m of altitude. Along the first 3 km, the trail crosses late secondary and mature rainforests, with a lot of epiphytic species and very few lianas. Al along the trail there are a few taquaral spots. The rainforest has an average height of 20 m, but some trees reach 28 m of height. After the first 3 km, the forest height gradually decreases and it becomes more opened.
- **Trilha da Caçadinha.** Distance covered: 4.5 km. This trail was opened one week before the census period in Barra Grande. The starting altitude is 800 m, and the final one is 840 m. The entrance to the trail is by the track to São Pedro, less than 0.5 km away from Barra Grande. It goes along an area that includes long sections of taquaral. The rainforest areas crossed by the trail are quite opened, with dense undergrowth and with plenty of lianas. The maximum height of the rainforest is 25 m.
- **Trilha Rancho Queimado.** Distance covered: 4.5 km. The starting altitude is 810 m and the final one is 775 m. This trail was also opened one week before the census. The entrance to the trail is by the track between Barra Grande and São Pedro, 3 km away from Barra Grande. Most of it crosses taquaral areas, which makes the sightings quite difficult. There are only some badly preserved rainforest areas.

4. SÃO PEDRO AREA

Situation

The base São Pedro is placed in the southeastern area of the P.E. Intervales. It can be reached through a 30 km track from Intervales that used to go as far as A Pedra. The river São Pedro cuts the track now, and A Pedra can only be accessed on foot.

Geographical characteristics

The base São Pedro is placed at an altitude of 460 m. Trails and paths around it are distributed between 350 and 860 m. The area is generally mountainous but it does not show steep slopes except for the trails that follow the streams or those that, exceptionally, run near the peaks.

The area is placed in the São Pedro, Santana, Jararaca, Xaxim, Tartaruga and Limão water basin. The river São Pedro is the most important one in the area; its width varies between 10 and 20 m. The remaining ones are tributaries to the São Pedro and they collect waters from the basins and valleys that end up in the São Pedro valley.

Vegetation

The base is placed in an open area that used to host ancient sweet corn and mandioca plantations. The forest surrounding the base has recovered most of the deforested areas and there are some fields with banana and fruit trees around the house. Except for this altered area, the region is covered by well preserved vegetation, generally mature forest and some secondary forest. Along the main track and some trails, there are taquarais that show the alteration suffered by the original forests.

Logistic conditions of the base São Pedro

The base is a two-bedroom house made of wood; a porch is used as kitchen and dining area. There is no electricity available. This base is used for surveillance and two or three park rangers usually inhabit it. Its location allows the connection between the Sede region and the Vale do Ribeira.

Description of the trails (*trilhas*)

A total of 11 trails were covered from the base. They can be distributed in two groups: the first one includes the main track to São Pedro and the trails starting on it; the second group includes the trails that start at the base itself and the ones on the other side of the river, which are more abrupt because they go over a pass:

- **Caminho São Pedro - Sede.** Distance covered: 3.7 km. This is the main connection between the base São Pedro and the Sede of P.E. Intervales. It is a dirt track about 3 or 4 m wide, almost flat. There are many taquarais on the sides, but also tall trees and bromelias. Altitudes range between 410 and 520 m, and the maximum height of the forest is 35 m.
- **Trilha de Xaxim.** Distance covered: 1.95 km. This trail starts on the track between São Pedro and the Sede. It is approximately 8 km away from the base, beyond the river Santana, heading

towards 340º. It is quite straight: it keeps a direction between 300º and 330º. It ends at the river Santana. There are many taquarais on the way. Altitude ranges between 500 and 550 m, and the maximum height of the forest is 22 m.

- **Trilha de São Pedro acima - Xaxim.** Distance covered: 3.27 km. This trail leaves the base and follows the river São Pedro. Approximately 1.15 km away there is a crossroad; there is a trail to Xaxim (different from the one above) on the left and a trail to Tartaruga on the right. The trail carries on towards Xaxim, following the river Xaxim in a direction 330º - 340º. Mature and old secondary forest and many taquarais compose the vegetation around. Altitude ranges between 410 and 480 m, and the maximum height of the forest is 30 m.
- **Trilha de São Pedro abaixo.** Distance covered: 4.5 km. The trail is longer than 4.5 km, but the census was performed up to the river São Pedro only. Generally, the trail follows the right margin of the river, going across a little degraded vegetation and open areas. Altitude ranges between 410 and 450 m, and the maximum height of the forest is 29 m.
- **Estrada da Pedra.** Distance covered: 5.26 km. This trail follows the ancient track between São Pedro and A Pedra. It is not used now, and some trees have fallen across the way. Nevertheless, it is 3 or 4 m wide. It goes steadily uphill and, in some sections, there are views of the valley and the hills ahead. Altitude ranges between 410 and 570 m, and the maximum height of the forest is 27 m.
- **Trilha de São Pedro acima - Tartaruga.** Distance covered: 4 km. This trail corresponds to one of the branches of the Trilha de São Pedro acima, the trail on the right at the crossroad on the other side of the trail to Xaxim. The census was performed up to the river Tartaruga, but the trail continues on to Limão. Mature and old secondary forests and some taquarais compose the vegetation. Altitude ranges between 410 and 530 m, and the maximum height of the forest is 34 m.
- **Trilha do Barranquinho to Barraca do Limão.** Distance covered: 2.3 km. The trail starts as a branch of the Estrada da Pedra and links up to the Trilha de Limão that reaches the Barraca do Limão. The trail does not end at the river Limão, but it carries on beyond it. It is quite abrupt, with dense vegetation and a low visibility. Altitude ranges between 470 and 580 m, and the maximum height of the forest is 36 m.
- **Trilha do Limão.** Distance covered: 2.2 km. This trail runs between the Barraca do Limão and the Trilha da Tartaruga, following the river Limão. It goes across dense and shady vegetation and it is quite abrupt. Altitude ranges between 530 and 580 m, and the maximum height of the forest is 27 m.
- **Trilha da Jararaca.** Distance covered: 2.4 km. This trail starts in the main track, approximately 5 km away from São Pedro. Most of it goes across taquaral areas. Altitude ranges between 480 and 530 m, and the maximum height of the forest is 25 m.
- **Trilha do Cedro Nova.** Distance covered: 4.4 km. This trail starts in Barranquinho and goes across a mature and old secondary forest area where taquara is also abundant. Altitude ranges between 470 and 560 m, and the maximum height of the forest is 27 m.

- **Trilha da Pedra**. Distance covered: 5.7 km. The starting point of this trail is placed at the end of the Estrada da Pedra. It goes across an area of relatively low and open vegetation, although in some sections the maximum height of the forest is 29 m. Altitude ranges between 470 and 560 m.

5. SAIBADELA AREA

Situation

The base Saibadela is placed in the middle of the Saibadela river valley, in the Sete Barras County (24º14'S, 48º05'W; altitude: 80 m). It is one of the ten watching and research bases in the Parque Estadual Intervales.

Geographical characteristics

The region is full of steep little streams, brooks and rivers. Most watercourses have a rocky bottom, but some sand bottoms appear in flat areas. The main rivers in the area are the Saibadela, the Quilombo and the Forquilha, all of them belonging to the Ribeira river water system. The three valleys are contact zones between the Alto Ribeira region and the Paranapiacaba mountain range. Temperatures and rainfall are high when compared to higher areas of the Parque Estadual Intervales.

Vegetation

The river Saibadela limits the western border of the park in a W-E direction. The Southern side of the valley is beyond the park's protected area, and it reaches maximum heights of 400 m. This area shows a degraded secondary vegetation, banana plantations and pastures for cattle. The Northern side of the valley, where censuses were performed, is within the park's protected area. The census area also included the Forquilha river valley and the western side of the river Quilombo. The altitudes sampled in the three valleys range between 60 m and 400 m, although they reach 610 m in one of the transects.

Vegetation in this area is mainly mature and old secondary lowland and hillside Atlantic rainforest (Hueck, 1972a,b), with heights ranging between 17 and 40 m. Forests near the base are not dense in their lower levels, with plenty of epiphytes. The most common plant families found are Myrtaceae, Sapotaceae, Euphorbiaceae, Moraceae, Lauraceae and Leguminosae. The palmito palm (*Euterpe edulis*) is common in the area. The absence of taquara (*Merostachys* sp.) is remarkable. Several results of anthropic actions were detected in the area: presence of introduced plant species such as lemon, banana and orange trees; the remains of ancient little mines and dirt tracks; a widespread path network opened by rangers and researchers; the remains of a palmito exploitation.

Logistic conditions of the base Saibadela

The base Saibadela has two buildings: one is used by forest rangers, and researchers or visitors use the other one. The researcher's house can host up to ten people and it has a kitchen, a sitting room, two bedrooms and two bathrooms. Electricity and a fixed radio are available. The base can be accessed through a well preserved dirt track.

Description of the trails (*trilhas*)

The vegetation covering the surroundings of the base Saibadela is highly preserved, which makes the area an interesting subject for research works. There are a high number of paths in the area, and some of them could be closed in order to favour their natural recovery. The base Saibadela used to be visited by tourists, but it is not any longer. There is currently a discussion to include the option of a selective tourism program for the area in the Environmental Management Plan of the P.E. Intervales. At the moment, the Saibadela area is included in the Environmental Management Plan as a "Special use area" -IIIb-, with the possibility of research and forest management activities and the proposal of establishing a permanent research area next to the base.

People living in settlements near the base are poor, and they sometimes hunt in the park or extract palmito from the P.E. Intervales. Environmental education programs as well as economical alternatives where the conservation of natural richness in the P.E. Intervales and surroundings is prioritised are highly needed (see chapter 16).

During the census, 27 transects were covered in 22 trails spread across the Saibadela, Quilombo and Forquilha river valleys. A total of 54.7 km were covered in 57 h 46' during 11 effective censusing days. The estimated sampled area was 1200 ha:

- **Trilha da Adriana.** 2.7 km; 60 - 200 m. Old secondary forests.
- **Trilha do Quilombo.** 4.9 km; 60 - 250 m. Mature forests.
- **Trilha do Rolado.** 4 km; 60 - 300 m. Mature forests.
- **Trilha da Figueira.** 2.5 km; 60 - 250 m. Mature forests.
- **Trilha da Serra I.** 2.4 km; 60 - 250 m. Mature forests.
- **Trilha da Serra II.** 3 km; 60 - 350 m. Mature forests.
- **Trilha da Beira do Rio.** 1.5 km; 60 m. Old secondary forests.
- **Trilha da Mina.** 1 km; 200 - 60 m. Mature forests.
- **Trilha da Cachoeira Saibadela.** 1 km; 60 m. Mature forests.
- **Trilha do Valmir.** 1.5 km; 350 - 200 m. Mature forests.
- **Trilha da Divisa.** 1.5 km; 60 - 125 m. Old secondary forests.
- **Trilha da Jararaca.** 2 km; 125 - 60 m. Mature forests.
- **Trilha do Barraco.** 3 km; 60 - 200 m. Mature forests.
- **Trilha do Prado.** 1.8 km; 60 - 200 m. Mature forests.
- **Trilha da Laranjeira.** 0.8 km; 200 - 150 m. Mature forests.
- **Trilha do Guapuruvu.** 2 km; 60 m. Mature forests.
- **Trilha do Aleixo.** 0.5 km; 200 - 250 m. Mature forests.
- **Trilha do Desvio.** 2 km; 150 - 200 m. Mature forests.
- **Trilha da Mangueira.** 2 km; 60 - 150 m. Mature forests.
- **Trilha da Cachoeira do Quilombo.** 1.6 km; 60 - 200 m. Old secondary forests.
- **Trilha do Sapo.** 1.5 km; 120 - 280 m. Mature forests.
- **Trilha da Encosta.** 4.5 km; 60 - 610 m. Old secondary and mature forests.

6. SEDE AREA

Situation and Geographical characteristics

The headquarters (Sede) of the Parque Estadual Intervales are placed in the Northwestern region of the park, at 860 m of altitude. The area around the Sede is relatively flat, surrounded by little steep hills of between 100 and 200 m of height. Several brooks cross the whole area and there are also artificial lagoons and little dams.

Vegetation

Vegetation around the Sede has been modelled by a strong anthropic influence as shown by the predominance of young secondary forests. One of the obvious signs of human influence is the absence of palmito palms. Species that are typical from early successional stages are abundant in the area: taquara (*Merostachys* sp.), imbaúbas (*Cecropia* spp.) and quaresmas (*Tibouchina* spp.). Some areas, particularly the bottom of some valleys, host well preserved old secondary forests.

Logistic conditions

Since it hosts the park's headquarters, the Sede has plenty of infrastructures. There is also a good communication network: telephone, fax, fixed radios, and vehicles. Some of the people working in the Sede (field guides) have a deep knowledge of the paths in the area. Buildings in the area are:

- Three lodging buildings, maximum capacity: 85 people.
- Restaurant, maximum capacity: 100 people.
- Visitor centre, available for recreational purposes as well as for conferences and meetings.
- Reception, for reservations and check in on arrival. There is a small store with general necessity items and regional arts and crafts.
- Visitor area, including bathrooms and kiosks, providing services to up to 40 visitors per day.
- Research headquarters: hosts 12 beds as well as research facilities such as a laboratory. Occasionally opened for tourists.

Description of the trails (*trilhas*)

The trails used for the faunal checklists are placed around the Sede and they cover a set of altitudes ranging between 735 and 925 m:

- **Trilha da Gruta Colorida + Trilha da Roda d'Água.** Distance covered: 6 km. The trail goes across young secondary forest areas with plenty of pioneer species. The undergrowth is very dense, and taquaras and lianas are highly abundant. The maximum height of the forest is 25 m.
- **Trilha da Bocaina.** Distance covered: 6 km (3 km dirt-track + 3 km trail). It is a circular trail, starting and ending at 880 m of altitude. The trail goes across a well preserved secondary forest with many epiphytes but also with some taquaras. The vegetation around the dirt track is lower and less preserved.

- **Trilha do Lago Negro.** Distance covered: 2.5 km (1.2 km dirt-track + 1.3 km trail). There are plenty of taquaras along the trail. Along the track, the forest is young and has many imbaúbas. The starting height is 735 m and the final one is 915 m.
- **Trilha do Palmito.** Distance covered: 1.5 km.
- **Trilha Nova da Gruta Colorida.** Distance covered: 5 km. Old secondary forests alternate with areas where the vegetation is at earlier successional stages. The undergrowth is dense in some areas. The maximum height of the trees is 30 m.
- **Trilha do Mirante da Anta.** Distance covered: 1.5 km. The starting altitude is 800 m and the final one is 925 m. In the last bit, trees disappear and dense bushes, which are typical from the peaks of the Paranapiacaba mountain range, appear instead
- **Trilha da Caçadinha.** Distance covered: 5.5 km (1.8 km river + 3.7 km trail). The starting altitude is 755 m and the final one is 780 m. The river section is frequented by groups of tourists covering guided visits to the area.

ESTAÇÃO ECOLÓGICA DE XITUÉ

Area: 3095 ha

Administration: Instituto Florestal/Fundação Florestal.

History: the Estação Ecológica de Xitué was originally two private properties. It is a mountainous area next to P.E. Intervales, one of the most fragile regions of the Paranapiacaba ecological *continuum* because of its small area. There is no visit history. Illegal hunting is the main anthropic pressure, although it has recently decreased thanks to the support of P.E. Intervales staff.

Location: Between the Ribeira Valley and Southwestern São Paulo, including part of the Paranapiacaba mountain range, between Apiaí and Iporanga Counties. 24º 22’ S 48º 25’ W.

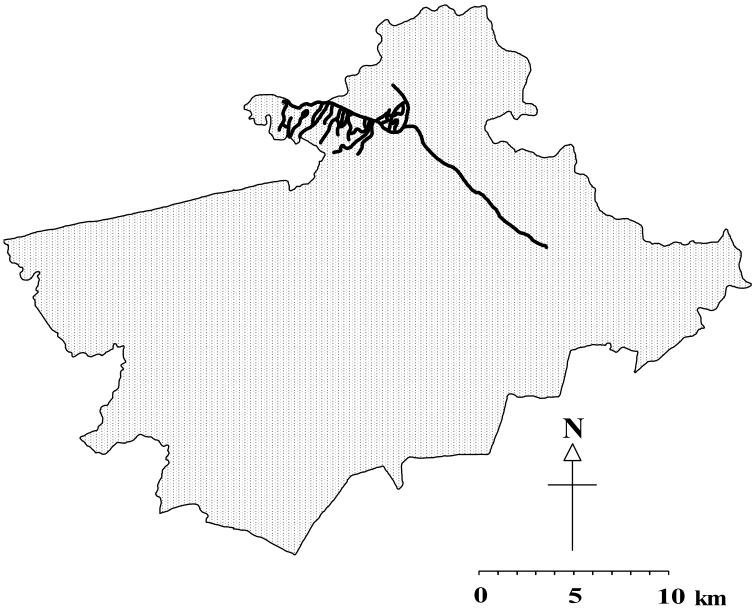
Legal protection: Created by Decree nº 26890 on 12 March 1987.

Altitude: 750 to 1005 m.

Infrastructure: One park ranger camp only.

PARQUE ESTADUAL CARLOS BOTELHO

Figure 4. Parque Estadual Carlos Botelho showing the Sede area.



Area: 37644 ha

Administration: Instituto Florestal

History: The area was already considered as a forest reserve before it became a park in the 1920s. In the 1940s, four contiguous reserves were created: Carlos Botelho, in São Miguel Arcanjo County, Sete Barras and Travesso, in Sete Barras, and Capão Bonito, in Capão Bonito County. A 33 km long road (SP 139) was opened through the area in 1929, connecting São Miguel Arcanjo with Sete Barras. P.E. Carlos Botelho was created in the 1980's, after property land censuses that led to several expulsions and recognition of returned properties. It combined four former forest reserves.

Location: Between the Ribeira Valley region and Southwestern São Paulo, including part of the Paranapiacaba Mountain Range, between São Miguel Arcanjo, Capão Bonito, Sete Barras and Tapira Counties. Between 24º 47’ 18’’ - 24º 14’ 41’’ S and 47º 47’ 18’’ - 48º 07’ 17’’ W.

Legal protection: State Park since 10 September 1982 by State Decree nº 19499.

Altitude: 20 to 1000 m.

Staff: Approximately 45 people working on administration, guarding, and general services.

Infrastructure: There are two Service Areas (called "núcleos"), Núcleo São Miguel Arcanjo (where the park's headquarters are located) and Núcleo Sete Barras. Data on frugivores censuses, check list of birds and mammals and the Southern river otter observations were collected only in Núcleo São Miguel Arcanjo. Facilities and services available are:

Núcleo São Miguel Arcanjo (Sede do Parque)

- Hostel for researchers and technicians involved in the Unit's projects. Maximum capacity: 12 people.
- Visitor centre, including a 40 seats auditorium.
- Education centre, including a museum and a reading room.
- Monitored trails and a free access trail for visitors.

Núcleo Sete Barras - it is mainly orientated to accommodate technicians involved in projects in the park, but it also offers logistic support and lodging to park rangers and visitors:

- Hostel, maximum capacity: 5 people
- Visitor centre, maximum capacity: 50 people

1. SEDE AREA (NÚCLEO SÃO MIGUEL ARCANJO)

Situation

The Park's headquarters (Sede) are accessed through the road SP-139, starting in the quarter of Abaitinga (Taquaral) in São Miguel Arcanjo. The distance between the Sede and the São Miguel Arcanjo town is 25 km.

Geographical characteristics

The Sede is placed at 800 m of altitude, in an abrupt area where rainfall is abundant. There is a brook in almost every little valley. The service track acts as a water divisor and therefore the trails in this area are distributed in two slopes: that of the river Taquaral and that of the river Planalto. Some trails are located near the river Ribeirão Grande.

Vegetation

The dominant vegetation in the P. E. Carlos Botelho is the hillside Atlantic rainforest (between 100/150 m and 900 m of altitude) and the lowland Atlantic rainforest (between 30 m and 100/150 m). Most of these forests are late secondary and mature rainforests, especially inside the park and by the Núcleo de Sete Barras. In the limits of the park, there are some areas covered by young secondary forests at different developmental stages and neighbouring areas with old eucalyptus and some araucaria (*Araucaria angustifolia*) plantations. By the Sede there are pastures and shrublands.

Logistic conditions of the base

The Sede has a hostel made of brick and a wooden one. Up to 12 people can be hosted there. The brick building has two bathrooms, a kitchen and a living room that can be used as a working room. There is also a visitors centre that includes a conference room for 40 people and an environmental education centre that comprises a museum and a reading room. There is a telephone and a fax: during the censuses, we did not have a radio and therefore communication with the other bases was carried out by phone through the Sede of P.E. Intervales.

Description of the trails (*trilhas*)

Most trails start by the service dirt track that goes 24 km into the park. There is a trail network relatively close to the Sede: this network has some main trails starting on the track and some short ones connecting them. There are also some quite long but badly preserved trails known as "trilhas de via". A good part of the track has also been used for censusing purposes.

Most of the sampling area corresponds to mature and old secondary rainforests. Many of the trails are totally or partly on water courses.

This is the list of trails used during the censuses, indicating distance covered (km) and altitudinal range (m):

- **Água Taquaral-Araucaria.** 1 km; 695-730 m
- **Guapeva.** 1.2 km; 760-750 m
- **Água-Transversal.** 1.2 km; 740-700 m
- **Cachoeiras.** 2.3 km; 790-660 m
- **Vale Velho.** 3.5 km
- **Água Defino.** 2.5 km
- **Educação Ambiental-Tucano.** 1.2 km; 760 m
- **Taquaral.** 2.9 km; 755-650 m
- **Água.** 1.4 km; 680-740 m
- **Formigueiro-Carangujo-Estrada.** 3 km; 700 m
- **Água Defino-Encontro-Água Seca-Conexão-Passo-Estrada.** 2.5 km
- **Água lado Taquaral.** 2 km; 775-650 m
- **Água –Espigão.** 1 km; 825-750 m
- **Carvoeiro-Onça.** 1.8 km; 650-790 m
- **Serelep.** 1.5 km; 805-745 m
- **Água Defino-Rancho.** 3 km; 780-740 m
- **Mono-Beira Rio-Estrada.** 3.2 km
- **Muriquí.** 1.3 km; 745-725 m
- **Guapeva.** 1.2 km
- **Manavá-Caminho.** 1.1 km; 720 m
- **Vale-Volta.** 1.8 km
- **Estrada.** 12.2 km; 650-790 m

CENSUSES OF FRUGIVORES

Chapter 4

AN OVERVIEW TO THE COUNTING METHODS OF THE PARANAPIACABA FRUGIVORE VERTEBRATES SURVEY

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INTRODUCTION

Frugivore vertebrates constitute a key element within tropical forest fauna, not only because of their interest as a group but also because they play a fundamental role in the maintenance of the forest by dispersing seeds (Estrada & Fleming, 1986). Estimating abundances of guans, parrots, toucans and monkeys in more or less well preserved areas of the forest was therefore a top priority objective of the work to be developed in the Paranapiacaba fragment. These bird and mammal groups are the main seed dispersers or seed predators of the Atlantic rainforest (Guix, 1995).

Devising specific counting methods for each one of these groups would have been necessary in ideal conditions. However, considering the short duration of our expedition, we were forced to plan a census strategy flexible and robust enough to allow simoultaneous count of as many groups of vertebrates as possible. Several of the following standard counting methods (Tellería, 1986; Bibby *et al*., 1992; Sutherland, 1996) were initially considered:

-*Absolute counts:* They consist on counting every single individual in the study area. These are useful in studies involving small areas, as well as those involving conspicuous, territorial or gregarious species that group together to sleep, eat or reproduce.

-*Plot counts:* These involve the delimitation of representative plots in the study area, then counting every single individual in each plot and extrapolating the results to the total area surveyed.

-*Line transects:* They consist on covering randomly distributed routes in the census area, either on foot or on a vehicle. Strip transects are the simplest ones: a straight line is traversed by an observer who counts all the animals detected within a predetermined distance on either side of the centre line. If it is assumed that all the animals within this strip are detected, density can be calculated by dividing the number of animals sighted by the strip area $2.w.L$, being L the length of the strip and w the width of the strip on either side of the observer. This method tends to underestimate density values, since most times only some proportion of the objects in the strip is detected and recorded. The method of Distance Sampling (Buckland *et al*., 1993) enables the resolution of this underestimation. When using distance sampling, there is no predetermined

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

census width strip. It is assumed that all animals on the centreline are detected, and that those placed progressively away from it have a progressively reduced chance of being detected. Observers record the number of animals detected as well as the perpendicular distance from each animal or group of animals to the centre line. Plotting these distances in a histogram of frequencies allows the calculation of a detection function that shows the probability of detecting an animal placed at a given distance from the census line. This function enables the calculation of the effective strip width (ESW), the width on each side of the centreline that has effectively been censused, defined as the distance for which unseen animals within the ESW equals the number of animals seen farther than ESW. Then, density can be estimated as the total number of detected animals divided by 2·ESW·L.

-*Point counts:* They consist on establishing a series of randomly distributed points within the census area. On every point, a fixed amount of time is spend recording all the animals detected. Point counts can be considered as line transects of zero length. Same as in line transects, the sighting radial distance can be fixed, assuming that all animals within that distance are detected, or an effective radius of detection (ERD) can be estimated in an analogous way to the ESW estimation in line transects.

-*Abundance index calculation:* When estimation of the number of animals inhabiting a certain area is considered to be too difficult, or when the aim of the study is more related to the monitoring of population trends than to the measurement of their size, an abundance index is calculated. In this case, results of line transects or point counts are expressed as number of animals or traces detected per unit of effort employed (i.e.: distance walked, time counting etc.). These indexes are easier to obtain than real abundances and enable the survey of larger areas with similar effort.

DISTANCE SAMPLING USING LINE TRANSECTS

Because we intended to survey very large areas in a very short period of time, absolute counts were unaffordable. Plot sampling might have solved this limitation, but it was also not appropriate. Plots would still have had to be very large, since the species we intended to count censusing are very scarce. On the other hand, delimiting and accessing plots in the rainforest is difficult, and ensuring complet sampling of the plots would have been impossible. Therefore, this method was also dismissed.

In our situation, distance sampling based on line transects or point counts was considered as the most appropriate methodology to achieve our objectives. Line transects were selected instead of point counts because they are more efficient regarding the information obtained against unit effort, and because they are more accurate than point counts, since error in distance estimates in point counts affect the estimation of the censused area in a quadratic way (Buckland *et al.*, 1993).

Development of censuses through distance sampling depends on five main assumptions (Buckland *et al*., 1993). Because of fieldwork limitations and the particularities of the counted species, these are seldom 100% fulfilled. However, they all had to be considered in relation to the particular goals, species and habitats considered in our survey, in order to value whether the selected methodology and census strategy were appropriate, as well as to enable the interpretation of the potential biases resulting from total or partial failure of some of these assumptions.

Assumption 1.- Objects are randomly distributed in the census area. Probably that is not true, since individuals or groups tend to cluster around optimal areas or distribute themselves according to specific gradients. When designing and analysing data, we stratified the transect lines considering those factors that may have an effect on animal distribution (i.e.: forest characteristics, altitude).

Assumption 2.- Transect lines are randomly placed, at least with respect to the distribution of objects. Transects were not randomly distributed, since path and track availability determined their location. A priori, though, we did not know how animal and path distribution could be related and we assumed independence between both variables.

Assumption 3.- Objects directly on the line or very close to it are always detected. This is probably true for guans and monkeys. In toucans and parrots, that exploit the highest strata in the canopy, it is likely that some individuals placed on the census line may go undetected if they do not make noises or fly away. Failure of this assumption would result in an underestimation of abundance.

Assumption 4.- Objects are detected at their initial location, prior to any movement in response to the observer. This assumption is generally true for all groups, since detection histograms obtained in preliminary censuses (Guix *et al*., 1997) showed monotonous decreasing tendency, which do not suggest movement towards or away from the transect line in response to the observer.

Assumption 5.- Distances are measured accurately. Observers were trained to estimate distances in the forest. During data treatment, data were grouped into distance intervals in order to reduce the effects of inaccuracy in their estimates (Buckland *et al*., 1993).

CENSUSED SPECIES

Only species inhabiting the highest vegetation strata were considered in our counts, because those using the lowest strata are more difficult to detect at large distances. Among monkeys (*Cebidae*), we selected *Cebus apella, Brachyteles arachnoides* and *Alouatta guariba,* among guans (*Cracidae*), *Penelope obscura* and *Pipile jacutinga*, among toucans (*Ramphastidae*), *Ramphastos dicolorus, Ramphastos vitellinus, Selenidera maculirostris* and *Baillonius bailloni*, and among parrots (*Psitacidae*), *Pionus maximiliani, Pyrrhura frontalis*, *Forpus crassirostris*, *Pionopsitta pileata*, and *Brotogeris tirica*.

DATA COLLECTING

Counts were conducted during the prebreeding season of birds in the region. Between 18 August and 4 September 1998, a total of 352.4 km were walked on 100 different tracks and trails spread in seven localities in the study area (Figure 1 and Table 1, see chapter 3 for a complete description of each area). Transect placement depended on track and path availability in the forest. A total of 127 transects were conducted, covering a wide range of lengths and altitudes (Figure 2).

Figure 1. Location of the study areas, indicating the limits of the Natural Reserves (thin lines) and the placement of the transect lines (thick lines). A: Parque Estadual Turístico do Alto Ribeira; B: Parque Estadual Intervales; C: Parque Estadual Carlos Botelho; D: Estação Ecológica de Xitué; 1: Núcleo Caboclos area; 2: Alecrim area; 3: Carmo area; 4: Barra Grande area; 5: São Pedro area; 6: Saibadela area; 7: Sede Carlos Botelho area.

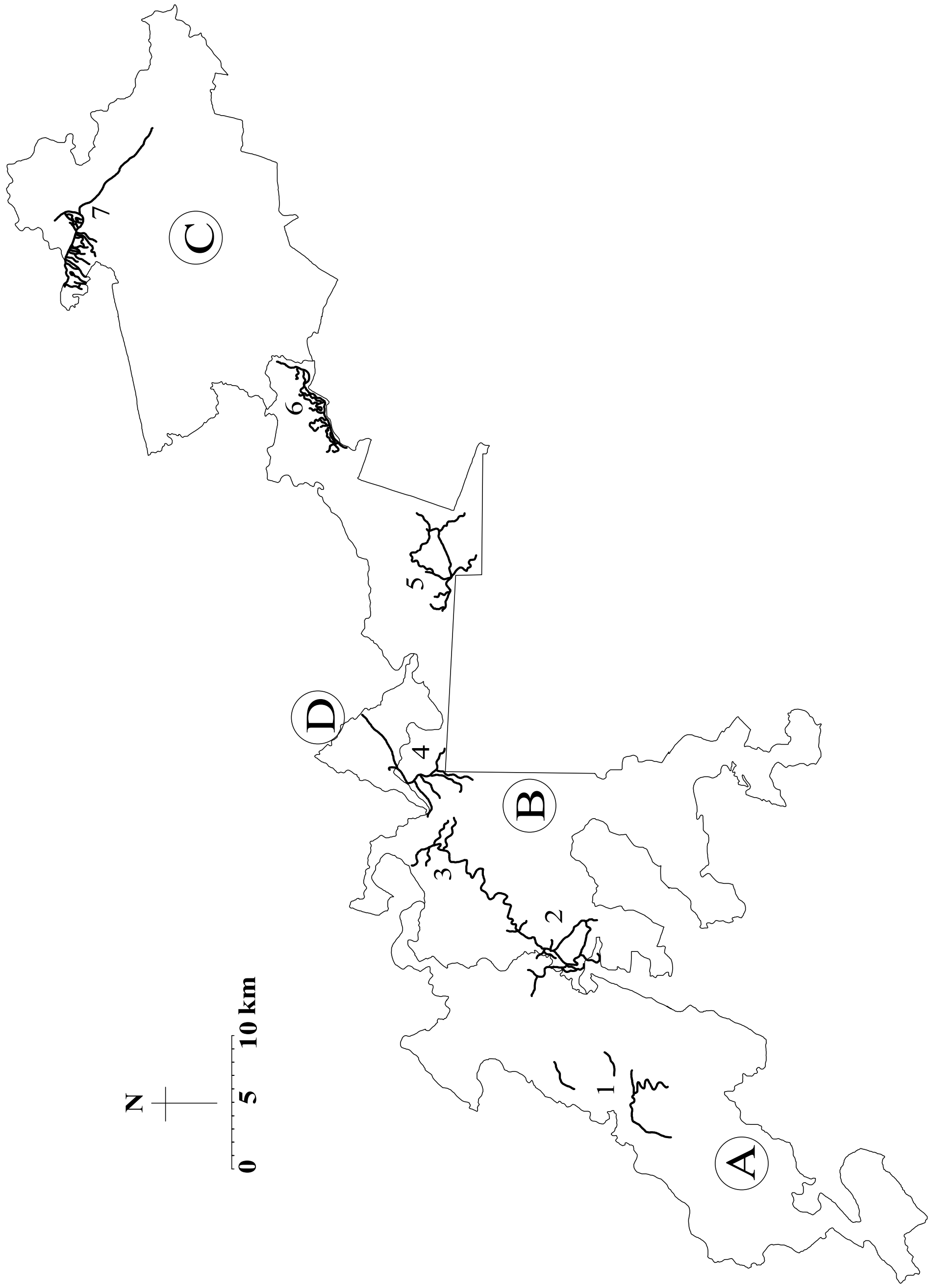
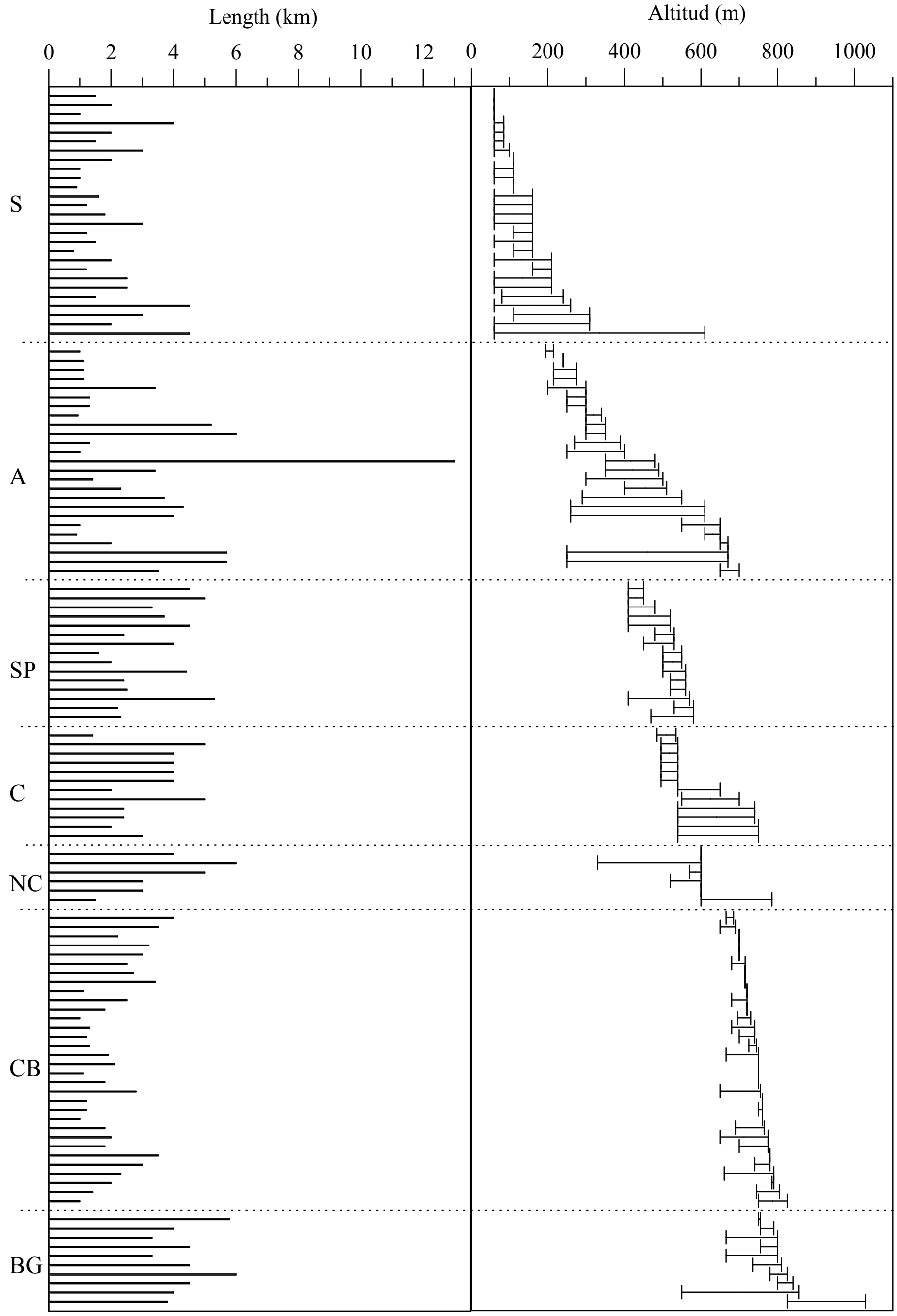


Figure 2. Length and altitudinal range covered by each of the 127 transects conducted during our survey of frugivorous vertebrates on the Paranapiacaba forest fragment. Areas are sorted from higher to lower average altitude. Within each area, transects are sorted from higher to lower maximum altitude. BG: Barra Grande; CB: Sede Carlos Botelho; NC: Núcleo Caboclos; C: Carmo; SP: São Pedro; A: Alecrim; S: Saibadela.



All transects were made in areas covered by mature and old secondary forests (100000 ha in the Paranapiacaba fragment, according to Landsat TM5 satellite images), and covered an altitudinal range between 60 and 1030 m (Table 1), which nearly corresponds to the total altitudinal range in the fragment (20-1095 m). Estimated area of census strip (total walked kilometres multiplied by the maximum strip width, excluding outliers) was 352 km x 100 m = 35.2 km^2.

From the total distance covered, 23.6% corresponded to forest tracks, 44.9% corresponded to easy walk paths and 31.5% corresponded to difficult paths. Transect length varied between 800 and 6000 m (including one only case of 13000 m), with an average length of 2775 ± 149 (s.e.) m. In 27 cases, all or part of a transect was repeated (Table 1), leaving a minimum of one week interval between consecutive counts. Whenever possible, censuses were conducted under good weather conditions. From the total distance walked, 47.2% was covered under good or very good weather conditions, 41.7% under fair weather conditions, and 11.0% with a slight rainfall or wind.

Table 1. Characteristics of the line transects walked on each area. (P.E.: Parque Estadual).

Census areas	num. transects	covered distance (km)	Minimum Censused altitude (m)	maximum censused altitude (m)	different paths
P.E.TURÍSTICO ALTO RIBEIRA					
Núcleo Caboclos	6	22.50	330	785	6
P.E.INTERVALES					
Alecrim	25	75.64	195	700	17
Carmo	12	39.20	485	750	6
Barra Grande	10	43.70	550	1030	8
São Pedro	15	50.10	410	580	11
Saibadela	27	54.70	60	610	22
P.E.CARLOS BOTELHO					
Sede Carlos Botelho	32	66.60	650	825	30
Total	127	352.44	60	1030	100

The 31.5% of the distance was covered below 400m of height, 12.6% between 400-500 m, and 55.9% above 500 m. Two time fringes were established to carry out censuses, one in the morning between dawn and noon, and one in the afternoon during the two hours before dusk. Most census effort was made in the morning (274 km) and only a small part was made in the afternoon (78 km).

Each census team consisted of a guide familiar with the area and two or three observers walking in front of the guide. Covered distances were estimated using cartography and a digital step meter. Census teams moved at a more or less constant speed without stopping for long periods of time. Average speed in the 127 transects was 1.4 ± 0.06 (s.e.) km h^{-1}, with a maximum speed of 3.9 km h^{-1} and a minimum speed of 0.4 km h^{-1}. In each transect, observers had to fill a form registering transect location, date, length walked, start and end local time, members of the team, altitudinal range sampled and weather conditions. When a group of animals was sighted, observers had to note down the species, number of individuals, time, perpendicular distance to the transect line, height of the group above ground, maximum height of the forest in the sighting point, forest strata used by the animals, local topography and further comments regarding behaviour, age and sex composition of the group.

Generally, selected species made slow and short movements relative to the movement of the census team. It was therefore unlikely that one same group of birds was sighted twice along the same transect. Parrots deserve particular considerations in this respect, because they were often sighted while flying, or flied away immediately after being spotted. Observers had to pay attention to the direction and length of the movement to minimise chances of repetition.

DATA PROCESSING

Data of perpendicular distances were processed using the Distance 2.02 suite (Laake *et al.*, 1993). This program fits several mathematical functions to the observed data and selects the best model according to Akaike's information criterion (AIC). It finally estimates the effective strip width (Buckland *et al.*, 1993) and density. Four mathematical models can be used to fit the detection function: the half-normal model, the hazard rate model, the uniform model and the negative exponential model. In order to improve the estimates of the detection functions and ESW for some species where few observations occurred in 1998, data collected in previous surveys to the area (González-Solís *et al.*, 1996; Guix *et al.*, 1997) have been pooled to the data collected in the 1998 survey. Densities were then calculated using these global detection functions and ESW, but considering only the number of sightings and kilometres walked in 1998.

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CONSIDERATIONS ON DISTANCE SAMPLING METHODS APPLIED TO RAINFOREST HABITATS

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FLYING BIRDS

Line transect methods for estimating bird densities in terrestrial surveys have typically considered birds as stationary objects (Hayne, 1949; Andersen & Pospahala, 1970; Emlen, 1971, 1977; Eberhardt, 1978; Burnham & Anderson, 1984) so methods based on recording perpendicular distances of each bird to the route can be applied (e.g. Buckland *et al*.,1993). Several methods can be successfully applied to those bird species of the rainforest that do not fly frequently, such as guans and toucans (Guix *et al*., 1997; Martín, 2000). However, some bird species in the rainforest, particularly parrots, are often seen flying across the observer´s field (e.g. Casagrande & Beissinger, 1997; Marsden, 1999). In a recent assessment of parrot populations in the Atlantic rainforest, Guix *et al*. (1999) used sightings of parrots both flying or perched for estimating absolute densities. However, the use of flying birds for determining absolute densities, either from a defined band transect technique or from estimates of perpendicular distance when detected, is problematic as the chances of a bird being in the area surveyed depends on relative speed between the bird and the observer. The faster the target bird moves in relation to the observer the larger will be the overestimate of the bird density (Burnham *et al*.,1980). Indeed, an observer recording from a point or a walking observer on a rainforest path can be regarded as an "static" object in relation to the motion of a flying parrot. Hence, a continuous count of all birds crossing the observer´s field in flight will measure both flux and density. In addition, frequently, flying birds are more easily detected than stationary birds. Thus, if aereal birds that cross the census area are included along with the non-aerial individual present, then the number of birds recorded can be greater than if aerial birds are ignored, which is likely to result in an overestimation of bird densities. Continuous counts of flying birds should be recorded because they may be adequate for comparisons between areas or between different periods in the same area. However, they should not be included when calculating absolute densities of very mobile species. For instance, the inclusion of flying parrots in a survey in Indonesia estimated densities between 127% and 364% higher than those excluding them (Marsden, 1999).

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The problem of flying birds concerns only those birds that genuinely fly over or into the transect or point count surveyed and not to the birds that were into the observer´s field and fly in response to the observer´s intrusion. If birds move evasively prior to detection, the perpendicular distance from the transect to the initial location of the birds should be estimated when possible by, for example, relying on vocalizations (Casagrande & Beissinger, 1997; see also Guix *et al*., 1999 and chapter 8).

Because in many seabird species most birds detected are in fligth during at sea surveys, some observers of seabirds at sea have long recognised the problem produced by the bird movement on absolute densities (Tasker *et al*.,1984 and references therein). Censuses of seabirds at sea from a ship usually include all birds counted within a pre-determined area, often a strip 300 m wide. Tasker *et al*. (1984) proposed a method that sampled continuously nonflying birds within a defined band transect whereas flying birds would be sampled by means of successive instantaneous counts named "snapshots". The frequency of the snapshots is determined by the speed of the ship and the distance ahead of the vessel at which all flying birds can reliably be seen. One snapshot comprises the reliably visible area ahead of the vessel out to the width of the transect. A new snapshot should be made every time that the ship reaches the end of the area that comprised the last snapshot (see Tasker *et al*., 1984; Webb & Durinck, 1992 for a detailed explanation of the method). For instance, from a ship sailing at 10 knots and with a reliable forward visibility of about 300 m, this would mean that one snapshot was taken every minute, since at this speed the ship covers about 310m in one minute. Counts of birds on the water and counts of flying birds by means of snapshots can be summed to calculate an overall absolute density. Comparisons of censuses of birds at sea showed that continuous counts of flying and nonflying birds in the southern oceans resulted in bird density estimates about twice as high as densities derived from counts using snapshots for flying birds, although the bias fluctuated widely among species (van Franeker, 1994). This method could hardly be applied in rainforest transects, since visibility ahead of the transect varies substantially depending on the path course and width. However, snapshots in point counts may be aproppiate, by counting for solely on time flying birds after an arbitraty period of time in the observation point. Ideally, flying bird counts during the snapshot should be as instantaneous as possible, otherwise fast-flying species could be still overestimated (Gaston *et al*., 1987).

Alternatively, correction factors for flying birds could be applied, but it would require adequate information on flying activity for each bird species. Telemetry studies may provide that information. However, flying activity may vary substantially with time of day, environmental conditions, observation site or the breeding cycle (Casagrande & Beissinger, 1997; Gilardi & Munn, 1998; Marsden, 1999). Marsden (1999) suggested a list of sensible recommendations for censusing parrots as well as a new method to estimate a correction factor for compensating the proportion of flying birds. This technique relies on long watches overlooking a large area of forest from a vantage point. The observer should time out, as many times as possible for the target species, the flight and the non-flight period of a bird since it lands into the observer´s field until it alights and land again (see Marsden, 1999 for details). This technique will probably underestimate the proportion of flying birds because long flights over the observed area will not be recorded, but when applied it should result in a smaller underestimation of the absolute density than ignoring flying birds.

Look down methods by means of long watches from vantage points overlooking forested valleys, as used for censusing raptors (e.g. Mañosa & Pedrocchi, 1997; see also chapter 14), may also be suitable for some parrot species. Apparently, this method has been successfully used for monitoring parrot populations on Caribbean islands (Bibby *et al*., 1998). However, not all parrot species fly above the canopy (e.g. Gilardi & Munn, 1998) so look down methods will only work well with large conspicuous species, which are easily detected when flying above the canopy.

When estimating bird densities from line transect, ignoring flying birds may give less biased estimate (but see also discussion in chapter 8), as done in some studies (e.g. Marsden *et al*., 2000). In such case, the underestimation of densities will be as large as the average proportion of birds flying at any instant for the respective species. In many species, as most of guans, toucans, hornbills, trogons, etc, this proportion is probably low. However, the underestimation of density of parrots may be larger as they tend to fly long distances (e.g. Lindsey *et al*.,1991), giving an underestimation of absolute densities which will probably fall between 2 and 25% lower than the actual density (Marsden 1999). In species flying long distances, if correction factors are not possible to apply due to lack of adequate information on bird lifestyle (frequent fligth or not), snapshots from point count may be a relatively effortless solution to account for flying birds.

DETECTION FUNCTION

Detectability of animals varies according to many factors. Some of them are usually common for a given species, for instance size, colour and behaviour (e.g. macaws and some parrots species; Gilardi & Munn, 1998). Consequently, when calculating density estimates based on perpendicular distances of each animal to the route, the detection function obtained will vary according to the characteristics of each species. Thus, it is important performing independent analyses for each species considered in the census.

Robustness of the detection function can be improved by pooling data from several surveys of the same species and habitat, provided that detectability between surveys do not vary. For instance, data can be collected over more than one year, preferably at similar times of the year, even when density values of the species studied are changing. Once we obtained a robust detection function for a given species, we can calculate the density values for each year separately.

DOUBLE COUNTS

Double-counting the same individual or group can inflate density estimates. For some species of the rainforest, for example primates, this is unlikely because the motion of the species is relatively slow and the observers usually overpass the group. However, some birds, particularly parrots, can be flushed out and fly forward into the census area. Thus, it is important keeping in mind the features of detected groups (number and composition of the group) and tracking the direction of the flushed birds to evaluate the likelihood of double counting them in the same walking transect. Those birds that are suspected to be previously counted should be discarded (see chapter 8). In general, only few individuals of the same species are recorded in a given transect, so the detection of two similar groups in a short time interval can be suspicious of double counting.

GROUP SIZE

In general, group size cannot be adequately estimated by line transect methods, since a careful inspection of a group usually involves some time and searching effort around the group, which may interfere the detection of other species surveyed. Thus, group size estimated during a walking transect must be considered as a minimum group size. When not all individuals of the group are seen, group size can be estimated relying on vocalizations or vegetation movement. When it is not possible to assess the group size, the mean of the known group sizes for the species detected may be used in order to calculate densities.

TRANSECT ROUTES

Ideally, transect routes should be allocated randomly, but in practice in the rainforest the only possible transects are usually the already existing paths. Some paths, however, may follow a feature such as a stream or a contour line. Such features can affect animal distributions, in which case these paths should be discarded. To minimise the effect of the path on animal distributions, it is convenient to close them some weeks ahead of the census when possible. In addition, to avoid unnecessary noise on the day of the census, old paths can be cleared some weeks in advance.

In some cases, point counts may perform better than transects, depending on the target species (Jones *et al.,* 1995). Marsden (1999) pointed out several sensible considerations in case this method is used. However, line transects usually produce a higher encounter rate per unit of effort than point counts (Buckland *et al.,* 1993), which can be advantageous when rare species are included in the census.

USE OF OTHER CENSUS METHODS

The use of other sampling methods, such as hearings and point counts, simultaneously to line transects has often been suggested for result comparison.

Using more than one sampling method at the same time would imply dividing observers in (at least) two groups, and that would reduce sampling effort in at least 50%. This would considerably diminish the chances of collecting data on less frequent species (such as those that are globally threatened). Those species, because of their precarious conservation status, are precisely the ones that need periodical quantitative valuations on their populations.

CENSUSES IN THE SUMMER

Performing censuses in the summer has also been suggested, so that data from two climatologically opposite periods can be compared. Although it is an extremely interesting suggestion, the main difficulty to carry it out in the Paranapiacaba fragment is of practical nature. Performing censuses during the breeding season is not appropriate because part of the female population is nesting (lay, incubation, chick rearing). This fact reduces adult activity, not only that of females but also that of mating males, which usually assist the female during incubation and breeding. This would probably result into an underestimation of the overall population size due to detectability problems.

On the other hand, it is not recommended performing censuses during the rainy season, which lasts beyond the breeding season, because rainfall diminishes animal detectability. This would force counts to be performed only on days with fair weather conditions and stopping them during heavy rain periods, which would mean increasing sampling effort and time and therefore having to increase the necessary resources to attain similar results to those obtained in 1994 and 1998. Moreover, the presence of juveniles after the breeding season might result, in some cases, in an overestimation of the adult population of some species

EXTRAPOLATIVE SURFACE

The Paranapiacaba fragment area is not flat. In fact, most of its surface has an abrupt relief with steep slopes and "V" shaped valleys. Park and protected area surfaces are usually inferred from a flat projection, that is, without taking into account the type of relief in the same manner as a vertical aerial photograph in which the use of a stereoscope is disregarded. This means that the real size of the Paranapiacaba fragment is actually much larger than 140000 ha (Figure 1). Considering the actual surface of uneven reliefs may have two consequences: (1) population size may actually be bigger than the population size extrapolated on a flat projection; and (2) the actual area for a home range will be larger than the area estimated on a flat projection.

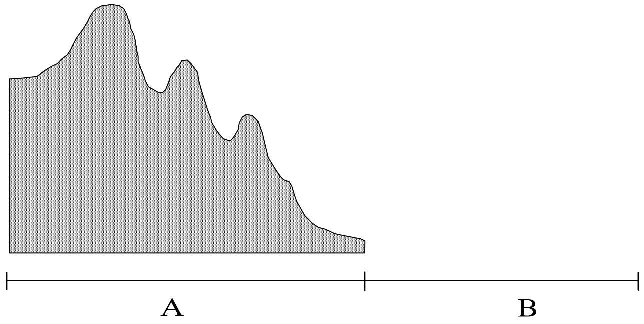

Figure 1. Flat projection (A) and real length (A+B) of an ideal representative profile of the Paranapiacaba fragment. Because of the abrupt relief of the Serra de Paranapiacaba, the extrapolative surface of the fragment is bigger than 140000 ha.

Nevertheless, we must be extremely cautious when considering a theoretical increase in some of those populations. The fact that the fragment surface is bigger than the 140000 ha resulting from its flat projection does not mean that the whole of the additional surface is covered by forest. It is known that the summits of many mountains in the “Serra do Mar” range and the Serra de Paranapiacaba itself are not covered by Atlantic rainforest but various bushy and grassy formations (see "summit effect" in Hueck, 1972). It is therefore expected that vegetation and animal communities in those areas are not the same as those occurring on hillsides and valleys, and that the absence of forests results in a lack of large size frugivorous vertebrates that may appear there by mere chance.

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DENSITY ESTIMATES OF GUANS (AVES: CRACIDAE): *PIPILE JACUTINGA* AND *PENELOPE OBSCURA*

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ABSTRACT.- Between 18 August and 4 September 1998 a census was performed on the guan populations of three areas of the Serra de Paranapiacaba, SE Brazil. The two guan species found - the Black-fronted piping-guan (*Pipile jacutinga*) and the Dusky-legged guan (*Penelope obscura bronzina*) - were censused through lineal transect methodology. Based on perpendicular distances to the transect, the detection function was established for each one of them. In 1994, the same sampling methodology was applied in the P.E. Intervales, so both censuses are compared here in order to evaluate population behaviour. Factors affecting population variation are analysed. Occupation of the vegetation strata is compared between the two species and their differences discussed. Finally, the distribution pattern relative to altitude is considered for each species and compared between them by taking into account the fruition state of vegetal species. Results attained in the current study are compared with those by other authors and an explanation is searched for the observed differences. The role of each species as an indicator of the environmental quality in mature and secondary Atlantic rainforests is discussed. From this analysis, conservation measures to be applied to both species and to the whole of the ecosystem are considered.

KEY WORDS: Brazilian Atlantic rainforest, census, *Pipile jacutinga*, *Penelope obscura bronzina*, population size.

INTRODUCTION

Two guan species inhabit the Paranapiacaba rainforest: the Black-fronted piping-guan (*Pipile jacutinga*) and the Dusky-legged guan (*Penelope obscura bronzina*) (Guix, 1997). *Pipile jacutinga* is considered as a *vulnerable* species and it is quoted in the CITES Appendix 1 (Collar *et al.*, 1994; CITES, 1997; UNEP-WCMC, 2001). Currently, three subspecies of *Penelope obscura* are accepted. Of those, *P. o. bronzina* is discontinuously distributed unlike the other two, and it is endemic to the Brazilian Atlantic rainforest (sensu Hueck, 1972 a,b). Although *Penelope obscura* is not endangered, *P. o. bronzina* is considered as threatened.

P. jacutinga and *P. o. bronzina* are basically frugivorous (del Hoyo, 1994; Guix, 1995; Galetti *et al*. 1997). They inhabit mature and old secondary forests and they are very sensitive to their alteration. Guan species are also extremely sensitive to human pressure and hunting, and they represent the largest percentage of the hunted biomass in the Neotropical area (Galetti, 1997). They are frugivorous species and therefore directly dependent on fruit availability. Exploitation and diminishment of some vegetal species such as the palmito palm (*Euterpe edulis*) can affect

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

their status, especially that of *P. jacutinga*. These factors point out the importance of these species as indicators of the quality of the forest.

Based on an exhaustive census across an altitudinal gradient in different points of the forest (including monitoring in the three parks), the current work yields new and more complete data on the two species. The aim of the current work is assessing and describing the guan population status in a still well preserved area and comparing it with descriptions provided by other authors.

MATERIAL AND METHODS

The census was carried out between 18 August and 4 September 1998 using line transects methodology at different altitudes. Methodology was the same as used in a census carried out in 1994 when these same species were censused too (Guix, *et al.*, 1997), and information from that study has been used when necessary in order to round off the sample. The detection function was determined through Distance Sampling (Buckland *et al.*, 1993) using the Distance 2.02 suit (Laake *et al.*, 1993) with joint data from the 1994 (291 km) and 1998 censuses (352.44 km) (Figures 1 and 2).

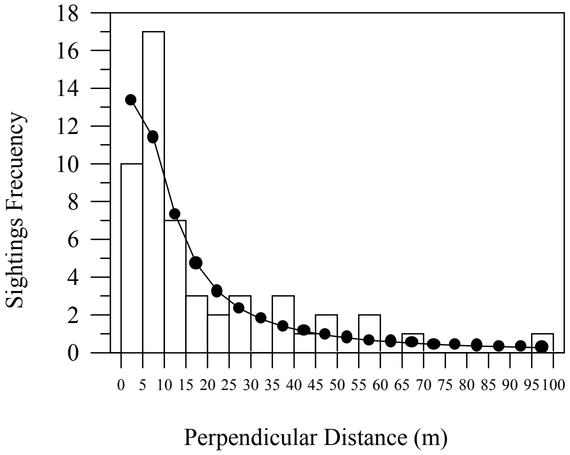


Figure 1.- Frequency distribution of the perpendicular detection distance for *P. jacutinga* from 1994 and 19998 data. Fitted detection function are shown by solid line. Hazard Rate was the selected model. Detection function was estimated for pooled encounters. Observed values are distributed in 5 m intervals (the total amount of contacts was 51).

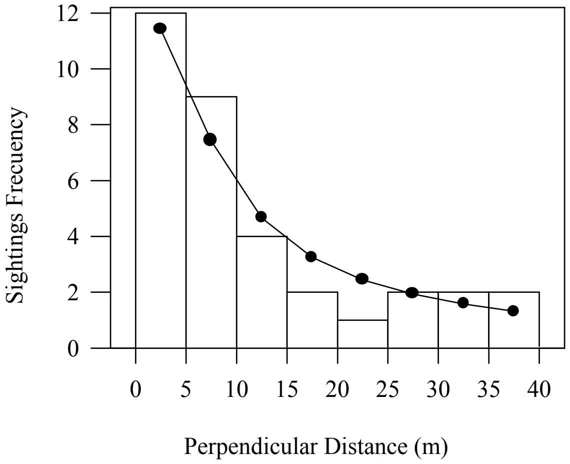


Figure 2.- Frequency distribution of the perpendicular detection distance for *P. o. bronzina* from 1994 and 19998 data. Fitted detection function are shown by solid line. Hazard Rate was the selected model. Detection function was estimated for pooled encounters. Observed values are distributed in 5 m intervals (the total amount of contacts was 34).

Distances were grouped into 5 m intervals. No data were truncated for *P. jacutinga*, and one contact at 200 m in the 1994 census was truncated for *P. o. bronzina*. The best model fitting each species was selected using Akaike's Information Criterion. The Hazard Rate model was selected to estimate the detection function in both species. This function fits quite well the observed frequencies in both species. In *P. jacutinga* the goodness of fit is: χ^2 = 19.636, df = 17, p=0.293 (Figure 1). In *P. o. bronzina* the goodness of fit is: χ^2 = 2.250, df = 5, p=0.814 (Figure 2). Based on the maximum sighting distance and the number of contacts, a total of twenty 5m intervals were considered for *P. jacutinga* and only eight for *P. o. bronzina*.

The detection function was estimated for pooled encounters (1994 and 1998 data from P.E. Intervales and 1998 data from P.E. Carlos Botelho and P.E.T. Alto Ribeira). In order to compare 1994 and 1998 data from P.E. Intervales, only one replicate from transects that were repeated more than once in the 1994 census was randomly picked to be used in the calculations - many counts had been performed in the same transects over a short period of time. From the estimated detection function, parameters describing densities and population estimates were calculated for 1994 in P.E. Intervales (Alecrim, São Pedro and Funil areas, a total of 120.6 km), for 1998 in P.E. Intervales (Alecrim, São Pedro, Saibadela, Carmo and Barra Grande areas, adding up to 263.34 km) and for 1998 in the whole of the three parks that were sampled that year (P.E. Intervales, P.E. Carlos Botelho and P.E.T. Alto Ribeira, totalling 352.44 km), for both *P. jacutinga* (Tables 1 and 2) and *P. o. bronzina* (Tables 3 and 4). Calculating all these parameters from the same detection function allows the comparison of data because the effective strip width is the same. The goodness of fit of the detection function is better this way because of the larger sample size on which it is based. Individual density was obtained by multiplying group density estimates by average group size.

During the census, the height at which the groups were found was noted down, as well as the maximum height of the forest at the spot and the vegetation strata at which they were sighted (emergent forest, canopy, subcanopy, shrub, ground or flying by). Guix (1995) points out that the two species occupy different forest strata.

Comparisons between relative heights at which individuals were found were performed through non-parametric statistics (Kruskal-Wallis). It was tested whether individuals' distribution across the vegetation strata fitted the expected one (χ^2).

P. jacutinga and *P. o. bronzina* population variation relative to altitude was considered. During the 1998 census it was noticed that the palmito fruition state depended on altitude and this species was considered an indicator of general fruition. Below 400m no ripe fruits were found, between 400 and 500 m of height their fruition varied depending on area, orientation etc., and above 500 m most trees showed ripe fruits. The possibility that frugivorous species stratification was determined by fruit availability was considered. This altitudinal variation has been pointed out by Guix (1995). In the case of guans, the palmito fruits are an important component in the diet of *P. jacutinga*. *P. o. bronzina* also feeds on it but it shows a much more diversified diet. In order to test this hypothesis about stratification, densities and encounter rates were compared between species depending on transect altitudes. Transects were divided into three categories considering average height: equal or below 400 m, between 400 and 500 m and above 500 m. Intermediate ones (those with an average height between 400 and 500 m) were not included in the analyses. Only data from the 1998 census were used. A total of 40 transects (covering 80.84 km) were considered in the lower stratum (below 400 m), and 71 transects (193.20 km) were taken into account in the upper one (above 500 m).

An indicator of the height in the vegetation strata at which individuals were sighted relative to the maximum height of the forest at the spot was established. It was based on 1998 data:

(individual or group height / maximum forest height)x100

and it showed at which relative height in the forest (in percentage) sightings were placed. Non-parametric statistics were applied on this indicator to test whether statistically significant differences were found between the two species.

Table 1.- Results of the detection function for *P. jacutinga* of the amount of valid transects, distance and effective strip width from 1994 and 1998 pooled data. Distances and widths are given in metres; sampling effort is expressed in kilometres. Standard errors are indicated when appropiate.

Pipile jacutinga	
Amount of transects	195
Sampling effort	643.04
Maximum distance	100
Average distance	19 ± 3
Median distance	10
Model	Hazard rate
Effective strip width	19 ± 5

Table 2.- General results of population estimates for *P. jacutinga*: in 1994 at P.E. Intervales (replicates performed within 7 days have not been considered), in 1998 at P.E. Intervales and in 1998 for the three parks. Distances are expressed in metres and densities in km^2. Standard errors are indicated when appropiate. Population estimates in P.E. Intervales for the 1994 and 1998 censuses have been calculated taking into account 60% of the park's surface (230.14 km^2) that corresponds to the area covered by secondary and mature rainforests. The 1998 global surface estimate has been calculated for 1000 km^2 corresponding to mature and old secondary forests in the Paranapiacaba fragment.

	P.E. Intervales 94	P.E. Intervales 98	Global 98
Amount of groups	7	13	28
Amount of individuals	10	16	37
Group size	1.43 ± 0.2 (1-3)	1.23 ± 0.12 (1-2)	1.286 ± 0.87 (1-2)
Encounter rate	0.058 ± 0.02	0.049 ± 0.015	0.079 ± 0.019
Group density	1.49 ± 0.71	1.27 ± 0.50	2.080 ± 0.71
Individual density	2.13 ± 1.06	1.56 ± 0.63	2.67 ± 0.93
Population estimate	490 ± 244	359 ± 145	2670 ± 930

Treatment of 1994 and 1998 data

Data obtained in 1994 were considered because the sampling method used was the same as the one used in 1998. Distribution function and data used in the 1994 study (Mateos & Mañosa, 1996; Guix *et al.*, 1997) have only been partially considered. Transect replicates that had been performed over intervals of less than one week (three to five days) were removed from the analyses since there was a high probability of dependence between observations. Those transects were not considered to calculate the 1994 density estimates but they were included in the estimation of the density function. In the case of *P. o. bronzina*, results are not affected by the removal of those transects, but they are in the case of *P. jacutinga*. This variation can be explained by the dependence of samples when replicates are included in calculations. In species that tend to stay in the same area for long periods of time, considering transect replicates can bias results towards an overestimation of population sizes. *P. o. bronzina* is not easy to sight and it moves around considerably, so the use of replicates does not necessarily affect results. The number of replicates in 1998 was much lower and they were performed over intervals larger than one week – samples can therefore be considered as independent and they were included in the calculations.

The 1994 census data – without replicates – are directly comparable with those obtained in 1998 in the P.E. Intervales. If only transect data without replicates are considered for 1994, sampling effort (in km) is larger in 1998. Comparing the two sampling years allows the analysis of population variations over a four years period. On the other hand, global 1998 data can yield more information on the Atlantic rainforest total area, although it can only be extrapolated to forests showing similar succession stages (mature and old secondary forests) in the Paranapiacaba mountain range.

Table 3.- Results of the detection function for *P. o. bronzina* of the amount of valid transects, distance and effective strip width from 1994 and 1998 pooled data. Distances and widths are given in metres; sampling effort is expressed in kilometres. Standard errors are indicated when appropiate.

Penelope obscura bronzina	
Amount of transects	195
Sampling effort	643.04
Maximum distance	40
Average distance	12 ± 2
Median distance	8
Model	Hazard rate
Effective strip width	14 ± 5

Table 4.- General results of population estimates for *P. o. bronzina*: in 1994 at P.E. Intervales (replicates performed within 7 days have not been considered), in 1998 at P.E. Intervales and in 1998 for the three parks. Distances are expressed in metres and densities in km^2. Standard errors are indicated when appropiate. Population estimates in P.E. Intervales for the 1994 and 1998 censuses have been calculated taking into account 60% of the park's surface (230.14 km^2) that corresponds to the area covered by secondary and mature rainforests. The 1998 global surface estimate has been calculated for 1000 km^2 corresponding to mature and old secondary forests in the Paranapiacaba fragment.

	P.E. Intervales 94	P.E. Intervales 98	Global 98
Amount of groups	6	15	20
Amount of individuals	12	27	37
Group size	2.0 ± 0.33 (1-4)	1.80 ± 0.24 (1-3)	1.75 ± 0.19 (1-3)
Encounter rate	0.05 ± 0.02	0.057 ± 0.018	0.057 ± 0.015
Group density	1.77 ± 0.96	2.02 ± 0.97	2.014 ± 0.88
Individual density	3.53 ± 2.12	3.64 ± 1.81	3.52 ± 1.59
Population estimate	812 ± 488	838 ± 417	3520 ± 1590

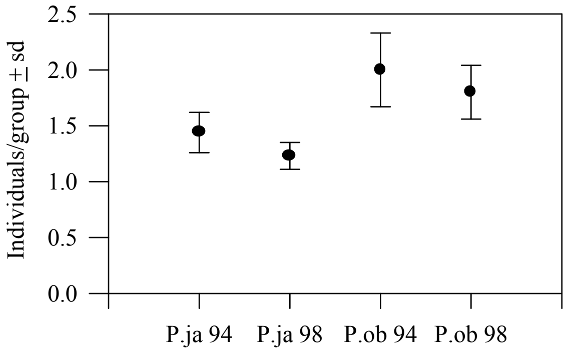


Figure 3.- Comparison of average group sizes for both species, considering the two censuses (1994, 1998) separately. Average group size has been considered as the average amount of individuals per group. P.ja: *Pipile jacutinga*; P.ob: *Penelope obscura*.

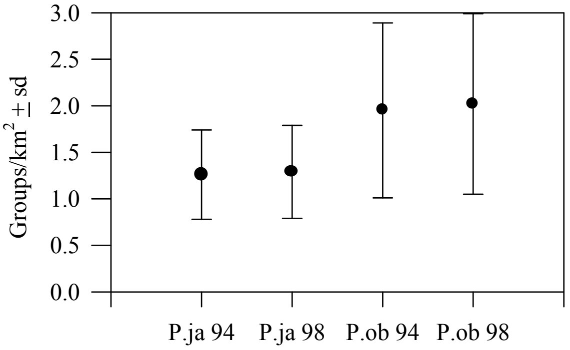


Figure 4.- Comparison between group densities for both species considering the two censuses (1994, 1998) separately. Average group density has been considered as the average amount of groups per km^2. P.ja: *Pipile jacutinga*; P.ob: *Penelope obscura*.

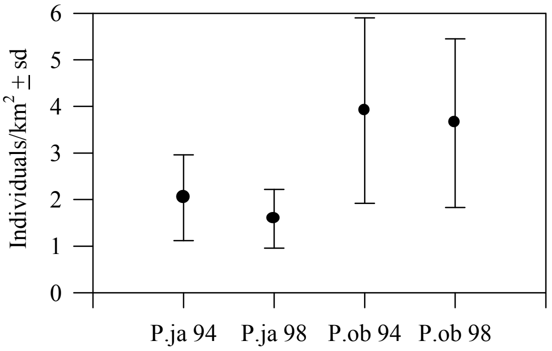


Figure 5.- Comparison between individual densities for both species considering the two censuses (1994, 1998) separately. Average individual density (considered as the average amount of individuals per km^2) and its standard deviation are shown. P.ja: *Pipile jacutinga*; P.ob: *Penelope obscura*.

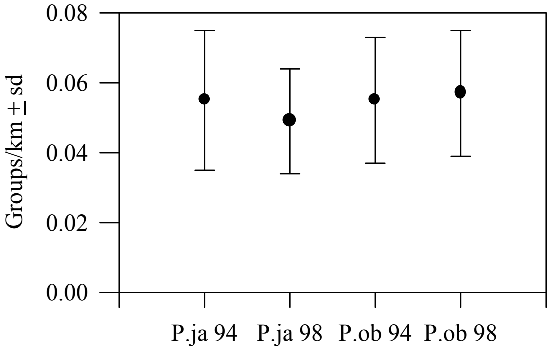


Figure 6.- Comparison between encounter rates for both species considering the two censuses (1994 and 1998) separately. Average encounter rates were estimated as the average amount of groups per linear km of census. Standard deviations are shown also. P.ja: *Pipile jacutinga*; P.ob: *Penelope obscura*.

RESULTS

Comparison between 1994 and 1998 census data

Table 2 shows how in P.E. Intervales the number of *P. jacutinga* groups and individuals had not changed much between 1994 and 1998, which is reflected by very similar encounter rate values. Group densities were also quite similar, which can be explained by the fact that densities depend on encounter rates: individual's density was (although not significantly) higher in 1994 than it was in 1998, which means that groups found in 1994 were slightly larger (Figures 3, 4, 5 and 6). Population density estimates in *P. jacutinga* inhabiting mature and old secondary forests were bigger in 1994.

When comparing those results with the general ones obtained in 1998 in the three parks, it becomes apparent that group size in the whole of the three parks is twice as big. The encounter rate in the whole of the three parks is also much higher than the one found in P.E. Intervales in 1994 and 1998, and group and individual densities are larger in the 1998 global census.

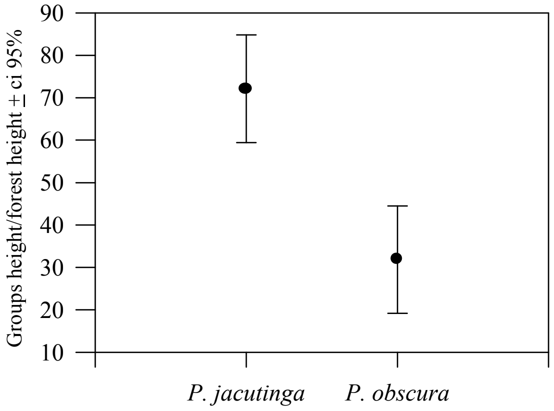
Table 5.- Results by altitudinal strata (< 400 m, > 500 m) for *P. jacutinga* and *P. o. bronzina* from 1998 census data. In all cases, the detection function model used has been Hazard rate. Data were not truncated. Distances and widths are expressed in metres; sampling effort is expressed in kilometres. Standard errors are indicated when appropiate.

	Stratum < 400 m	Stratum > 500 m
Sampling effort	81	193
P. jacutinga		
Total amount of groups	6	19
Total amount of individuals	6	25
Average group size (range)	1 (1)	1.32 ± 0.11 (1-2)
Maximum observation distance	60	48
Average observation distance	12 ± 3	12 ± 2
Median observation distance	6.5	7
Effective strip width	19 ± 5	19 ± 5
Encounter rate (groups/km)	0.074 ± 0.031	0.098 ± 0.031
Group density (groups/km^2)	1.94 ± 0.94	2.57 ± 1.03
Individual density	1.94 ± 0.94	3.39 ± 1.38
P.o.bronzina		
Total amount of groups	4	11
Total amount of individuals	5	36
Average group size (range)	1.25 ± 0.25 (1-2)	1.73 ± 0.24 (1-3)
Maximum observation distance	40	20
Average observation distance	17 ± 4	6 ± 1
Median observation distance	10	6
Effective strip width	14 ± 5	14 ± 5
Encounter rate (groups/km)	0.049 ± 0.037	0.057 ± 0.017
Group density (groups/km^2)	2.02 ± 0.95	1.76 ± 1.44
Individual density	2.53 ± 1.19	3.04 ± 2.49

In *P. o. bronzina*, differences between 1994 and 1998 in P.E. Intervales are minimal in terms of amount of groups and individuals found (Table 4), and average group sizes and encounter rates are similar in both years. Group and individual densities are similar too (Figures 3, 4, 5 and 6). The 1994 population estimate is slighty larger than that obtained in 1998, but this difference can probably be explained by larger group sizes detected in 1994.

Comparison considering sampling altitude

Table 5 shows results for both species at both altitudes. Census strip width does not vary with altitude but maximum sighting distance and average and median distances do. Although those differences are not statistically significant, a certain set of tendencies can be observed: the amounts of *P. jacutinga* and *P. o. bronzina* contacts are very low at and below 400 m. Nevertheless, group and individual densities in *P.jacutinga* are larger at and above 500 m. In the case of *P. o. bronzina*, group densities are larger at and below 400 m, but individual densities are lower. When considering average group sizes, there are not big differences at different altitudes but both species tend to show larger group sizes at and above 500 m.



Species Figure 7.- Altitude distribution of *P. jacutinga* and *P. o. bronzina* across the vegetation strata. Relative height has been estimated as the height at which the group was spotted relative to the height of the forest in that point.

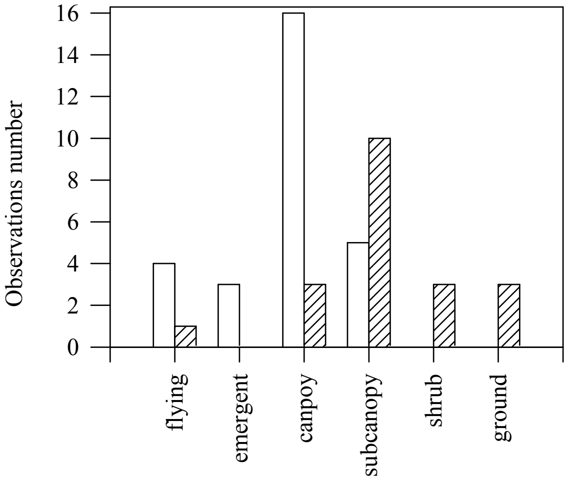


Figure 8.- Occupation of the vegetation strata by the Black-fronted piping-guan (*P. jacutinga*, white bars) and the Dusky-legged guan (*P. o. bronzina*, ruled bars). Vegetation strata have been divided into six levels: "flying" for those birds that were observed while passing over the forest; "emergent trees" for those individuals that were seen on the emergent trees of the forest and therefore in a spot that was isolated from the rest of the canopy; "canopy" for those individuals that were observed perched at the highest strip of the canopy but not over it; subcanopy for birds seen under the canopy but still on trees; "bushes" for those contacts representing individuals placed in the bushes; and "ground" for contacts made at an altitude of 0 m.

distribution relative to forest height

Stratification of both species in the Atlantic rainforest is statistically significant (Kruskal-Wallis, $\chi^2 = 16.446$; df= 1; $p < 0.001$ with n=39 observations) (Figure 7). These results back up Guix's observations. Distribution frequencies of both species across the vegetation strata (Figure 8) are significantly different. *P. jacutinga* (n=19; $\chi^2 = 20.652$; df= 3; $p<0.0001$) occupies the highest strata: emergent trees, canopy (mainly) and subcanopy. The number of sightings of *P. o. bronzina* (n=16; $\chi^2 = 9.625$; df=4, $p<0.05$) is much lower in each one of the strata and therefore results must be considered with care; nevertheless, there is a clear tendency towards the occupation of the intermediate (subcanopy) and lower (shrub and ground) levels of vegetation

DISCUSSION

The study method allows the evaluation of the guan populations' status in the study area. Since the applied method was the same in 1994 and 1998, the evolution of populations over that period can be considered without any risk of bias. Considering results obtained through the sampling method used by Galleti (1998a) would introduce an error linked to differences in both species detectability.

Comparison between 1994 and 1998 census data

When comparing *P. jacutinga* results in P.E. Intervales only, no variation was observed between 1994 and 1998, which indicates a steadiness in its populations. The fact that the 1994 population estimate is larger might be due to the larger amount of individuals sighted, but illegal hunting and movements related to fruition phenology could also lead to variations in population sizes.

Group size is twice as big when considering the whole of the three parks than it is when taking into account P.E. Intervales only, which indicates that average group sizes are much bigger in P.E. Carlos Botelho and P.E.T. Alto Ribeira. Encounter rates and group and individual densities suggest the same and therefore the contribution of P.E. Carlos Botelho and P.E.T. Alto Ribeira is very important to the *P. jacutinga* population.

P.E. Carlos Botelho and P.E.T. Alto Ribeira have been subject to protection for much longer than P.E. Intervales and that can be reflected in the conservation status of their fauna, particularly relative to illegal hunting and palmito extraction. Although illegal hunting still occurs in the three parks, it is in P.E. Intervales where it represents a bigger problem (Aleixo & Galetti, 1997; K.Pisciota pers. comm.). *P. jacutinga* is a conspicuous species, easily detected by hunters; it is large and it is not densely distributed, which means that hunting can affect it deeply even if only a few individuals are captured.

In the case of *P. o. bronzina*, differences between the number of individuals and groups found in 1994 and 1998 are minimal and they are also quite small when considering the whole of the three parks in 1998. The same tendency was found in densities and encounter rates. The lack of variation in *P. o. bronzina* data along the study is quite remarkable.

P. o. bronzina is a relatively cryptic species, which could favour its conservation in front of illegal hunting. That could explain the lack of variation in the three studied areas.

Results found in the current census for both species in P.E. Intervales were compared with those found by Galetti *et al*. (1998a). Comparisons are not easy because methodologies applied were different and their sampling area was located below 300m. These authors considered not only visual contacts but also acoustic registers; also, they did not take into account the effective strip width (ESW), which meant that their data yielded results on encounter rates but gave no information regarding densities. Nevertheless, for *P. jacutinga*, Galletti *et al*. (1998a) found an encounter rate of 0.04 individuals per hour (approximately 0.054 individuals per km), which is similar to the one we obtained (Table 2).

In the case of *P. o. bronzina*, Galetti finds an encounter rate of 0.02 individuals per hour (approximately 0.027 individuals/km), which is much lower that the one we found in both years (Table 4). This difference could be due to the different methodologies applied. However, Galetti *et al*. (1998 a) point out that the abundance of *P. o. bronzina* is not related to the diminishment of fruit availability since no correlation was found, month after month, between the abundances of fruits and this species.

Galetti (1997) suggests that the main factors affecting *P. jacutinga* status are not fruition but hunting and habitat fragmentation or loss. He points out that the species disappears in fragments below 15 km^2. Variation between areas is remarkable in our study. When considering protection measures it should be considered that the hunting of low-density species such as *P. jacutinga* has an important effect on their general population status even if only a few individuals are captured. Considering the palmito's fruition phenology as an indicator of general fruition (Guix, 1995), the altitude of the area sampled in P.E. Carlos Botelho and P.E.T. Alto Ribeira could partly explain the important increase of the species' population parameters when including these parks in the 1998 study. They correspond to areas where food would be highly available because the palmito would be coming to fruition (the altitudinal gradient is closely related to fruition phenology as stated by authors such as Greenberg (1981), Levey (1988) and Loiselle & Blake (1991). Considering P.E. Intervales, during the 1994 study the palmito was starting to come to fruition in many of the census areas (some of them below 400 m), while it had already yielded fruits in those areas or in areas placed at a similar altitudinal range in 1998. The lack of available fruits could limit the occurrence of the species, but the fact that there are not remarkable variations between the two years suggests that even though fruition phenology can influence the species distribution, it is not the parameter that can best explain differences between areas. Several authors (Sick, 1993; Guix, 1995; Galetti *et al*., 1997) point out that possible altitudinal movements in guans depend on the availability of fruits belonging to a wide variety of woody plants, but also that some individuals could remain in their original areas without following fruition. These observations fit our own results, and they could explain the small amount of guans detected in 1998 in low areas where the palmito (and some other trees) had already yielded fruit.

Comparison considering sampling altitude

The tendency to higher individual densities in both species at and above 500 m could be related to the availability of ripe fruits in the canopy of higher areas. So, regardless of the small sample size (an enormous sampling effort should be invested in order to increase the sample size due to the low individual density), the fruition status could explain differences between the amounts of groups and individuals.

Species distribution considering forest height

P. jacutinga tends to occupy the highest vegetation strata while *P.o.bronzina* prefers the lowest ones. Guix (1995) points out that in some areas where the forest was altered in the 1970s and it was recovered after, *P. o. bronzina* might be more affected than *P. jacutinga* because nowadays the subcanopy level remains damaged in terms of vegetal diversity but not in terms of structural complexity.

In the census, the maximum perpendicular distance at which each species was found is different, and it might vary depending on the vegetation strata that they occupy. While the maximum perpendicular distance at which *P. jacutinga* was detected is 100 m, it was only 40 m in the case of *P. o. bronzina*. These differences might be reflected in the impact of illegal hunting, since *P. jacutinga* is far more detectable than *P. o. bronzina*.

CONCLUSIONS

The status of guan populations in P.E. Intervales remains steady without increases even though it has been subject to conservation policies for a long time. P.E. Carlos Botelho and P.E.T. Alto Ribeira host important populations. In the case of P.E. Intervales, the possibility of movement linked to fruition phenology must be taken into account. Nevertheless, strict conservation policies should be applied in order to diminish illegal hunting and protect species such as *P. jacutinga* and *P. o. bronzina*, since they are two of the few frugivorous species disseminating large size seeds (Guix, 1995) and they play an important ecological role within the Atlantic rainforest ecosystem.

Considering fruit phenology and using the palmito as a general fruition indicator, the amount of guan populations seems to be linked to altitude. The fact that the differences we found were not statistically significant might be due to the small sample size.

The two guan species inhabiting the study area show a clear stratification in their distribution that could be reflecting stratification in their use of resources. The Black-fronted piping-guan (*P. jacutinga*) eats the fruits that grow in the highest vegetation strata (emergent trees and canopy) while the Dusky-legged guan (*P. o .bronzina*) eats those in the subcanopy and shrubs.

Both *P. jacutinga* and *P. o. bronzina* are frugivorous species and characteristic of mature and old secondary rainforests. Those areas are currently endangered, and both species act as indicators of habitat quality. When organising the management of those areas, it must be taken into account that both species need to be protected from illegal hunting, illegal exploitation of vegetation (palmito) and habitat fragmentation. *P. jacutinga* can act as a good indicator of forest quality because it is very sensitive to habitat fragmentation. *P.o.bronzina* can be a good indicator of the quality of the lowest vegetation strata, which can be very important since they are usually the first ones to be degraded and therefore they indicate the beginning of a forest destruction process.

Group sizes found in both *P. jacutinga* and *P. o. bronzina* are smaller than those found in other periods of the year (Guix, 1995). Both censuses were performed during the pre-reproductive season, when the amount of individuals in each group tends to be smaller than during the reproductive season.

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DENSITY ESTIMATES OF SYNTOPIC SPECIES OF TOUCANS (AVES: RAMPHASTIDAE)

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ABSTRACT.- Toucans (Ramphastidae; Piciformes) are a group of birds that develop an important role in the dispersal of tree and bush seeds from the tropical and subtropical forests of the Neotropical region. Between 18 August and 4 September 1998, 352.44 km of lineal transects were performed in the Paranapiacaba forest fragment (southeast of the State of São Paulo, Brazil) in order to estimate toucan species abundance in the area. For *Ramphastos dicolorus* and *R. vitellinus* density estimates were performed using the Distance Sampling method. Estimates obtained were 3.23 ± 1.25 and 2.81 ± 1.46 individuals/km^2, respectively. It was not possible to apply the same method to *Selenidera maculirostris* and *Baillonius bailloni*. In the first species, a minimum density of 1.34 individuals/km^2 was estimated, while it was impossible to estimate densities for *B. bailloni* due to the low number of sightings. Encounter rates obtained were 0.062±0.17 contacts/km in *R. dicolorus* (1.77 ± 0.23 individuals/group), 0.037 ± 0.14 contacts/km in *R. vitellinus* (2.61 ± 0.64 individuals/group), 0.0653 ± 0.0147 contacts/km in *S. maculirostris* (1.65 ± 0.13 individuals/group) and 0.017 ± 0.0073 contacts/km in *B. bailloni* (3.0 ± 1.0 individuals/group). Results obtained are of great importance because of the size and good state of conservation of the study area; they can be used to value the state of conservation of other fragments as well as the situation of populations in the study area.

KEY WORDS. Brazilian Atlantic rainforest, census, density estimates, population, Ramphastidae, toucans.

INTRODUCTION

Toucans (Ramphastidae; Piciformes) are a group of birds of exclusively arboreal habits that inhabit only the Neotropical biogeographical region (Sick, 1993). Their beak is especially adapted to a frugivorous diet (Gould, 1854; Sick, 1993; Bühler, 1996), although they can also feed on leaves, flowers, arthropods, other birds' chicks and little mammals (Sick, 1993; Remsen *et al.* 1993; Galetti *et al.*, 2000). Together with other medium and large size bird families (e.g. Cracidae, Cotingidae) and some mammals (e.g. cebid monkeys, leaf-nosed bats), they develop an important role in dispersing large size seeds from several tree and bush species in tropical and subtropical forests (Guix, 1995).

Despite the great importance of Ramphastidae in sustaining tropical ecosystems, the knowledge about the situation of populations and species is very weak. Most studies refer to biological and biogeographical aspects, but data on population sizes are scarce (but see Martín, 2000).

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Up to seven toucan species can be found in southeastern Brazil (Sick, 1993): *Ramphastos toco*, *Ramphastos dicolorus*, *Ramphastos vitellinus*, *Pteroglossus castanotis*, *Pteroglossus aracari*, *Baillonius bailloni* and *Selenidera maculirostris*. From those, *R. dicolorus*, *B. bailloni* and *S. maculirostris*, are restricted to tropical rainforests and subtropical forests. Reduction and fragmentation of those forests has led to the fragmentation of Ramphastidae populations and to their disappearance from small fragments (Willis, 1979; Guix *et al.*, 2000).

Population density estimates of toucans becomes particularly interesting when considering their conservation status and the size of the study area relative to those of other regions in the Atlantic rainforest (see chapter 3). Thus, the main goal of the current study is achieving a first approach, through density estimates or encounter rates, to the situation of Ramphastidae populations in one of the largest and best preserved Atlantic rainforest fragments. Those results should also become a management tool to value the degree of conservation of other forest fragments and they should be the bases to monitor the changes in time of populations in the study area.

On the other hand, the availability of a broad sampling area, which included a wide range of heights, enabled the study of matters such as abundance and group size in two altitudinal strata. The use of different forest strata by species as well as altitudinal segregation in the two *Ramphastos* spp. has also been considered.

MATERIAL AND METHODS

Following the general methodology (see the chapter 4), the number of individuals and their perpendicular distance to the transect was recorded for each sighted species of Ramphastidae over 352.44 km of lineal transects. Data on type of forest strata, height above ground at which perched groups were sighted and height of the forest in the location where the contact occurred were recorded.

Density estimates for *Ramphastos dicolorus* and *R. vitellinus* were obtained through the Distance Sampling method of analysis (Buckland *et al.* 1993). Perpendicular distances were grouped into 10 m intervals. Two observations were considered as outliers according to the detection function and they were not taken into account (a group of *R. vitellinus* at a distance of 200 m and a group of *R. dicolorus* also at a distance of 200 m). Since both species present similar morphological and ethological characteristics (Sick, 1993) and they both use the same forest strata (Guix, 1995), all data were considered jointly in order to calculate the detection function. This way, the effective strip width was the same in both species. Data were treated using the Distance 2.02 suite (Laake *et al.,* 1993) choosing the Hazard Rate model function according to Aikake's information criteria. The detection curve obtained (Figure 1) and the values of adjustment of observed frequencies to the curve (χ^2 = 3.78; df= 5; p = 0.581) show that the function fits quite well. Individuals both flying and perched were considered (see the discussion section). Density values were calculated independently for each species.

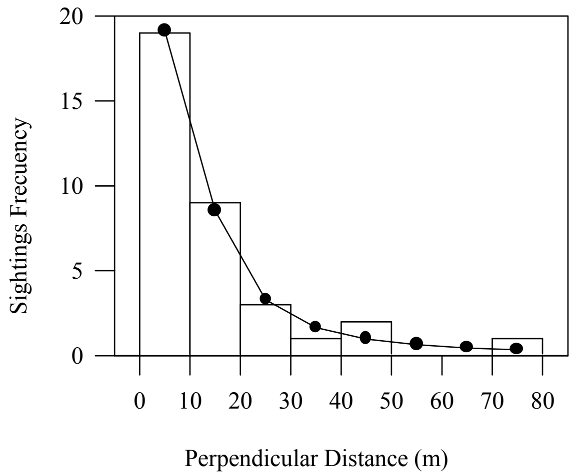

Figure 1. Observed frequencies (bars) and expected frequencies (line - from the estimated detection function) in *Ramphastos dicolorus* and *R. vitellinus*.

Distance Sampling method could not be used to obtain density estimates of the other two species occurring in the study area, *Selenidera maculirostris* and *Baillonius bailloni*. In the case of *B. bailloni*, density estimates could not be performed due to the low number of sightings. In the case of *S. maculirostris*, observation distances were distributed too close to the transect line and obtaining a wide enough effective strip width to carry out reliable estimates turned out to be impossible. This could be related to the fact that the methodology applied had been designed for species inhabiting the highest forest strata. Since *S. maculirostris* tends to stay in the intermediate strata and *B. bailloni* seems to use almost any of them (Guix, 1995), the possibility that observers did not spot some of the individuals in the band must be considered. This problem might be particularly serious in *S. maculirostris*, which does not have outstanding colours and that can go easily unnoticed with its behaviour. Minimum density was calculated for this species using Kelker's formula (Glanz, 1985; Tellería, 1986) modified according to:

$$D = n / (2 \cdot L \cdot P)$$

where "D" is density, "n" is the number of contacts, "L" is the total distance covered and "P" is the maximum perpendicular distance of observation. This formula considers the maximum perpendicular distance of observation to be the effective strip width. It can be used as an estimate of minimum density (see the Discussion section) because it does not take into account the individuals which were not spotted and that potentially could have been sighted within the census strip. The distance value reflecting the detection limit of the species in the area should be used as the maximum distance value. By checking the histogram showing the frequencies of contacts along the census strip, it can be decided whether all data should be taken into account or whether some values must be considered as outliers, since excessively distant specific values should be dismissed. In the case of *S. maculirostris*, no data were removed. The value of density of individuals is obtained by expressing the number of contacts (n) as the total number of individuals.

Encounter rate, average group size and 95% confidence intervals were calculated for all species using the Distance 2.02 suite (Laake *et al.*, 1993).

The whole of the study area can be considered as the potential occupation area for the four species. Nevertheless, sampling was performed in mature and old secondary forests. Because of that, density estimates can only be extrapolated to areas dominated by those kinds of forests and therefore the considered area covers 100000 ha (approximately 70% of the Paranapiacaba fragment).

On the other hand, toucan species abundance relative to fruit availability was considered. Fruition periods in many species vary along the altitude gradient. Thus, it was considered whether species were more abundant in areas where there was a supposed higher availability of fruits. The presence of fruits of the palmito palm (*Euterpe edulis*, Arecaceae) along the altitudinal gradient was taken as an indicator of general fruition in order to delimit areas with different levels of availability (Guix, 1995). According to this criterion, two altitudinal strata were considered: a lower stratum lacking ripe palmito fruits (transects of an average height between 60 m and 400 m), and an upper stratum presenting ripe fruits (transects of an average height between 500 m and 1030 m). Sampling effort on these strata was 80.84 km and 193.2 km, respectively. In order to test whether there were any significant differences between strata, 95% confidence intervals of the encounter rates obtained by the Distance 2.02 suite (see Buckland *et al.*, 1993 for details) for each species were compared. All species, except for *B. bailloni*, were considered.

This analysis enabled the study of presumable altitudinal segregation between the two species of *Ramphastos*. This altitudinal segregation would be of great interest, since both species share similar resources and competition could occur between them. From distribution data, Sick (1993) describes *R. dicolorus* as a more montane species, but quantitative data from a single locality are not available to prove this tendency. A chi-square test was performed with the contact frequency distribution in the two strata being the same in both species as the null hypothesis.

Two aspects regarding group size were also considered. Group size differences between different species were compared using a Kruskall-Wallis test. Moreover, since fruit availability and fruit distribution were probably different at each altitud, the group size of the two *Ramphastos* species in each altitudinal stratum was considered. Relationships between group sizes and trophic availability have been studied in many species and several hypothesis have been suggested to explain them (see Pulliam & Caraco, 1984; Krebs & Davies, 1993). In this case, the altitudinal strip between 400 m and 500 m was considered to avoid losing sample size, even though fruition in this strip was intermediate. A lower altitudinal stratum (transects of average height between 60 m and 450 m) and an upper one (transects of average height between 450 m and 1030 m) were therefore delimited. U Mann-Whitney tests were performed to infer differences between the upper and lower strata in group size values for each species. The same test was also applied to both *Ramphastos* species together according to its ecological similarities (Guix, 1995; Guix *et al.*, 2001) and the group size patterns observed in both strata.

Forest strata where species were sighted were considered. This can yield information on differences between vegetation strata use. Two kinds of data were analysed. Firstly, height at which individuals were sighted, expressed as a percentage relative to the total height of the forest around the sighting point. Relative heights were compared using a Kruskall-Wallis test. On the other hand, vegetation strata where groups were sighted were recorded (shrub, subcanopy, canopy, emergent trees). Since some categories showed a low number of sightings, they were grouped into an upper level (emergent trees, canopy) and a lower level (subcanopy, shrub). A chi-square test was performed to check whether sighted groups distribution in the two strata was independent from the species considered, which were *R. dicolorus*, *R. vitellinus* and *S. maculirostris* (the *B. bailloni* sample size was far too low).

RESULTS

A total of 129 individuals belonging to four Ramphastidae species (*Ramphastos dicolorus*, *Ramphastos vitellinus*, *Baillonius bailloni* and *Selenidera maculirostris*) were sighted in 64 contacts.

All species were sighted between 60 and 800 metres of height, except *R. vitellinus*, which was spotted between 60 and 700 metres of height. Most sighted *Ramphastos* spp. individuals were perched in the canopy, and the few individuals spotted while flying (5 *R. dicolorus* individuals and 1 *R. vitellinus* individual) were always seen at a low height over the canopy. *B. bailloni* and *S. maculirostris* groups were perched below the canopy, except for 3 *S. maculirostris* individuals that were sighted while flying just below the canopy.

Table 1. Main results for *Ramphastos dicolorus* and *Ramphastos vitellinus*. The analysis comprises 352.4 km in 127 transects. Standard errors are indicated.

	Ramphastos dicolorus	*Ramphastos vitellinus*
Number of groups	22	13
Number of individuals	39	34
Group size (range)	1.77 ± 0.23 (1-5)	2.61 ± 0.64 (1-9)
Maximum sighting distance (m)	75	50
Mean sighting distance (m)	17 ± 4	11 ± 4
Median sighting distance (m)	11.5	8
Effective strip width (m)	17 ± 4	17 ± 4
Encounter rate (groups/km)	0.062 ± 0.17	0.037 ± 0.14
Model	Hazard rate	Hazard rate
Density (groups/km^2)	1.82 ± 0.68	1.08 ± 0.49
Density (individuals/km^2)	3.23 ± 1.25	2.81 ± 1.46
Number of individuals in secondary and mature forest areas (100000 ha)	3230 ± 1250	2810 ± 1460

In the whole of the study area, *R. dicolorus* density is higher than that of *R. vitellinus* (Table 1). Twice, mixed groups of *R. dicolorus* and *R. vitellinus* were sighted, with a proportion of individuals of each species being 1:1 and 5:4 in each case. This means that two of the 35 *Ramphastos* spp. groups that were sighted were mixed (5.7%).

S. maculirostris was sighted 23 times (encounter rate 0.0653 ± 0.0147 contacts/km) totalling 38 individuals (group size 1.65 ± 0.13 individuals/group). All sightings were of either lonely individuals or pairs and only twice of a group of three (two males and a female). Minimum density estimated was 0.816 groups/km^2 and 1.346 individuals/km^2 (covered distance 352.44 km; maximum perpendicular distance 40 m; average perpendicular distance 10.5 ± 2.5 m).

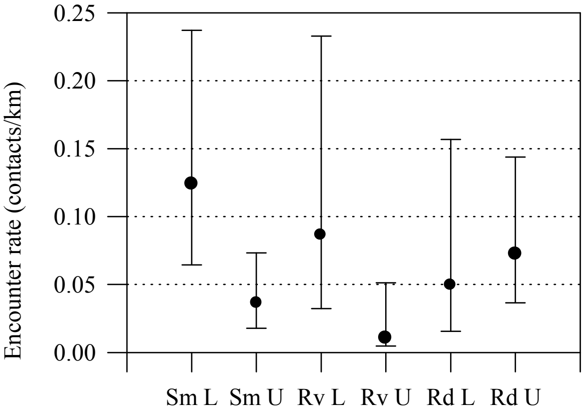

Figure 2. Encounter rates (contacts/km) with their associated 95% confidence intervals for *Ramphastos dicolorus* (Rd), *Ramphastos vitellinus* (Rv) and *Selenidera maculirostris* (Sm) in altitudinal strata (L=lower, U=upper). About 193.2 km in 71 transects were covered in the upper stratum (500-1030 m) and 80.8 km in 40 transects were covered in the lower one (60-400 m).

B. baillonus was sighted only six times (encounter rate 0.017 ± 0.0073 contacts/km) with a total of 18 individuals (group size 3.0 ± 1.0 individuals/group; range 1-7 individuals/group).

Species abundance relative to the considered altitudinal stratum showed a tendency of *R. vitellinus* to stay at lower altitudes, during the study period, and a less marked preference of *R. dicolorus* for higher altitudes (Figure 2). Regardless of the observed tendencies, there were not significant differences between encounter rates of the two species in the two altitudinal strata when analysing their 95% confidence intervals. On the other hand, frequency distributions of sightings in the two altitudinal strata were significantly different for the two species ($\chi^2_{1\,df} = 7.177$; $p = 0.007$). The adjusted standardized residuals showed that observed frequencies of *R. vitellinus* in the lower altitudinal stratum were much higher than expected and that exactly the opposite occurred in *R. dicolorus*. In the case of *S. maculirostris*, encounter rates were 0.0362 contacts/km in the upper stratum and 0.1237 contacts/km in the lower one (Figure 2). Analyses of the 95% confidence intervals of the encounter rates did not show significant differences either, since a certain overlap occurred. It must be considered, though, that confidence intervals are very wide because of the little sample size, and that the overlap is very small relative to those intervals (see Figure 2).

Group size analyses between species (see Figure 3) show that regardless of the tendency of *R . dicolorus*, *R . vitellinus* and *B . bailloni* to form relatively large groups (something that was never observed in *S. maculirostris*), there are not significant differences between group sizes (Kruskal-Wallis test, $\chi^2_{3,74}=2.757$; $p = 0.431$).

Figure 3. Group size frequencies in contacts made with the different species.

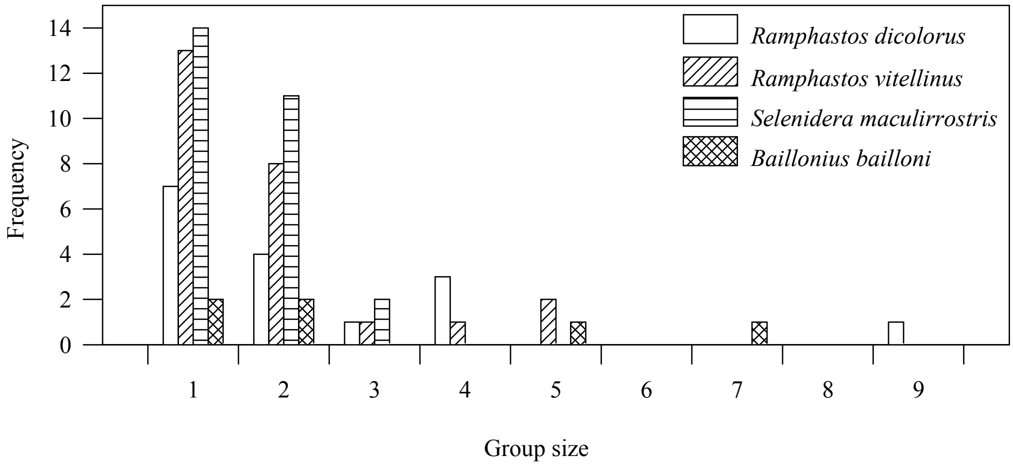

Table 2 shows statistics on group size for the two *Ramphastos* species in the two altitudinal strata. It must be noticed, though, that data might not be representative in some cases because of the small sample size. No significant differences appeared when analysing group size in the two strata (*R. dicolorus*, U = 34, p = 0.156; *R. vitellinus* U = 11.5; p = 0.133). When considering both species together, though, significant differences appear (U = 122.5 ; p = 0.017), *Ramphastos* spp. groups being larger in the lower altitudinal stratum.

Table 2. Main statistics on group sizes relative to altitudinal strata. sd: standard deviation

ALTITUDINAL STRATUM	GROUP SIZE STATISTIC	*R.vitellinus*	*R.dicolorus*
LOWER (60-450 m)	median	2	2
	mean	2.83	2.67
	sd	2.29	1.63
	minimum	1	1
	maximum	9	5
	n	12	6
UPPER (450-1030 m)	median	1	1
	mean	1.25	1.58
	sd	0.5	0.96
	minimum	1	1
	maximum	2	5
	n	4	19

A tendency of *Ramphastos* spp. to preferably use the canopy and the emergent vegetation was observed. *S. maculirostris* and *B. bailloni* tended to use intermediate levels (Figs. 4 and 5). Contact frequency distributions in the two vegetation strata were almost significantly different between *R. vitellinus*, *R, dicolorus* and *B. bailloni* ($\chi^2_{2\ df}$ =5.501 ; p = 0.064). Analysis of relative heights at which perched individuals of the three species were detected follows the same tendency, although differences found were not significant either (Figure 5; Kruskal-Wallis, $\chi^2_{2,43}$=5.112 ; p=0.078).

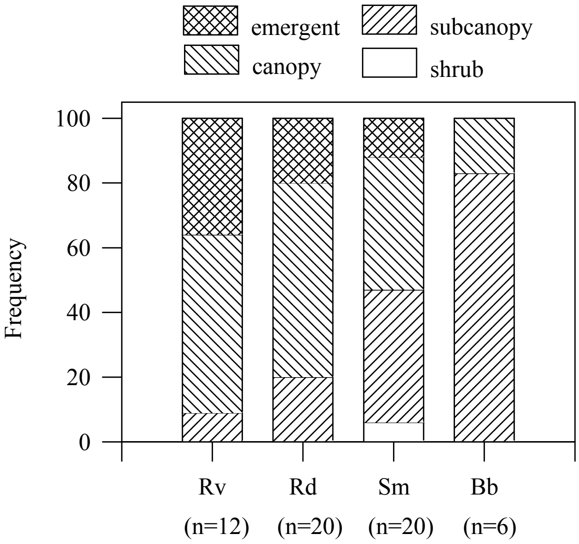

Figure 4. Vegetal strata in which Ramphastidae individuals were detected (percentage over the total number of sightings of perched individuals). *Ramphastos dicolorus* (Rd), *Ramphastos vitellinus* (Rv), *Selenidera maculirostris* (Sm), *Baillonius bailloni* (Bb).

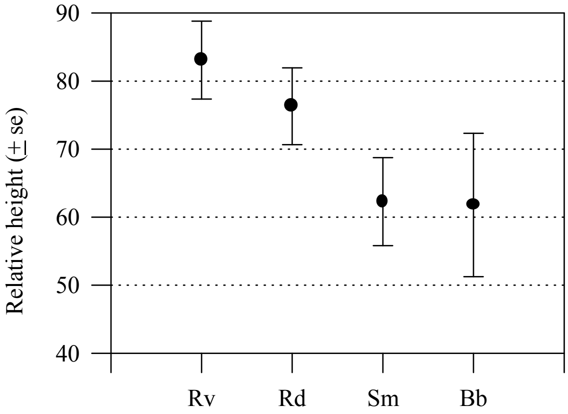

Figure 5. Relative height at which groups were sighted. Data in percentages (group height/forest height) with mean standard error. *Ramphastos dicolorus* (Rd), *Ramphastos vitellinus* (Rv), *Selenidera maculirostris* (Sm), *Baillonius bailloni* (Bb).

DISCUSSION

The four Ramphastidae species observed are syntopic in the study area (Guix, 1995). Information on the state of their populations is scarce. Most references indicate only presence or absence of a certain species in a certain area or they show abundance relative to the number of sighted individuals (Haffer, 1974; Willis, 1979; Willis & Oniki, 1981; Barros *et al.* 1989; Sick, 1993; Olmos, 1996). The only density estimates available are those of *B. bailloni* in the study area (Guix *et al.*, 1997, 2000) and those of *R. dicolorus* on São Sebastião island (Martín, 2000). Those data were collected using the same methodology as the current study, which is an advantage. In the first case, though, since we could not obtain density estimates, only encounter rate can be compared. Galetti & Aleixo (1998) show data on contacts per hour in line transects performed in the Saibadela region (60-300 m), which is located within the study area. Nevertheless, contacts refer to individuals detected either by direct sighting or through hearings, which make them hardly comparable to the ones in the current study (see also discussion in chapter 8).

***Ramphastos* spp.**

Methodology used allowed the obtaining of density estimates for the two *Ramphastos* species. The shape of the function (Figure 1) shows how detectability decreases as perpendicular distance to the transect increases. This suggests that, generally, birds were sighted at their initial location and that it did not change as a response to the observers, which is one of the main assumptions in the Distance Sampling method (see chapter 4). On the other hand, goodness of fit tests shows that the observed values match quite well the estimated function. Moreover, obtaining a wide enough effective strip width with a low standard error enabled the calculation of reliable density estimates. These estimates are very important, since they are the first ones obtained for these species (see also Martín, 2000).

Including individuals that were sighted while flying might involve a methodological problem in some species because it may lead to an overestimation of density values (Burnham *et al.*, 1980). Nevertheless, this matter concerns those groups that break into the field of vision of the observer, coming from far away. It does not affect those birds alighting as a response to the observer's intrusion. Since Ramphastidae do not fly over long distances, the few individuals that were sighted while flying (probably as a response to the observer) should not affect our estimates.

Martín (2000) calculated a density value for *R. dicolorus* of 16.96 ± 13.37 individuals/km^2 (118.5 km of line transects; altitude between 40 and 900 m) on São Sebastião island (33593 ha, State of São Paulo), while *R. vitellinus* does not occur on the island. This density value is remarkably higher than the one obtained in the study area even though conservation status is similar in both areas. The difference could be partly explained by the absence of *R. vitellinus*, but the value on the island is not reached by adding up density values of the two species in the study area. The absence of some predators on São Sebastião island (Olmos, 1996) might explain this fact.

Analyses of encounter rates and contact frequencies distribution in the two altitudinal strata defined showed a clear tendency of *R. vitellinus* to occupy lower areas and a less marked tendency of *R. dicolorus* to inhabit the upper ones. This proves the necessity of wide samplings when estimating densities in areas covering a broad range of heights, since samplings limited to small altitude ranges may lead to biased estimates. This aspect must also be taken into account whenever comparing abundances of these two species in different areas. In the current study, density values obtained for both *R. dicolorus* and *R. vitellinus* are representative for the whole of the study area.

On the other hand, altitudinal segregation between *R. vitellinus* and *R. dicolorus* is extremely interesting from not only an ecological point of view but also regarding conservation. Considering species ecology, results show that there is a certain degree of segregation in space between them. Some authors (Sick, 1993; Stotz *et al.* 1996) point out that *R. dicolorus* is a montane species, while *R. vitellinus* inhabits lowlands in South-eastern Brazil. Galetti & Aleixo (1998) provided rates of contacts per hour in forests of the Saibadela area where palmito extractions are not performed. Important differences were observed between the two (0.02 contacts/hour in *R. dicolorus*, 0.45 contacts/hour in *R. vitellinus*), and those data show that *R. vitellinus* is more abundant in the lowlands. Until the current work, though, no quantitative data had shown segregation between the two species in a single area. The fact that both species have similar feeding habits and the fact that they both use the same vegetation strata (Guix, 1995; Guix *et al.*, 2001) suggest that competition for resources between the two species could be high. A tendency towards altitudinal segregation would be a way to reduce competition between them.

Regarding conservation, it must be considered that the impact of human activities in a certain area could affect in a different manner species occurring in the whole of the area. In the Paranapiacaba fragment case, lowlands have been subject to intense illegal hunting and illegal palmito extractions (Galetti & Fernández, 1998; K.Psiciotta & Ocimar, pers. com.). Therefore, *R. vitellinus* populations could not only have been affected in the past, but they could also be diminished in the future if these sorts of activities continue.

Sensitivity of *R. dicolorus* and *R. vitellinus* to environmental changes produced by humans is difficult to value from available information. Stotz (1996) considers them relatively common regarding their abundance. According to this author, *R. dicolorus* has a medium sensitivity to environmental changes, which causes a decrease in populations outside protected areas, while *R. vitellinus* shows a high sensitivity to those changes. In this sense, Willis & Oniki (1981) studied 13 areas in the State of São Paulo. *R. dicolorus* occurred in six areas and *R. vitellinus* occurred in one of those six and it was not detected alone anywhere. This could suggest a higher degree of sensitivity in *R. vitellinus*, but when considering altitudes we realise that only two of those 13 areas included lowlands. On the other hand, a high relative abundance of birds (four categories) in four areas of Rio de Janeiro and one of Espirito Santo was registered by Scott & Brooke (1985). *R. vitellinus* occurred in four areas (common to rare), while *R. dicolorus* appeared in only one area (rare).

These data do not show a clear tendency concerning species sensitivity. It is worth considering, though, that *R. dicolorus* is a more generalist species, regarding not only the use of trophic resources but also its habitat use. It gets to occupy areas that are exclusively covered by secondary forests (Guix, 1995). Moreover, *R. vitellinus* distribution is more restricted to lower altitudes. All this suggests that *R. vitellinus* could have a higher sensitivity to environmental changes.

Regarding biogeography of these two species, *R. vitellinus* has a much wider distribution. A subspecies (*R. vitellinus ariel*) occurs in South-eastern Brazil and it spreads across the Southeastern region of the Amazonia (populations with blue periophtalmics) and along the Eastern Brazilian coast, from the State of Pernambuco to the State of Santa Catarina (populations with crimson periophtalmics). On the other hand, *R. dicolorus* is endemic to South-eastern Brazil (Sick, 1993). Concerning phylogenetics of the medium size *Ramphastos* spp. group, *R.dicolorus* and the two trans-Andean toucan species (*R. sulphuratus* and *R. brevis*), they appeared from stocks that separated before the Amazonian forms differentiated (i.e. *R. vitellinus* subspecies; Haffer, 1997). According to Guix (1995), *R. vitellinus ariel* could have recently colonised the Atlantic rainforest in Eastern Brazil (end of Pleistocene) with populations from the Amazonian basin. The fact that in the syntopic distribution area of the two species *R. dicolorus* is more widely spread (Sick, 1993; Willis & Oniki, 1981), and it occurs in a wider altitude range, supports this idea.

Finally, it is worth considering the sightings of two interspecific groups of *R.dicolorus* and *R.vitellinus*. They were observed not only perched but also flying, which suggests that they did not meet up by chance next to a food source such as a ripe fruit tree. One of the groups consisted of one individual of each species. The fact that mixed pairs have been reported breeding in the State of Santa Catarina (Sick, 1993), suggests that it might be a case of hybridisation.

Selenidera maculirostris

To start with, it is important that a minimum density value was obtained for a species on which little information is available. Contact frequencies distribution relative to perpendicular distances to the transect did not allow the use of the Distance Sampling methodology (most sightings occurred between 0 and 10 m). On the other hand, we must be aware that the estimate achieved is not exact, and its value can differ a lot from the real density value. Nevertheless, it is an objective estimation that can be easily calculated and it can give us an idea about population status.

S. maculirostris was one of the two Ramphastidae species that appeared more often. Its encounter rate value was close to that of *P. jacutinga*, which was the most common species of seed spreader frugivour in the current census. Taking into account that the sampling strategy applied was not the best one for this species but that, nevertheless, it was often sighted, it does not seem that the *S. maculirostris* population is at risk in the study area. Further estimations should be carried out in the future. Previous data do not exist in order to value whether population changes have occurred. There are not any data available either regarding other areas in its distribution range, so it cannot be checked whether the minimum density value achieved is a high one or a low one. Recent literature only mentions its presence/absence in relatively large fragments of Atlantic rainforest and subtropical forest (Willis, 1979; Willis & Oniki, 1981; Scott & Brooke, 1985; Collar *et al*. 1987; Olmos, 1996). Nevertheless, some recent data point out a diminishment of population sizes in unprotected areas and a negative effect of deforestation (Stotz *et al.*, 1996; Guix *et al.*, 2000).

Baillonius bailloni

B. bailloni was spotted in very few occasions. Because of the vegetation strata that it uses, there might be problems regarding its detection (see Material and Methods), but unlike *S. maculirostris*, it has conspicuous colours and it should be easy to see considering its behaviour. In 1994, encounter rate values were 0.072 ± 0.021 groups/km in the study area (Guix *et al.* 1997), much higher than the ones estimated in the current study (see Results). Interpreting this difference is not easy, but the fact that the sampled area has now been bigger suggests that the 1998 data might be more representative. It could also be that a drastic diminishment in the number of individuals has occurred, but it seems quite unlikely, since that would be the case in this species only and over a relatively short period. Galetti & Aleixo (1998) did not see any specimen of *B. bailloni* along 255.4 km of mature forests, while they obtained an encounter rate of 0.06 contacts/hour in 58.6 km of altered forests (about 0.02 contacts/km considering mature and altered forests jointly). There are not data on population density estimates for *B. bailloni* in other areas of the Atlantic rainforest. The fact that its distribution area is the Atlantic rainforest (Aleixo & Galetti, 1997) but it is absent from many localities within it (Willis & Oniki, 1981; Scott & Brooke, 1985; Sick, 1993) shows, though, that this species is in a worrying situation (Guix *et al.*, 2000). It is considered very sensitive to human intrusions and currently retreating (Stotz *et al.* 1996) although it is only considered as *Lower risk*/*near threatened* in the IUCN Red List of Threatened Animals (see UNEP-WCMC, 2001). Based on its continuous habitat loss and its rare occurrence in the remaining fragments of Atlantic rainforest and subtropical forests, it has recently been proposed to be included in the list of threatened species as *vulnerable* and within Appendix I of the CITES regarding species trade regulation (Guix *et al.*, 2000).

Toucan abundance and fruit availability

Several studies have shown a variation in fruition phenology along the altitudinal gradient (Greenberg, 1981; Levey, 1988; Loiselle & Blake, 1991; Morellato & Leitão-Filho, 1992). Following this gradient, altitudinal migrations occur in many bird species, including some Ramphastidae (Loiselle & Blake, 1991; Guix, 1995). In the case of *R. vitellinus* and *S. maculirostris*, the species abundance pattern observed in the two altitudinal strata suggests that movements following fruition do not occur, at least not during this time of the year. It might be, though, that these movements occur in *R. dicolorus*. In fact, Stotz (1996) pointed out that this species makes movements in height. Alternaively, it might be considered that altitudinal segregation observed between the two *Ramphastos* spp. might happen all year through, in which case the observed distribution would not be a consequence of fruit availability.

Group size

Group sizes found in *Ramphastos dicolorus* and *Ramphastos vitellinus* in the September 1998 census are quite smaller than those found in that same area and other areas of the State of São Paulo on different periods (cf. Guix, 1995). This is probably because the 1998 sampling was performed during the pre-reproductive season, when many adult individuals go away from big groups in pairs, searching for tree cavities to nest. That would explain why no differences were found with *S. maculirostris*, which is a species that does not tend to form big groups.

Regarding group sizes relative to altitudinal strata, results suggest that factors conditioning group sizes in *Ramphastos* spp. could be different between strata. These factors can be very diverse, but the most important ones are predation pressure and quality, abundance and distribution of food (Krebs & Davies, 1993). In our case, we consider the ones concerning food sources because the two altitudinal strata were in different fruition states. The most accepted theory in this sense predicts that, generally, a diminishment in food availability results in a diminishment of group size (Pulliam & Caraco, 1984). In addition, aggregated food sources support a smaller number of individuals than disperse food sources (Goss-Custard *et al.* 1992). Results achieved do not follow the expected pattern, but we must consider the fact that group size can be influenced by factors such as food quality (Pulliam & Caraco, 1984), predation pressure (Krebs & Davies, 1993) or relationships between individuals within a group in social species (Delestrade, 1999).

Use of vertical vegetation strata

A tendency of *Ramphastos* spp. to use higher vegetation strata and of *B. bailloni* and *S. maculirostris* to use the lower ones was clearly observed. The fact that almost significant differences were found in the two analyses performed with quite small sample sizes suggests that a differential use of the strata exists between these species. Therefore, as suggested by Guix (1995), large species would be adapted to exploit high vegetation strata and small ones would preferably use intermediate levels (see also Guix *et al.*, 2001). A larger beak would be favoured in upper strata because of the difficulty in accessing fruits (Guix, 1995). Studying several morphological characters in toucans relative to the species on which they feed can show coevolution (cf. Bühler, 1996).

On the other hand, species using lower vegetal strata (*B. bailloni* and *S. maculirostris*) are very sensitive to its alteration and they tend to disappear in young secondary forests and small forest fragments (Willis, 1979). The study area shows a good conservation status. The fact that it belongs to the largest Atlantic rainforest ecological *continuum* in the State of São Paulo favours the presence of these two species.

Final considerations

Valuing our results is quite difficult because of the lack of previous information on the conservation status of the four Ramphastidae species found in the study area. Nevertheless, we must highlight the important role of the P.E. Carlos Botelho - P.E. Intervales - E.E. Xitué - P.E.T. Alto Ribeira ecological *continuum* in the conservation of Ramphastidae species in Eastern and Southern Brazil. Knowing about the status of populations and monitoring their evolution in a well preserved area such as this one provides a comparative reference frame for populations inhabiting other areas. This is particularly important in the cases of *B. bailloni* and *S. maculirostris* because of their more restricted ecological requirements. Based on this study, new quantitative valuations of these species will enable the knowledge of their populations and the adoption of management measures for their future conservation. Further specific studies on the biology and ecology of these species are needed to establish their conservation status and to understand why some of them are in regression.

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DENSITY ESTIMATES OF FIVE SYNTOPIC SPECIES OF PARROTS (AVES: PSITTACIDAE): POPULATION STATUS IN THE PARANAPIACABA FRAGMENT

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ABSTRACT. Between 18 August and 4 September 1998, a parrot census was performed in one of the largest forest fragments of Atlantic rainforest in eastern Brazil. Nine parrot species were detected in the fragment during the survey. The most frequently observed ones in 352.4 km of line transects were (in encounter rates, groups/km ± se): *Pyrrhura frontalis* 0.28 ± 0.04, *Brotogeris tirica* 0.25 ± 0.05, *Pionus maximiliani* 0.13 ± 0.03, *Forpus crassirostris* 0.06 ± 0.02 and *Pionopsitta pileata* 0.055 ± 0.034. Group sizes varied between 1 and 20 individuals per group in *B. tirica* and *F. crassirostris* and between one and four individuals in *P. pileata*. Minimum density estimates using the modified Kerker's index were (in individuals/km^2): *B. tirica* 10.53, *P. frontalis* 8.80, *F. crassirostris* 3.08, *P. maximiliani* 2.59 and *P. pileata* 0.90. *Triclaria malachitacea* seems to be suffering a quick process of population isolation and a diminishment of its distribution range (the Atlantic rainforest and the subtropical forests). On the other hand, the rare *Touit melanonota*, an endemic species of the southeastern Atlantic rainforest, has a more restricted distribution range. Considering that the Paranapiacaba forest fragment is the largest and best preserved area where *T. malachitacea* and *T. melanonota* still exist, the future of both parrot species could be closely related to the future of the pristine forests in this protected area.

KEY WORDS: Brazilian Atlantic rainforest, census, conservation status, population size, Psittacidae.

INTRODUCTION

The so-called Paranapiacaba forest fragment is an area with a wide diversity of environments. Although it might seem covered by a homogeneous forest structure, differences in altitude (between 20 and 1095 m) and climate (see chapter 1) give shape to the distribution pattern of a large number of plants and animals.

This diversity of environments allows a large number of psittacid species (Family *Psittacidae*) to inhabit relatively small forest areas. For instance, in the area starting in Base Guapiruvu (120 m of height), going through Base São Pedro (450 m) and Galo Perdido (860 m), to Base Alecrim (250 m), covering about 250 km^2, eight psittacid species were found: the Blue-winged parrotlet (*Forpus crassirostris*), the Brown-backed parrotlet (*Touit melanonota*), the Plain parakeet (*Brotogeris tirica*), the Reddish-bellied parakeet (*Pyrrhura frontalis*), the Red-capped parrot (*Pionopsitta pileata*), the Blue-bellied parrot (*Triclaria malachitacea*), the Scaly-headed parrot

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

(*Pionus maximiliani*) and the Vinaceous-breasted parrot (*Amazona vinacea*) (Guix *et al.*, 1992; Pedrochi & Souza, 1996; and see chapter 15). In 1998, a ninth psittacid species (*Amazona amazonica*) was found in P.E.T. Alto Ribeira, near the Rio Formoso valley (Base Alecrim-P.E. Intervales), although individuals sighted might have just been going across the area. This species richness is probably the biggest found in an Atlantic rainforest area and it is only comparable to the neotropical species diversity found in much larger areas of the Amazonia (for instance, north of the state of Mato Grosso, in Brazil (Roth, 1984) or at the Manú park, in Peru (Collar, 1997).

Unlike other frugivorous species considered in this study, psittacids mostly behave as seed predators (Janzen, 1971; Guix, 1995), that is, seeds of the fruits they consume are destroyed mechanically with their beak or through digestion. Nevertheless, some small size seeds (such as those from *Ficus* spp., Moraceae) can be dispersed and they germinate in natural conditions (Guix, 1995).

Syntopic species in most groups inhabiting the Paranapiacaba fragment have a very marked vertical stratification in the forest (i.e.: guans (Family Cracidae), toucans (Family Ramphastidae) and monkeys (Family Cebidae) (Guix *et al.*, 2001; see also chapter 9)). Unlike them, most psittacid species use the upper vegetation strata (canopy and emergent trees) to be able to feed, which implies a considerable habitat overlapping particularly between *F. crassirostris, B. tirica, P. frontalis* and *P. maximiliani*, common species in the Atlantic rainforest (Sick, 1993; Collar, 1997).

Some other species are more limited by altitude. In the Paranapiacaba mountain range, *P. pileata* is more common in higher areas while *T. malachitacea* tends to inhabit lower areas, although the latter appears in areas up to 800 m in height at certain times of the year (Pizo *et al.*, 1995). *A. vinacea* is the largest species occurring in the area, but it appears irregularly. The least conspicuous species and the one for which less information is available in the Paranapiacaba fragment is undoubtedly *T. melanonota*.

Considering factors such as habitat overlapping in psittacid species, fruit seasonal availability and differences in size between some of the observed species (Table 1), the following work hypothesis were established: **1-** small species form bigger groups than large species (Gilardi & Munn, 1998). A second hypothesis was based on the premise that the more food available, the bigger the groups formed by psittacids (Chapman *et al.*, 1989): **2-** for each species, groups were bigger in the altitudinal range where supposedly more fruits were available at the time of the census (higher areas). Taking into account competition for a resource (nesting site, food…) between similar size species, a third hypothesis was developed: **3-** similar size species are segregated in space.

The aim of this study is obtaining an approach to the status of the populations inhabiting the Paranapiacaba forest fragment. From the hypothesis quoted above, habitat use and group size variation are analysed for each species. Relative abundance and minimum density estimates are compared with those from other areas. Importance of the Paranapiacaba forest fragment for the conservation of threatened species is discussed.

MATERIAL AND METHODS

The 352.4 km of line transects covered were considered to estimate psittacid populations in the Paranapiacaba fragment. Data were collected following the census general methodology (see chapter 4).

Among all the frugivorous vertebrates censused in this study, psittacids are the most complex ones when it comes to make population estimates. Although they use the upper strata in the forest, their colours make them almost cryptic in the vegetation and, unlike guans and toucans, parrots tend to fly a lot and they do so at a considerable height. Therefore, 62.3% of the sightings corresponded to groups that were flying and, often, animals could be heard but not seen until a hole opened in the canopy. This fact, together with the lack of experience of some of the observers in counting birds that are usually on flight, meant that the perpendicular distance associated to most sightings did not correspond to that of the spot where animals were initially detected, which means that one of the premises established in the Distance Sampling methodology (Buckland *et al.*, 1993) was violated. Data were therefore analysed following a method that it is not so accurate as a mathematical tool to estimate densities but that it is more reliable when making population estimates. Flying individuals were not discarded because it was impossible to tell whether they were flying across the census line or they were reacting to the presence of the observers (see Buckland *et al.*, 1993).

Density estimates were not achieved through Distance Sampling methodology because establishing a reliable effective strip width turned out to be impossible. Minimum density (in individuals per km^2) was calculated for all the observed species except for *T. malachitacea*, due to its low number of sightings. Calculations were made using a modification of Kelker's formula (cf. Glanz, 1982; Telleria, 1986): $D = n / (2 \cdot L \cdot P)$; where "D" is density, "n" is the number of individuals, "L" is the total covered distance and "P" is the maximum perpendicular distance to the transect of all the observations for each species. This formula considers maximum distance to be the effective strip width, since it does not take into account the individuals that were not sighted and that potentially were within the census strip. When coming across a flying group or a group alighting as a response to the observers, it is important to follow their flight path to avoid counting them more than once and overestimating the population (Buckland, per. comm., 1998).

Two of the sightings of *P. frontalis* and one of the sightings of *F. crassirostris* were considered as outliers and they were discarded from calculations. In *P. pileata*, minimum density was calculated considering those transects placed at an average altitude above 400 m, since that is the potential occupation area of this species in the study area (see Discussion).

For each species, encounter rates (groups per linear kilometre) and group sizes with their associated standard error were calculated using the DISTANCE 2.02 suit (Laake *et al.*, 1993). Encounter rates were used as an estimator of variation in population size (see Guix *et al.*, 2000; Hochachka *et al.*, 2000).

In order to analyse relationships between species (in terms of abundances and group size) and food availability, two altitudinal strata were defined according to the presence/absence of ripe fruits. The presence of ripe fruits of palmito palm (*Euterpe edulis*, Arecaceae) was considered as indicator of general fruition of the plant species distributed along the altitudinal gradient. Therefore, the lower altitudinal stratum included those transects placed at an average height of between 60 and 400 m and it was considered as "not fructified" (that is bearing no fruits or undeveloped fruits). The upper altitudinal stratum included those transects placed at an average height of between 500 and 1030 m and it was considered as "fructified" (that is bearing ripe fruits). To avoid overlapping, those transects placed at an intermediate average height (between 400 and 500 m) were discarded.

Following the criterion indicated above, minimum density estimates were obtained for each altitudinal stratum in species with the same maximum distance. Encounter rates were also calculated in each altitudinal stratum for each species (except for *P. pileata* and *T. malachitacea*). They were compared using 95% confidence intervals obtained with the DISTANCE 2.02 suit (see Buckland *et al.*, 1993 for details) in order to check whether overlapping existed in terms of relative abundance.

Only species occurring across the whole altitudinal gradient at the time of the census (60 to 1030 m) were considered to test hypothesis. These species were *F. crassirostris* (size category A), *B. tirica* (categ. B), *P. frontalis* (categ. B) and *P. maximiliani* (categ. C).

Hypothesis num. 1 was tested through a correlation between weight and group size in each species (log. mass / log. average group size).

Comparing intraspecific group sizes between the upper and lower altitudinal strata tested hypothesis num. 2.

Hypothesis num. 3 was only tested in species sharing the same size category (*P. frontalis* and *B. tirica*). It was checked whether overlapping existed between encounter rates 95% confidence intervals at each altitudinal stratum. It was also tested whether these two species use the same forest space by comparing height in percentage ((group height/forest height)*100) in each sighting, taking into account perched groups only.

RESULTS

During the census, a total of 817 individuals belonging to six species were counted in 265 sightings: *P. frontalis* (n = 98 encounters), *B. tirica* (n = 87), *P. maximiliani* (n = 47), *F. crassirostris* (n = 20), *P. pileata* (n = 11) and *T. malachitacea* (n = 2). Animals were sighted either perched or while flying, in the forest or up to 50 m above the canopy, as single individuals or in groups of the same species.

Three of the species, *B. tirica*, *P. frontalis* and *P. maximiliani* were sighted between 60 and 825 m of altitude. *F. crassirostris* was detected between 60 and 810 m of height while *P. pileatta* and *T. malachitacea* were seen between 570 and 810 m and between 60 and 480 m respectively.

Table 1. Results from 352.4 km covered in 127 transects for *Forpus crassirostris, Brotogeris tirica*, *Pyrrhura frontalis*, *Pionus maximiliani* and *Pionopsitta pileata*. Only transects at or above 400 m of altitude (88 transects; 273 km) were included in the calculations of encounter rate and minimum density of *P. pileata* (see Discussion). Standard errors are indicated. Distances are given in metres.

	Forpus crassirostris 30 g	*Brotogeris tirica* 63 g	*Pyrrhura frontalis* 72-94 g	*Pionus maximiliani* 233-293 g	*Pionopsitta pileata* 98-120 g
Number of groups	20	87	98	47	11
Number of individuals	76	297	304	115	22
Mean group size (range)	3.8 ± 0.96 (1-20)	3.41 ± 0.36 (1-20)	3.15 ± 0.24 (1-12)	2.45 ± 0.25 (1-9)	2 ± 0.3 (1-4)
Maximum observation distance	35	40	49	63	45
Mean observation distance	8 ± 3	9 ± 1	10 ± 1	14 ± 3	9 ± 4
Median observation distance	0.5	7	5	4	5
Encounter rate (groups/km)	0.06 ± 0.02	0.25 ± 0.05	0.28 ± 0.04	0.13 ± 0.03	0.055 ± 0.034
Minimum density (groups/km^2)	0.81	3.09	2.84	1.06	0.448
Minimum density (ind/km^2)	3.08	10.53	8.80	2.59	0.895
Estimated min. population size (ind/1000 km^2)	3080	10530	8800	2590	895

Table 2. Minimum density, encounter rate and group size results for *Forpus crassirostris* (Fc), *Brotogeris tirica* (Bt), *Pyrrhura frontalis* (Pf) and *Pionus maximiliani* (Pm) in the lower (60 - 400 m) and upper (500 - 1030 m) altitudinal strata. A total of 80.84 km were covered in the lower stratum and 193.2 km were covered in the upper one. Standard errors are indicated. a: Non-overlapping intervals. b,c: Density was not calculated because maximum distances were different and therefore they could not be compared.

	Fc	Bt	Pf	Pm
lower altitudinal stratum (60-400m)				
Individuals	39	183	45	38
maximum distance (metres)	15	40	30	50
encounter rate (groups/km)	0.111 ± 0.043	0.668[a] ± 0.168	0.186 ± 0.047	0.186 ± 0.072
group size	4.33 ± 2.01	3.39 ± 0.49	3.00 ± 0.55	2.53 ± 0.35
minimum density (individuals/km^2)	-[b]	28.3	-[c]	4.7
upper altitudinal stratum (500-1030m)				
Individuals	16	58	211	50
maximum distance (metres)	30	40	49	51
encounter rate (groups/km)	0.031 ± 0.014	0.088[a] ± 0.02	0.336 ± 0.073	0.093 ± 0.021
group size	2.66 ± 0.33	3.41 ± 0.8	3.25 ± 0.31	2.78 ± 0.53
minimum density (individuals/km^2)	-[b]	3.75	-[c]	2.54

Species most frequently detected were *P. frontalis* (corresponding to 37% of the sightings) *B. tirica* (32.8%) and *P. maximiliani* (17.7%). *F. crassirostris* was detected in 7.6 % of the sightings while *P. pileata* and *T. malachitacea* represented only 4.15% and 0.75% of the sightings respectively.

All species were seen in mature forests and old secondary forests excepting *T. malachitacea* that was sighted in mature forests only.

Table 1 shows minimum density estimates. *B. tirica* and *P. frontalis* have the highest densities with very similar values. *P. maximiliani* and *F. crassirostris* also show similar density values, while the value in *P. pileata* is quite lower. Large size species were sighted at bigger distances than small size ones.

Only three *T. malachitacea* individuals were sighted (encounter rate 0.0057 ± 0.0027 individuals/km ± se). Nine *A. vinacea* individuals (flying above the forest in groups of between one and three individuals) and four *T. melanonota* individuals (two groups of two individuals perched in the canopy) were sighted while the census was not being performed.

Minimum density estimates and encounter rates in each altitudinal stratum are shown in Table 2. Minimum density value in *B. tirica* was seven and a half times bigger in the lower than in the upper altitudinal stratum. *B. tirica* is the only species in which encounter rates 95% confidence intervals did not overlap between strata (Figure 1). It showed a clear preference for the lower altitudinal stratum at this time of the year.

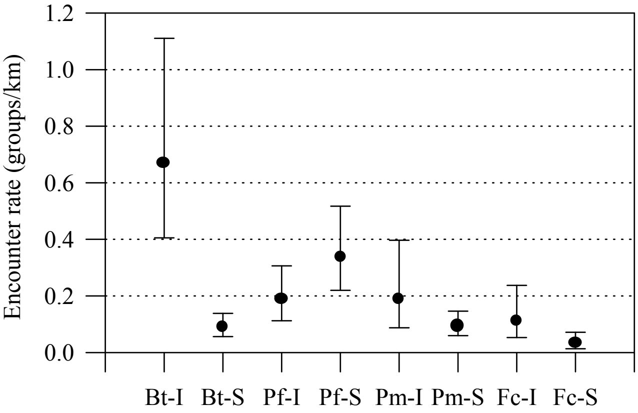
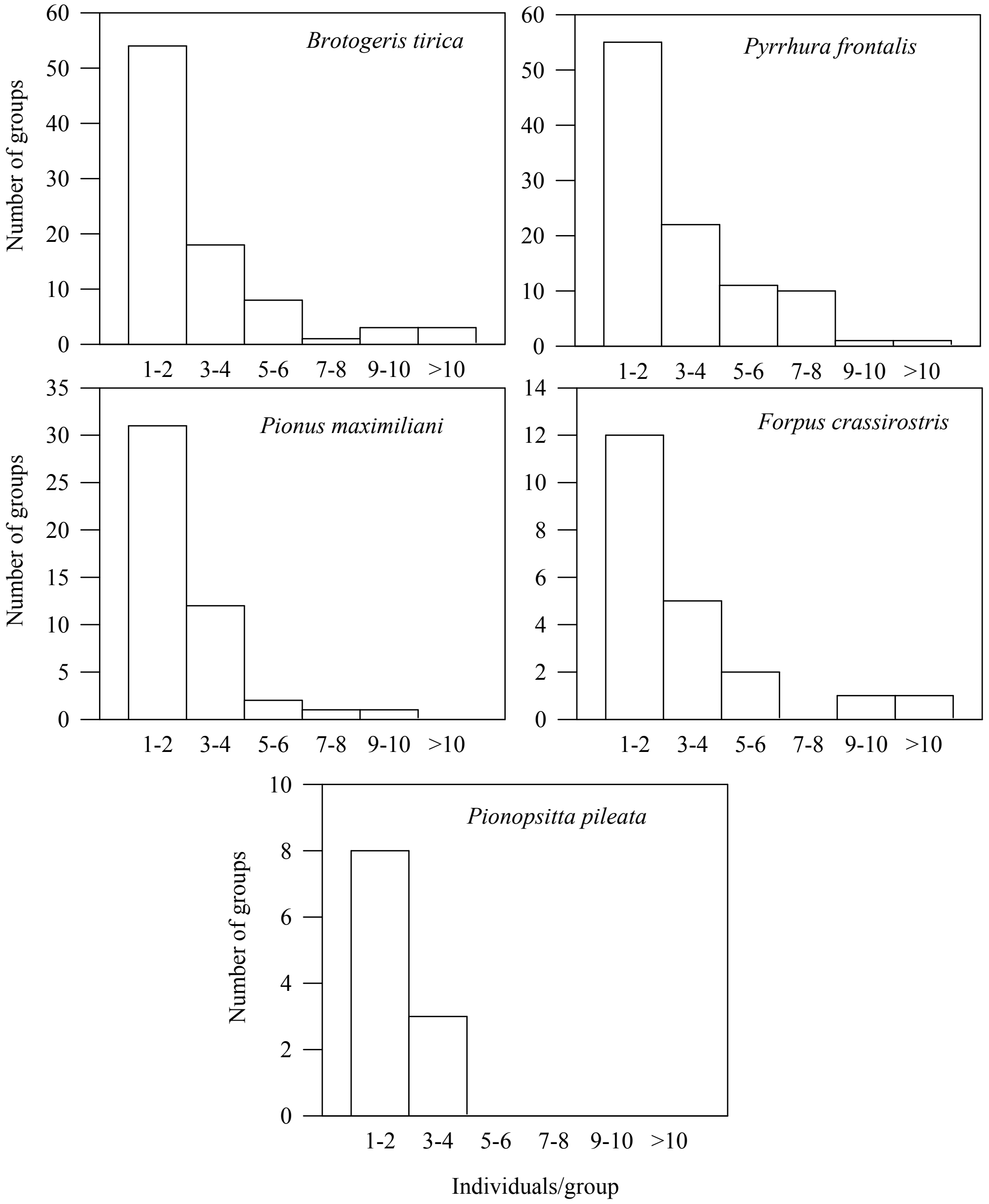


Figure 1. Encounter rates (groups per lineal km) with 95% confidence intervals against altitude for *Brotogeris tirica* (Bt), *Pyrrhura frontalis* (Pf), *Pionus maximiliani* (Pm) and *Forpus crassirostris* (Fc). I = stratum between 60 and 400 metres; S = stratum between 500 and 1030 metres.

In all species, most groups consisted of between one and two individuals (Figure 2). There was a statistically significant negative correlation between body weight and group size (Pearson's correlation $R^2 = 0.9981$; $P = 0.001$) (Figure 3). Maximum group sizes were bigger in small size species.

Group sizes were not significantly different between strata in any of the species (*F. crassirostris*, U-Mann-Whitney = 21, P = 0.425; *B. tirica*, U = 443, P = 0.818; *P. frontalis*, U = 485, P = 0.975; *P. maximiliani*, U = 127, P = 0.765). Differences were small as shown in Table 2.

Figure 2. Group size distribution for *Brotogeris tirica*, *Pyrrhura frontalis*, *Pionus maximiliani, Forpus crassirostris* and *Pionopsitta pileata*. Groups both flying and perched have been considered.



No overlapping was detected between the encounter rates 95% confidence intervals of *B. tirica* and *P. frontalis* in either altitudinal stratum (Figure 1). This suggests that, at this time of the year, these two species show altitudinal segregation. *B. tirica* occupies preferably the lower altitudinal stratum and *P. frontalis* tends to use the upper one (see Figure 4). No significant differences were found between this two species regarding preferences in the use of vegetation strata (U-Mann-Whitney = 512; P = 0.237), which suggests that their spatial distribution overlaps. Both species prefer the upper forest level (Figure 5).

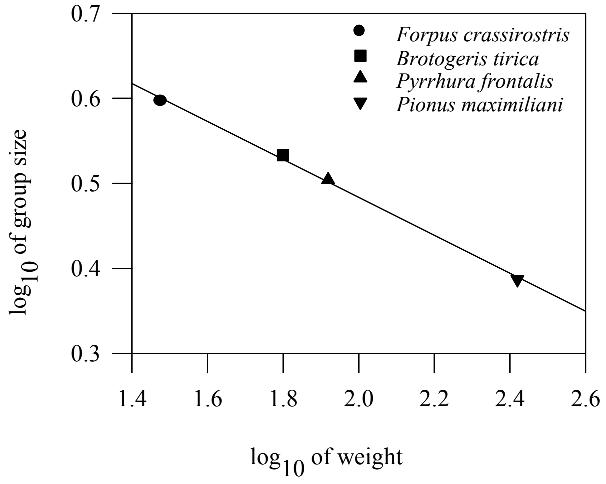


Figure 3. Logarithmic correlation between average weight and average group size for *Brotogeris tirica*, *Pyrrhura frontalis*, *Pionus maximiliani* and *Forpus crassirostris*.

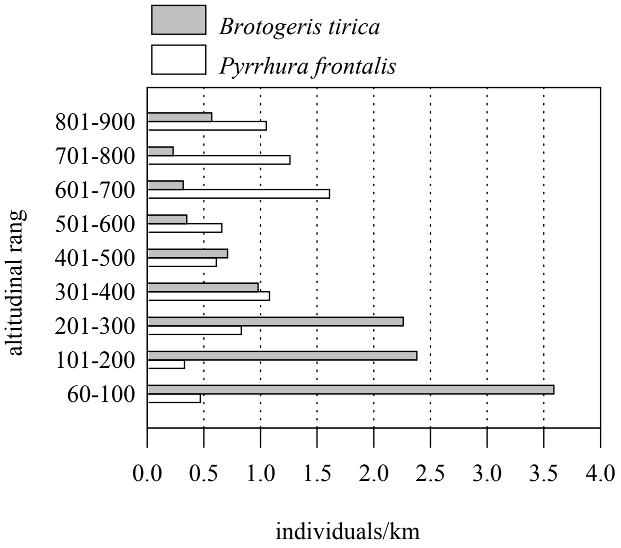


Figure 4. Encounter rate distribution across altitude ranges for *Brotogeris tirica* and *Pyrrhura frontalis*. Sampling effort has been weighted for each altitude range.

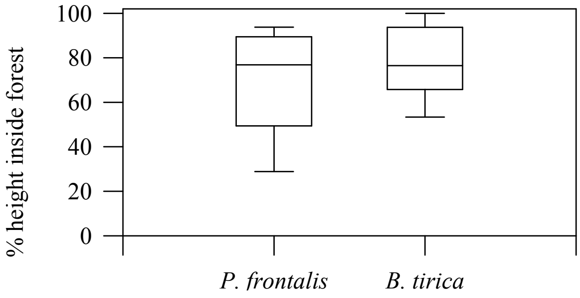


Figure 5. Distribution of perched groups sighted at different heights (in percentages of the total forest height in the area) for *Pyrrhura frontalis* and *Brotogeris tirica*.

DISCUSSION

Quantifying populations of parrot and parakeet species in tropical forests is not an easy task. They are medium size or small size species, they generally have cryptic colourings that make them difficult to spot and they can usually go undetected in dense vegetation. Moreover, most species tend to move a lot, flying over large distances, which makes the risk to count them twice quite high, especially in the most abundant species (Galetti & Aleixo, 1998). Nevertheless, and among all available techniques, line transects seem to be the ones yielding best results for these species relative to the invested sampling effort (Casagrande & Beissinger, 1997; Pizo *et al.*, 1995; Guix *et al.*, 1999). Line transects are also the best option for low density (Marsden, 1999). In the current study, density estimates could not be achieved through Distance Sampling methodology due to several factors. For instance, many of the groups were sighted at a very short distance from the transect line, which meant that the Effective Strip Widths (statistically inferred through Distance Sampling methodology) were very narrow. This complicates the calculation of the detection function for each species based on the distribution of perpendicular distances to the transect line (cf. Buckland *et al.*, 1993).

Excluding *a posteriori* those groups that are sighted while flying (those that fly into the census band but not those that alight as a response to the observer) would be a possibility to approach psittacid population estimates. This way, a calculation of minimum density based on perched groups only could be corrected afterwards through the addition of a percentage of groups and individuals spotted while flying (i.e.: see Marsden, 1999). The fact that factors affecting the percentage of flying groups to be considered are very variable between species (mobility, species size…) makes it very difficult to establish the real percentage in each species *a posteriori*.

On the other hand, excluding flying groups would bring down considerably the number of sighting. Since the number of sightings in threatened species tends to be very low, those exclusions would make it impossible to perform population estimates.

When excluding flying groups, a third point to take into account is the fact that flying groups tend to be larger than perched groups (i.e.: in the current study, groups sighted while flying were 8-12% larger than perched groups in *B. tirica*, *P. maximiliani* and *F. crassirostris*, but 23%

smaller in *P. frontalis*). This is probably because it is easier counting against the sky all the psittacid individuals in a flying group than it is counting all the individuals disguised among the trees and leaves in perched groups. This could be an important source of bias since most density estimates (among the ones used by Distance Sampling) use the average group size and its associated standard error. When using small groups only, without the addition of a group size correcting factor, the population (underestimated already by the exclusion of flying groups) would be underestimated again.

Since no previous studies had been performed in the whole of the altitudinal gradient of the study area, minimum density estimates obtained allow a first approach to the minimum densities of some species and assess their population status in the whole of the Paranapiacaba forest fragment. Galetti & Aleixo (1998) show encounter rates data using line transects for *B. tirica*, *P. frontalis* and *T. malachitacea* in the Saibadela area (60-300m.), within the study area. Values achieved are (in contacts-species/hour): *B. tirica* (2.42), *P. frontalis* (0.24), *T. malachitacea* (0.28). Nevertheless, in a previous work, Galetti (1997) gives different values for the same area in the same period: *B. tirica* (2.30), *P. frontalis* (0.22), *T. malachitacea* (0.27), *P. maximiliani* (0.56), *F. crassirostris* (0.16) and *P. pileata* (0.07). When interpreting his results, though, it must be taken into account that: **A**- only part of the altitudinal gradient in the Serra de Paranapiacaba was sampled, that is, an area placed between 60 m and 300 m in height dominated by a single type of forest (lowland Atlantic rainforest). The fact that a different type of forest (hillside Atlantic rainforest) dominates higher areas makes it very difficult to compare data, since densities could be affected by differences in vegetation. On the other hand, some species tend to occupy high altitude ranges (i.e.: *P. pileata*), while some others prefer low altitude ranges (i.e.: *T. malachitacea*) (Guix, 1990; Sick, 1993). This way, density estimates attained in a single altitudinal stratum could suggest that the global population is much higher or much lower than the real one depending on the species considered. **B**- Sampling effort was very large (up to three repetitions in each transect) for a relatively small area with a network of very close paths. **C**- the sampling period was very long; altitudinal distribution of the populations probably varied over that time. **D**- encounters refer to those animals that were sighted but also those that were heard.

The fact that psittacids move and vocalise a lot suggests that an overestimate could exist in the data yielded by these authors, which makes them hardly comparable. Although methods used Galetti (1997) and Galetti & Aleixo (1998) and ours are not the same, results agree in showing that, in low altitude areas in the Paranapiacaba forest fragment, encounter rates in *B. tirica* are clearly higher than those found in *P. frontalis* and *P. maximiliani*.

Hönfling & Lencioni (1992) showed encounter rate data for all species censused in the current study except for *P. pileata*, in an Atlantic rainforest area in the Salesópolis region (45º 51' W, 23º 31' S; altitude range: 550-1200 m), in the State of São Paulo. Values obtained were (individuals/hour): *B. tirica* (0.347); *P. frontalis* (1.055); *P. maximiliani* (0.347); *F. crassirostris* (0.271) and *T. malachitacea* (0.063). Since that study was performed between October and December 1988 over an altitudinal range that coincides only with the upper altitudinal stratum of the current work (see Material and Methods), we face again a hardly comparable situation.

Nevertheless, encounter rates obtained in the current study (expressed as individuals/km) in the upper altitudinal stratum are very similar to those attained by Hönfling & Lencioni (1992).

Before the current study, the only psittacid density data in an Atlantic Rainforest area correspond to a census performed in the São Sebastião Island (State of São Paulo; 23^0 50’ S, 45^0 20’ W; altitude range: 0-1379 m) (Guix *et al.*, 1999). Premises and sampling method applied in the current study were the same as the ones applied in the census of the São Sebastião Island, where the sampled altitude range was 0-900 m.

Pionus maximiliani density in the São Sebastião Island (minimum density: 6.54 ind/km^2) is two and a half times bigger than the one obtained in the current study. Due to the lack of available works on population estimates, it is difficult to decide whether the density of *P. maximiliani* is low in the Paranapiacaba fragment of very high in the São Sebastião Island. Estimated densities for *B. tirica* and *P. frontalis* in the Paranapiacaba fragment are similar to those obtained in the São Sebastião Island (7.01 ind/km^2 and 5.69 ind/km^2 respectively). In *F. crassirostris* and *P. pileatta*, only encounter rate data can be compared since no density estimates were performed for these species in the São Sebastião Island. *F. crassirostris* presents a very similar encounter rate (0.059 ± 0.029 groups/km ± se) while *P. pileatta* appears to be scarcer (0.0084 ± 0.0071 groups/km ± se). *T. malachitacea* is not quoted in reference works on the São Sebastião Island (cf. Olmos, 1996 and references therein).

Abundance distribution

One of the predictions that could be made regarding the distribution in space of different syntopic species belonging to the same family would be that their overlapping in the use of vegetation strata should force them to adopt a horizontal and altitudinal division. In fact, analyses of abundances in *B. tirica* and *P. frontalis* (two species with a similar body weight) along the altitudinal gradient in that time of the year show a tendency to segregation. Nevertheless, this sort of abundance distribution has not been observed in *P. maximiliani* and *F. crassirostris*.

It must be taken into account also that trophic strategy in psittacids is different from that one in other censused species. While ramphastids and cracids (that tend to split the vegetation strata) have specialised towards digesting ripe fruit flesh, psittacids feed on ripe fruit flesh as well as unripe fruit flesh, seeds or dry fruits (Guix, 1995). This wider or more generalist trophic strategy probably allows different species to overlap in the highest forest strata (canopy and emergent trees), which is the most productive one.

Group size

Fruit distribution in the forest influences variation of group sizes in psittacids (Chapman *et al.*, 1989). Pizo *et al.* (1995) carried out a study, with the same species, on group sizes in areas above 700 m in the Paranapiacaba fragment all through the year. They found significant interseasonal variations in *B. tirica* and *P. frontalis* group sizes. In the current study, there were no significant interspecific differences of group sizes, although the whole of the altitudinal gradient was sampled, including areas where fruits were abundant and areas where they were scarce.

When interpreting results, the time of the year when the study was performed must be taken into account. Most species start their reproductive season in September (Forshaw, 1989; Collar, 1997), when temperatures start raising. Pairs tend to form and group sizes diminish (cf. Krebs & Davis, 1993; Chapman *et al.*, 1989). Data on psittacid group sizes found in the August and September 1998 census can be considered as representative from the beginning of the reproductive season in the study area (see also comments on group sizes at the beginning of Discussion). At this time of the year, reproductive couples segregate from the group to search and defend holes where they nest, so it is probably the time when psittacid groups are smallest. Although between October and December group sizes might be even smaller (due to the incubation period of the female and the high number of "lonely" males around the nests), these group sizes can not be used to estimate densities because they would lead to an underestimation of the populations. Moreover, it is also the beginning of the rainy season in the study area, which makes it more difficult to detect groups in the forest. Carrying out censuses between October and December is not advisable at all because estimates might be extremely biased.

Assessment of the conservation status of the least common species in the Serra de Paranapiacaba

Triclaria malachitacea

Along 352.4 km of line transects performed across the altitudinal gradient of the Serra de Paranapiacaba, only three *T. malachitacea* individuals were contacted in the 1998 census, with an encounter rate of 0.57 ± 0.27 groups per 100 lineal kilometres (0.85 ± 0.49 ind/100km ± se). In 1991, along 110 lineal kilometres covered in well preserved areas of the P.E. Intervales, the encounter rate was higher (6.4 ind/100 km).

The distribution area of this parrot, which is considered as *vulnerable* and CITES II (Collar *et al.*, 1994; CITES, 1998; see UNEP-WCMC, 2001), comprises the coastal areas of southeastern and southern Brazil (from the State of Bahia to the northern limit of the State of Rio Grande do Sul), in regions covered by Atlantic rainforest. It has been quoted twice in subtropical forests of the Misiones region in Argentina (Collar, 1997).

Although it gets sometimes into highest areas of the Serra do Mar, it seems to prefer the lowlands up to 500 m to inhabit and nest. In the Paranapiacaba fragment, this altitude range corresponds to the area where the lowland and hillside Atlantic rainforests (*sensu* Hueck, 1972a, b) overlap.

In the P.E. Intervales, most *T. malachitacea* contacts were made at an altitude ranging between 60 and 400 m (Willis & Oniki, 1981; Guix, 1990; Guix *et al.*, 1992; Galetti & Aleixo, 1998) where, generally, forests were well preserved. Nevertheless, during the 1990's, forests at this altitude range have suffered more raids by illegal hunters and furtive collectors of palmito (*E. edulis*) than forests placed at higher altitudes (K. Pisciotta and Ocimar Bim, pers. comm.) and therefore the species could be affected.

Since it is a popular species in illegal bird trade (e.g. in the Caxias market, RJ) and psittacid breeders appreciate it, it is quite probable that illegal practices such as the collection of chicks from nests and adult hunting using sticky resins are being performed in the areas of Saibadela, Guapiruvu and Quilombo.

It must be pointed out that, among all the psittacid species occurring in the P.E. Intervales, *T. malachitacea* is the one most often detected in the subcanopy (J.C. Guix, pers. obs.). Although it is quite difficult to see inside the Atlantic rainforest, males can be detected by their peculiar vocalisations (squeaks or whistlings that remind of those made by some *Turdus* species in the area) especially during the pre-reproductive season (between July and October).

Considering the few forest areas in which the species has been detected in the last 20 years (Willis & Oniki, 1981; Scott & Brooke, 1985; Collar, 1997) and the low encounter rates found in the Paranapiacaba fragment (one of the biggest and best preserved fragment of the Brazilian Atlantic rainforest), it is quite possible that this species is in a worse situation of population regression than it was initially thought.

Pionopsitta pileata

The Red-capped parrot (*P. pileata*) is a small size psittacid but far more conspicuous than *T. malachitacea* and the two species from the genus *Touit* that are found in the study area. It is common seeing groups flying over the canopy and perching every now and then at the top of emerging trees. Its distribution area comprises the mountain ranges covered by Atlantic rainforest and the highlands covered by subtropical forests in inland SE Brazil (Stotz *et al.*, 1996), from the State of Bahia to the State of Misiones (Argentina) (Cracraft & Prum, 1988; Collar, 1997).

Although *P. pileata* is more widely distributed across SE Brazil than *T. malachitacea* and *Touit* sp. and probably more common and abundant in natural protected areas, not much information has been published about its natural history. Although it has lost a lot of habitat surface along its distribution, it is catalogued as *Lower risk/Near threatened* and CITES I (Collar et al., 1994; CITES, 1998; see UNEP-WCMC, 2001), and it is considered by some authors as quite abundant in the State of Paraná (Sick, 1985, 1993; Collar, 1997).

Table 3. Encounter rates for *Pionopsitta pileata* (individuals per lineal km) in 1991 and 1998 considering the whole of the altitudinal gradient (between 60 - 1030 m) and the highest areas only (between 400 - 1030 m)

Year	1991	1991	1998	1998
Areas	whole gradient	highest areas	whole gradient	highest areas
Sampling effort	110 km	83 km	352.4 km	273 km
Encounter rate	0.055	0.085	0.072	0.11

In 1991 and 1998, this species was only sighted in an altitude range between 400 and 980 m, which would confirm its preference for mountain areas. This would imply that the lower areas in the regions of Saibadela and Alecrim (placed between 60 and 300 m) could not be considered *a priori* as potential distribution areas. Therefore, the encounter rate that would be closest to the real one would be the one estimated in the altitudinal stratum ranging between 400 and 1030 m (0.11 ± 0.068 individuals/lineal km, see Table 3).

Touit spp.

The *Touit* species are small and not very conspicuous (neither in their colouring nor in their vocalisations) and they are difficult to detect in areas where the forest is tall and dense. This makes them difficult to identify at a specific level. In the study area, specimens belonging to this genus have always been observed between 60 and 400 m in (Guix *et al.*, 1992). Aleixo & Galletti (1997), based on vocalisations, concluded that the Saibadela area is inhabited by *T. melanonota* and they do not discard the possibility of the Golden-tailed parrotlet (*Touit surda*) occurring there too. Along the transect covered between Base São Pedro and Base Guapiruvu in October 1991, *Touit* specimens were observed twice (once next to the Rio do Tombo at 300 m of altitude and once by the Rio Etá at 200 m of altitude; Guix *et al.*, 1992). A yellow-headed specimen was sighted in the São Pedro valley, which suggests that it might have been *T. surda*. Although both species were detected in the Ilha do Cardoso (cf. Martuscelli *in litt*, *in* Collar *et al.*, 1992) and the distribution area of *T. surda* includes the Serra de Paranapiacaba, the existence of this species in the study area should still be confirmed.

Touit melanonota and *T. surda* are endemic to Eastern Brazilian forests, mostly inhabiting areas covered by Atlantic rainforest (sensu Hueck, 1972 a,b). Both species are catalogued as *Endangered* and CITES II (Collar et al., 1994; CITES, 1998; see UNEP-WCMC, 2001). *T. melanonota* has a more restricted potential distribution area than *T. surda* and the conservation status of its populations is probably more delicate than that of *T. surda* (Collar, 1997). The Paranapiacaba fragment is the largest protected area inhabited by this species and it is placed almost in the middle of its potential distribution area. Possibly, the future of this species in the next 50 years is closely linked to the future of the Paranapiacaba fragment.

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Chapter 9

DENSITY ESTIMATES, GROUP SIZE AND HABITAT USE OF MONKEYS (MAMMALS: CEBIDAE)

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ABSTRACT. A line transect survey of primates was performed in the largest fragment (ca. 1400 km^2) of the Atlantic rainforest of Serra de Paranapiacaba, Southeastern Brazil. the Brown capuchin monkey (*Cebus apella nigritus*) was the most common species found in the area. Detection function obtained for pooled encounters from a similar survey in August 1994 (12 encounters) and the current survey in August 1998 (20 encounters) estimated densities of *C. apella* of 3.52 ± 1.56 (mean ± standard error) and 5.31 ± 2.05 individuals per km^2 for each year respectively. Nine groups of the Brown howler monkey (*Alouatta guariba clamitans*) and eight of the Woolly spider monkey (*Brachyteles arachnoides arachnoides*) were also recorded in 1998, with a preliminary density estimate of 0.79 ± 0.40 and 2.33 ± 1.37 individuals per km^2 in 1998, respectively. *A. guariba* and *B. arachnoides* used almost exclusively the highest forest strata (canopy and emergent trees) while *C. apella* used mainly the subcanopy but also the rest of strata. Mean group size of *C. apella*, *A. guariba* and *B. arachnoides* differed significantly and were 4.3 ± 0.6, 1.8 ± 0.4 and 7 ± 2.1 individuals, respectively. Density estimates for these species in other fragments of Atlantic rainforest are reviewed, showing that primate densities in Paranapiacaba are among the lowest reported primate densities. It is suggested that the higher densities reported for isolated primate populations in small forest patches (<50 km^2), is related to the absence of main primate predators, the ecological plasticity of some primate species and the density compensation phenomenon. In contrast, local extinction in many small patches is probably related to hunting pressure. We suggest that the conservation strategy of the Atlantic rainforest Cebidae populations should prioritise the effective protection of the largest remnant forest fragments from illegal hunting and deforestation, instead of translocation of individuals or captive breeding programs to introduce monkeys in small forest fragments vulnerable to hunting and of uncertain future.

KEY WORDS. Brazilian Atlantic rainforest, Cebidae, census, density estimates, conservation, forest fragmentation, monkey survey.

INTRODUCTION

Deforestation of the Brazilian Atlantic rainforest has led to the prediction of imminent extinctions unless immediate conservation actions are taken (Brooks & Balmford, 1996). Generally, vertebrate species with large body size and large spatial requirements, such as primates, are expected to disappear when forest is reduced to only small fragments (Redford & Robinson, 1991; Chiarello, 1999). Habitat loss and fragmentation has frequently led to a significant decrease in primate densities and local extinctions (Estrada & Coates-Estrada, 1996). Forest fragmentation

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

and isolation may result in the confinement of a few primate groups per fragment, limiting the genetic flow between populations below the minimum size at which inbreeding occurs (Camara & Mittermeier, 1984). Forest fragmentation also facilitates access to hunters, which may lead to the extermination or depletion of large and medium-size primates by hunting (Robinson, 1996).

However, forest fragmentation may also favour density increase of some primate species by competitive release of the remaining species if potential competitors are depleted or extirpated by e.g. hunters (Peres & Dolman, 2000). Moreover, fragmentation may simplify the natural composition of top predators (e.g. Thiollay, 1993; Bender *et al.*, 1998), which may in turn increase primate densities (Wright *et al.*, 1994).

The Paranapiacaba fragment comprise one of the largest patches of Atlantic rainforest (*sensu stricto* Hueck, 1972). At least three species of primates are known to occur in the region: the Woolly spider monkey (*Brachyteles arachnoides arachnoides*), the Brown capuchin monkey (*Cebus apella nigritus*) and the Brown howler monkey (*Alouatta guariba clamitans*) (González-Solís *et al.*, 1996). *B. arachnoides* and *A. guariba* are endemic to the Atlantic forests (*sensu lato*) and they are considered to be threatened of extinction mainly due to habitat loss (Mittermeier *et al.*, 1982; UNEP-WCMC, 2001). Concerns over the conservation of primates in the Atlantic forest have led to proposals for the protection of areas of special relevance as well as translocation of individuals and captive breeding programs (e.g. Coles & Bonalume, 1990; Mendes, 1994; Pissinatti *et al.*, 1994).

Table 1. Abundances and group size of the Brown howler monkey *A. guariba*, the Brown capuchin monkey *C. apella* and the Woolly spider monkey *B. arachnoides* reported for Eastern Brazilian forest patches, sorted by size of the fragment. Ref = Reference number. ps = present study. Ind = Individuals. Enc = Encounter.
* indicates estimated values calculated from the original data. p: present, p nc: present but not confirmed, e or a: extinct or absent.
Site codes:
C.G.B.R. = Córrego Grande Biological Reserve; C.V.B.R. = Córrego do Veado Biological Reserve; E.B.C.= Estação Biológica de Caratinga, Fazenda Montes Claros, Minas Gerais; F.B.R.= Fazenda Barreiro Rico, Município de Anhembi, São Paulo; F.E. = Fazenda Esmeralda, Município de Rio Casca, Minas Gerais; F.N.T.B.= Floresta Nacional de Tres Barras, Santa Catarina; LAG. = Lageadinho, São Paulo; L.F.R. = Linhares Forest Reserve; M7/317=M7/317, Espírito Santo; Paranap. = Old secondary and mature forests in Paranapiacaba fragment (present study); P.E.C.= Parque Estadual da Cantareira, São Paulo; P.E.C.B.= Parque Estadual Carlos Botelho, São Paulo; P.E.I.= Parque Estadual Intervales, São Paulo; P.E.R.D.= Parque Estadual do Rio Doce, Minas Gerais; Putiri=Putiri, Espírito Santo; R.B.A.R. = Reserva Biológica Augusto Ruschi, Espírito Santo; R.C.V.R.D. = Reserva da Companhia Valle do Rio Doce, Espírito Santo; R.S.G.= Reserva de Santa Genebra, São Paulo; S.B.R.= Sooretama Biological Reserve, Espírito Santo; UNA = Reserva Biológica do Una, Bahia.
Reference codes:
1: Chiarello, 1999; 2: Chiarello, 1995; 3: Pinto *et al.* 1993; 4: Lemos de Sá, 1988; 5: Milton & Lucca, 1984; 6: Paccagnella, 1991; 7: Petroni, 1993; 8: Petroni, 1998; 9: Hirsch, 1995; 10: Torres de Assumpção, 1983; 11: Chiarello, 1993; 12: Mendes, 1985; 13: Perez, 1997; 14: Silva, 1981; 15: Rylands, 1982 (in Pinto,1993); 16: Mendes, 1989; 17: Strier, 1992; 18: Strier, 1987; 19: Stallings & Robinson, 1991; 20: Chiarello, 2000; ps: present study.

Species/site	Area	Primate abundance			Group size	Ref
	km^2	Density Groups/km^2	Density Ind/km^2 (CI 95%)	Enc rate Groups/100km		
A. guariba						
LAG.	0.5		98.0		6.0-12.0	10
Putiri	2.1			0 (e or a)		1
R.S.G.	2.5		177.0		4.9	11
M7/317	2.6			2		1
E.B.C.	5.7		110.0		6.8	12
E.B.C.	6.1		92.0-149.0		5.7	9
E.B.C.	8.0		117.0		6.7(3-10)	16
C.G.B.R.	15.0			0 (p nc)		1
C.V.B.R.	24.0			0 (e or a)		1
F.B.R.	32.6		14-38		6.4 (4-11)	10
R.B.A.R.	40.0	2.4	10.1		3.7 (2-6)	3
F.N.T.B.	44.6		64.0		6.0 (5-7)	13
P.E.C	56.5		80.9		5.8 (2-11)	14
R.C.V.R.D.	218.0	0 (p)				2
L.F.R.	218.0			2		1
S.B.R.	242.5			0 (p)		1
P.E.R.D.	322.1		1.8-49.0		2.8	9
Paranap.	1000.0	0.39	0.8	2.5	1.8	ps
C. apella						
UNA	1.0		10.9		15.0	15
Putiri	2.1		11.4 (10.1-13.0)	12		20,1
M7/317	2.6		21.4 (18.8-24.3)	22		20,1
E.B.C.	8.9	0.6	19.7-35.0		10.8 (3-26)	9
C.G.B.R.	15.0		6.2 (5.5-7.1)	6		20,1
C.V.B.R.	24.0		11.0 (9.7-12.5)	11		20,1
F.B.R.	32.6	0.2	25.0-50.0		11.8 (8-15)	10
R.B.A.R.	40.0	1.6	10.2		6.5 (2-13)	3
L.F.R.	218.0		25.8 (22.6-29.3)	25		20,1
R.C.V.R.D.	218.0	2.2				2
S.B.R.	242.5		15.8 (13.9-18.0)	15		20,1
P.E.R.D.	360.0				1.0-9.0	19
P.E.R.D.	361.1		58.9-63.9		4.1-5.8	9
Paranap.	1000.0	1.17	5.3	5.7	4.3	ps
B. arachnoides						
F.E.	0.4		34.1*		15.0	4
F.B.R.	4.2		10.7*		13.0-45.0	5
P.E.I.	8.6		2.8*			7
E.B.C.	8.8		5.5		25.0 (18-48)	17-18
E.B.C.	8.9		7.2-76.2		19.0 (5-33)	9
P.E.I.	12.2		3.2*			8
F.B.R.	32.6		6.0-13.0		13.0	10
R.B.A.R.	40.0	0.2	1.1		4-7	3
P.E.R.D.	361.1		0.4		13.5	9
P.E.C.B.	376.4		2.7*		11.3 (6-17)	6
Paranap.	1000.0	0.31	2.3	2.3	7.0	ps

The status of primates inhabiting most fragments of Eastern Brazilian forests, however, is poorly known. Indeed, most surveys are from small fragments of subtropical forest (with less than 1600 mm of annual rainfall) (Table 1). Data on the size of the clustered primate populations and absolute densities are required where possible to obtain a better understanding of the status of primate species in the current forest mosaic, and to provide a baseline for the study, management and conservation of the remnant patches of this ecosystem (González-Solís *et al.*, 2001).

In this study we present results from a survey of primates in the Paranapiacaba Atlantic rainforest fragment using line-transect methodology based on recording perpendicular distances of each sighting to the route (see chapter 4). Despite being one of the best preserved fragments of the Atlantic rainforest, with a high number of endemisms and species diversity, an assessment of the status of primate populations in the Paranapiacaba has not been undertaken yet. This fragment is still able to sustain important populations of primates and their natural predators (Mañosa & Pedrocchi, 1997; Guix, 1997), and thus, reported densities are supposedly close to original densities.

METHODS

Based on recording perpendicular distances from the transect to the objects, distance sampling method (see chapter 4) was used to perform density estimates. Data were processed using the DISTANCE 2.02 suite (Laake *et al.*, 1993) based on exact distances.

In order to produce a more robust estimate of the detection function to model detectability of *C. apella* we used the encounters from the present study plus the encounters from a similar study carried out in P.E. Intervales during August 1994 (González-Solís *et al.*, 1996). We assumed that detectability between years remained unchanged, since both surveys were undertaken at the same season and because there was no evidence of habitat alteration between the two surveys (the whole area was already protected before the 1994 survey).

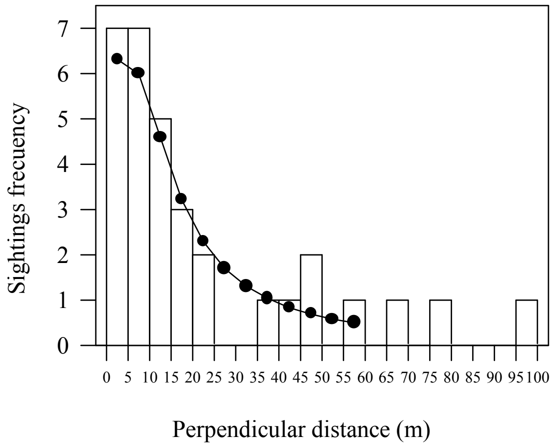

Figure 1. Distribution of sightings of 32 groups of Capuchin monkeys based on perpendicular distances to the progression line (bars), and the predicted values of the fitted Hazard-rate with cosine series expansion model (points). Data pooled from 1994 and 1998 surveys. Fitted model was truncated at 60 m perpendicular distance.
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Records from the two surveys were entered as two different subsets, a combined detection function calculated, and a density estimate derived for each survey. Occasionally, topographic characteristics of trails, hills and valleys allowed observers to detect primate groups up to 100 m from the transect, producing outliers in the distribution of perpendicular distances of sightings. Thus, outliers were ignored by truncating at 60 m, which discarded 11.1% of the encounters (Figure 1). To fit the model, Hazard-rate with cosine series expansion was selected according to Akaike´s information criteria used by the analysis program. Afterwards, we calculated the densities of capuchin monkeys for each year separately to detect possible changes in density between years. The detection function of *A. guariba* and *B. arachnoides* was calculated using the same model and truncation as for *C. apella*, using encounters only from the 1998 survey.

Data obtained in the surveys performed from 1987 to 1991 and in 1994 (González-Solís *et al*., 1996) in the Paranapiacaba fragment were used to compare encounter rates, group sizes and densities with those of the 1998 survey (Table 2). All surveys were led by the same senior researchers and the applied methodology is fully comparable, except for the 1987-91 survey when perpendicular distances where not recorded and only encounter rates could be compared.

Data on habitat use were also collected in two other Atlantic rainforest areas of the southeast region of the state of São Paulo (Figure 2) between December 1984 and October 1994: the Parque Estadual de Juréia e Itatins (24º 32' S, 47º 15' W; 79830 ha) and the Parque Estadual da Ilha do Cardoso (25º 10' S, 48º 00' W; 22500 ha). To analyse habitat use we grouped the vegetation strata into the following levels: (1) Upper level (canopy and emergent), (2) Medium level (sub-canopy), (3) Lower level (shrub and ground). Differences in habitat use between species were tested by chi-square. To avoid inclusion of each group in more than one level, we assigned each group of primates to the level at which most of individuals of the group were sighted.

Results are presented as means ± standard error except where otherwise indicated.

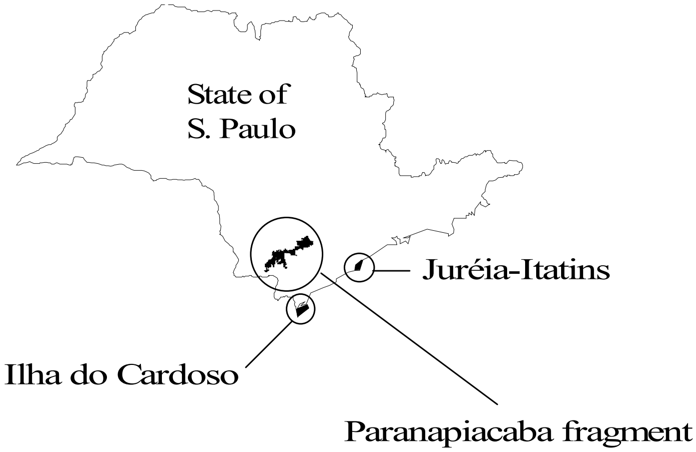

Figure 2. Location of the Parque Estadual Juréia-Itatins, Parque Estadual da Ilha do Cardoso and Paranapiacaba forest fragment.

RESULTS

Overall, 127 transects totalling 352.4 km of forest tracks and trails were surveyed, which represents about 7% of the total area. We recorded three primate species: *C. apella*, *B. arachnoides* and *A. guariba*, found between 40 and 950 m of height. Density estimates and number of sightings recorded in this study and those from 1987-91 and 1994 are shown in Table 2. *C. apella* was the most common species found in the area. Detection function estimated for pooled encounters from 1994 (12 encounters) and 1998 (20 encounters) estimated densities of 3.52 and 5.31 individuals per km^2 for each year respectively. Nine groups of *A. guariba* and eight of *B. arachnoides* were also recorded showing a density of 0.79 and 2.33 individuals per km^2 in 1998, respectively.

Table 2. Encounter rates, densities and total population (after truncation at 60 m) of primates sighted in the Paranapiacaba fragment (1000 km^2) obtained in the years 1987-91 (316 km walking transects), 1994 (291 km) and 1998 (352.4 km). Values of group size, encounter rates and densities are means ± standard error. The detection function for *C. apella* was obtained with pooled data from 1994 and 1998 surveys. Data from years 1987-91 and 1994 are from González-Solís *et al.,* 1996. N Grps = Total number of groups detected. N Ind. = Total number of individuals detected. Enc. Rate = Encounter rate. CI = Confidence Interval.

Year	nº grps	nº ind	Mean grp size	Density grps/km^2	Density ind/km^2	Enc.Rate grps/100km	Total population (CI 95%)
Cebus apella							
87-91	4	22	5.5 ± 0.3	-	-	1.3	-
94	12	58	4.8 ± 0.7	0.75 ± 0.32	3.52 ± 1.56	4.1 ± 1.2	3520 (1489-8322)
98	20	87	4.3 ± 0.6	1.17 ± 0.42	5.31 ± 2.05	5.7 ± 1.2	5310 (2528-11156)
Alouatta guariba							
87-91	1	8	8	-	-	0.3	-
94	0	0	-	-	-	0	-
98	9	16	1.8 ± 0.4	0.39 ± 0.17	0.79 ± 0.40	2.5 ± 0.8	789 (299-2083)
Brachyteles arachnoides							
87-91	2	22	11 ± 4.0	-	-	0.6	-
94	1	>4	>4	-	-	0.3	-
98	8	56	7.0 ± 2.1	0.31 ± 0.15	2.33 ± 1.37	2.3 ± 0.9	2330 (778-6976)

Table 3. Density estimates for the Capuchin monkey in 1994 depending on the detection function used. 1994=function obtained from 12 encounters in 1994 (data from González-Solís *et al*. 1996). 1994+1998= function obtained by pooling 32 encounters from 1994 and 1998 expeditions and by truncation of the perpendicular distance at 60 m. CV= Coefficient of variation. CI= Confidence Interval.

Detection function	Point estimate	%CV	95% CI
1994			
Density (Groups/ km^2)	0.37	74.3	0.09-11.53
Density (Individuals/ km^2)	1.79	75.8	0.42-7.51
Effective strip width (m)	55.8	68.5	14.0-222.5
1994+1998			
Density (Groups/ km^2)	0.75	42.2	0.33-1.67
Density (Individuals/ km^2)	3.52	45.4	1.49-8.32
Effective strip width (m)	23.0	28.5	12.9-40.8

We found different density estimates for the capuchin monkey in 1994, depending on what detection function was used, either the function obtained from 12 encounters in 1994 (González-Solís *et al.*, 1996) or the function obtained by pooling a total of 32 encounters from the 1994 and 1998 expeditions. Table 3 shows density estimates of groups and individuals and the effective strip width according to each function. Percentages of the coefficient of variation are clearly lower for the function obtained from the pooled data.

To know whether the distribution of encounter rates and mean group size of the three species detected in the present study (1998) are shown in Table 2, together with those data obtained in previous surveys in 1987-91 and 1994 in the same forest fragment. Encounter rates obtained in 1998 were greater than those in the 1994 and 1987-91 surveys for all three species. In 1998, mean group size of *C. apella*, *A. guariba* and *B. arachnoides* were on average 4.3, 1.8 and 7 individuals respectively, showing significant differences between them ($F_{2,34}$=5.01, p=0.01).

To know whether the distribution of monkeys was affected by altitude, we compared the observed frequencies of individuals and groups of each species found above and below 500 m with the expected frequencies according to the kilometres walked in each altitude category. *Alouatta guariba* did not show any significant differences in its distribution according to altitude either for number of individuals (n=16, χ^2=0.38, df=2, p=0.54) or group frequencies (n=9, χ^2=0.51, df=2, p=0.47). The number of *B. arachnoides* was significantly higher than expected above 500 m (n=56, χ^2=7.64, df=2, p=0.006) but the number of groups was not (n=8, χ^2=0.19, df=2, p=0.66). In the case of the *C. apella*, both frequencies of groups and individuals were significantly higher than expected above 500 m (individuals: n=87, χ^2=19.12, df=2, p<0.001; groups: n=20, χ^2=5.12, df=2, p=0.024).

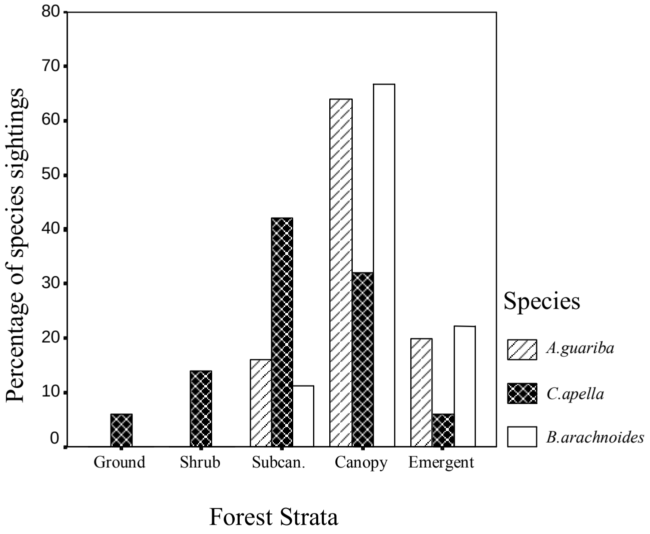

Figure 3. Percentage of groups sighted according to forest strata for each species of primate (each group can be in more than one stratum).

Significant differences were found in the use of forest strata by the three syntopic species (χ^2= 21.0 , df=4, p<0.001 , n=76 groups). *B. arachnoides* and *A. guariba* used mainly the upper level (canopy and emergent trees), and *C. apella* preferred the medium level (sub-canopy). *C. apella* was the only species that used all levels of vegetation and the only species found at the lower level (shrubs and ground) (Figure 3). No polyspecific association was observed during the surveys.

DISCUSSION

Factors affecting density estimates

One major underlying assumption of standard line-transect theory is that objects are detected prior to any responsive movement towards the observers. It was not possible to evaluate the effect of any movement of primates in response to the censusing group. If primates move from their original place before detected, it can bias estimates of population density through changes in the observed distribution of perpendicular distances. However, we are confident that this was not a problem on our survey since primates were seen to react when detected at short distances and it was always possible to identify the original place of the group by the noise that primates made when escaping. The shape of the function for *C. apella* also suggests a low bias on primate distributions due to response to the censusing group (Figure 1), that is, we obtained the same frequency of sightings between 0 and 5 m as between 5 and 10 m, and a progressive decline in frequencies with the increase of perpendicular distance to the transect.

We estimated half of the groups per square kilometer for the same set of *C. apella* sightings collected in 1994 (González-Solís *et al*., 1996) because we used a new detection function. This difference is explained by the low number of encounters of primate groups obtained in 1994, which precluded a precise estimation of densities for that year. A combined estimate of the detection function across years, i.e. pooling encounters from 1994 and 1998 surveys, was needed to gain precision when estimating densities of each year. Thus, estimated densities obtained from few encounters must be interpreted with caution (e.g. Plumptre, 2000). Nevertheless, given the threatened status of *A. g. clamitans* and *B. a. arachnoides* we estimated the density of both species to allow for a preliminary assessment of their status and for comparisons between areas, although the number of encounters was low.

We found an apparent increase in primate densities and encounter rates between 1994 and 1998 surveys, though differences were not significant (Table 2). A plausible explanation for this increase may be related to the inclusion of unhunted zones in the present survey as well as a possible increase of primate populations after protection of the P.E. Intervales in 1987. In 1994, the survey was confined to the P.E. Intervales whereas in 1998 the survey included other surrounding parks, which have enjoyed longer protection than P.E. Intervales. In the P.E. Intervales, hunting was allowed until 1987, which may have led to a local depletion of primates in that area. Cebids are game species widely hunted for meat (e.g. Puertas & Bodmer 1993). Recently, Alvard *et al*. (1997) and Hill *et al.* (1997) showed that encounter rates of *Cebus* spp. in hunted areas were lower than in unhunted areas. Similarly, Peres (1997) showed how *Alouatta* spp. density is profoundly affected by the degree of hunting pressure. Likewise, the decline in the Woolly spider monkey populations is suspected to be more related to hunting than to forest fragmentation (Lane, 1990; Pinto *et al*., 1993).

Results indicate lower densities of groups as well as number of individuals for *A. guariba* and *B. arachnoides* when compared to *C. apella*. These are probably related to the wider ecological plasticity as well as the smaller body size of the *Cebus* spp. (Robinson & Redford, 1986).

Population densities in our study area are among the lowest reported for the three species of primates in other localities of Eastern Brazilian forest (Table 1), although comparisons among areas are difficult to perform because of the important differences in the methodologies used between studies and the lack of confidence intervals for most of the density estimates available. Extensive deforestation of the Atlantic rainforest and Subtropical forests has led to isolation of many small groups of primates (Fonseca, 1985; Mittermeier *et al.*, 1987; Ferrari & Diego, 1995). Overall, in those fragments where primate populations still remain, the reported primate abundances seem higher than in the present study, either measured as density or encounter rates of individuals or groups. Particularly, reported abundances for *A. guariba* are only from small fragments (Table 1), where this species is able to reach high densities. Three main non-mutually exclusive reasons may explain the density increase of some primate species in small fragments.

Firstly, the absence of top predators. Large cats (e.g. *Panthera onca* Peetz *et al*., 1992) and birds of prey (e.g. Printes *et al*., 1996) are natural top predators of primates. However, top predators need large home ranges for hunting and do not occur in small fragments of Atlantic rainforest (e.g. Chiarello, 1999 and references therein). Most reported primate abundances are from Atlantic forest fragments smaller than 50 km^2 (Table 1), which are not able to sustain such predators. Nevertheless, jaguar as well as large raptors, are known to occur in the area surveyed in the present study (Guix 1997; Mañosa & Pedrocchi, 1997).

A second reason may be the ecological plasticity of *A. guariba*, *C. apella* and even *B. arachnoides*, which has been noted in several degraded forest fragments (Emmons, 1990; Martuscelli *et al*., 1994). These species are able to switch the diet between fruits, leaves and flowers, including secondary vegetation when necessary (Strier, 1991; Chiarello, 1994). This ability has probably allowed these species to survive or even increase their populations in small fragments of secondary forest or mosaics of mature and secondary forest vegetation (Fonseca, 1985; Pinto *et al*., 1993; Ferrari & Diego, 1995) provided that there is no hunting pressure.

A third explanation may be the density compensation phenomenon (Peres & Dolma, 2000). The increase in abundance of some primate groups in isolated patches may be allowed by the absence of other potentially interacting competitors such as other primate species. As it can be deduced from Table 1, in many small fragments only one or two from the three primate species here considered remained, while all species occurred in our study area.

In contrast with the increase of primate abundances in some small fragments, local extinction in many remaining fragments of the Atlantic forest has been reported for the three primate species recorded in this study. Besides the studies included in Table 1, Ferrari & Diego (1995) did not encounter any *B .a. arachnoides* in any of the 16 fragments between 0.14 and 2.16 km^2 near the Caratinga Biologiocal Station, where this species is known to occur. Likewise, these authors suggested that *A. guariba* may occur in only one-quarter of the visited sites. At another site, hunting has been identified as the main cause for local extinction (Pereira & Gonçalvez, 1995). Hunting could also be the main reason of extinction for many other small fragments where these species where not recorded (e.g. Chiarello, 1999), since the small size of the fragments make them readily accessible for hunters (Robinson, 1996).

Group size

Average group sizes of *B. arachnoides* were larger than those of *C. apella*, and both were larger than those of *A. guariba*. These results agree with those found in different areas of Atlantic and Subtropical forests (Table 1). Interspecific differences of group size are probably related to the feeding strategies of each species. Comparative studies of primates living in the same forest show that more frugivorous species tend to live in larger groups and have wider home ranges than folivorous species (Rabenold & Bromer, 1989). Howler monkeys (*Alouatta* spp.) are highly folivorous and this type of diet is related to low moving and low home ranges (Milton, 1979). Leaves are a low quality feeding resource and highly folivorous species tend to minimize the energy costs by minimizing their movements (Milton, 1979). Leaves are abundant and spread out, so that *Alouatta* spp. can live in small groups while exploiting a small area. Indeed, In P.E. Intervales, Steinmetz (1999) estimated that the home range of a group of six *A. guariba* was 44 ha. Conversely, *B. arachnoides* is more frugivorous than *A. guariba*. Fruits appear more clustered than leaves, promoting large group sizes with a high mobility.

Observed frequencies of individuals and groups of *C. apella* were significantly higher above 500 m than expected. Similar results were obtained for observed frequencies of individuals of *B. arachnoides*. However, *A. guariba* did not show any difference between observed and expected frequencies in relation to altitude. Primate abundance in neotropics is known to correlate with fruit production (Stevenson, 2001). Similarly, differences in monkey abundance above and below 500 m could be associated with a higher availability of fruits in uplands during the 1998 survey period. During the survey, it was noted that palmito palm was fructifying above 500 m. The palmito palm can be used as an indicator of the phenology of other plants producing fleshy fruits (Guix, 1995). Thus, the higher abundance of the two most frugivorous species of monkeys above 500 m may be related to higher fruit availability above this altitude.

Habitat use

While *B. arachnoides* and *A. guariba* tended to use the highest forest strata (canopy and emergent trees), *C. apella* used all strata, from the highest trees to forest floor. Although *B. arachnoides* and *C. apella* feed largely on the same species of fruit (eg. *Inga* spp., *Posoqueria* spp., *Hymenaea* spp., J.C. Guix personal observation), the high degree of folivory by *B. arachnoides* and *A. guariba* might explain the use of the same strata by these two species that was not used by *C .apella*. Both *B. arachnoides* and *A. guariba* have a folivore-frugivorous type of diet exploiting mainly young leaves (e.g. Milton 1979; Strier 1991), which are presumably more abundant in the highest vegetation level. In contrast, *C. apella* are seasonally flexible omnivores, feeding on fruits, seeds, insects and occasionally small vertebrates (Redford & Eisenberg, 1992), which are more widely distributed than young leaves in all forest strata.

Conservation status of the species

A. guariba clamitans lives in the South-eastern Brazil and Misiones forests and it was included in the IUCN's lists of threatened animals as a vulnerable subspecies (see UNEP-WCMC, 2001). *C. apella* is a widely distributed species ranging from southern Colombia to northern Argentina (Redford & Eisenberg, 1992). Populations of *C. apella* living in the Atlantic rainforest of southeastern Brazil are defined as an endemic subspecies (*Cebus apella nigritus*) and they are being considered as belonging to a separate species by some authors (Vivo & Gregorin, 2001). *C. a. nigritus* is subjected to the same types of human pressures, such as hunting, habitat loss and forest fragmentation, which are responsible for the decline of *B. arachnoides* and *A. guariba*. This subspecies is not included in any list of threatened animals (Rylands *et al.* 1997, UNEP-WCMC, 2001).

Brachyteles arachnoides was recently included in the IUCN's lists in the category of critically endangered species (see UNEP-WCMC, 2001). There are two distinctive metapopulations of *B. arachnoides* referred as full different species or just as subspecies depending on the authors: *B. a. hypoxanthus* for populations north of Serra da Mantiqueira chain and *B. a. arachnoides* for populations south of it (Fonseca *et al.*, 1996 and references therein). Regardless of their taxonomic level, however, it is recognized that these populations must be considered independently for conservation purposes (Martuscelli *et al.*, 1994; Mendes, 1994). Considering that the area covered by old secondary and mature forests suitable for *B. a. arachnoides* in Paranapiacaba is around 1000 km^2, the total population derived from our estimate of absolute density was 2330 individuals. The low number of sightings of this survey highlights caution before interpreting this number. Nevertheless, the estimated population is probably conservative. First, computation of total population is based on the size of the groups estimated by the line-transect method, which is probably slightly underestimated because this methodology does not allow for an extended inspection of the groups. Second, area of occupancy of the species could be larger if 400 km^2 of young secondary forests of the fragment surveyed are also considered as a potential habitat for *B. arachnoides* (see Martuscelli *et al.*, 1994). On the other hand, the expected population in the study is derived from the size of the home range described for this species in accordance with the density found in this study (Petroni, 1993, 1998). Our estimation of the whole population of *B. a. arachnoides* suggests that it could be larger than those stated in previous studies (Coimbra-Filho *et al.*, 1993; Martuscelli *et al.*, 1994). Apart from the population described in this study, *B. arachnoides* is known to occur in other isolated areas south of the Serra da Mantiqueira (cf. Mittermeier *et al.*, 1987; Martuscelli *et al.*, 1994), such as the 700 km^2 of Parque Estadual de

Juréia and Itatins in the State of São Paulo. Thus, according to the criteria used in the IUCN categories of threatened species (Akçakaya *et al.*, 2000; UNEP-WCMC, 2001), *B. a. arachnoides* could better fit into the category of *vulnerable* rather than *critically endangered*.

Given the importance of local extinctions in the small fragments of Atlantic rainforest and the relatively large size of the primate populations in Paranapiacaba, the conservation strategy for *C. a. nigritus*, *A. g. clamitans* and *B. a. arachnoides* should prioritise the effective protection of the largest remnant fragments of Atlantic rainforest from illegal hunting and deforestation, better than the translocation of individuals or captive breeding programs to introduce monkeys in small forest fragments of difficult protection and uncertain future. Breeding programs in captivity are economically very expensive and often the number of individuals obtained to release is very low. In addition, social monkeys are difficult to reintroduce in natural areas. Isolated individuals are usually not accepted by wild groups, becoming marginal or satellite individuals that do not breed. On the other hand in successful reintroductions, diseases acquired by animals reared in captivity can be easily spread, which becomes an important threat to wild populations (Henning, 1995).

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Chapter 10

GLOBAL ANALYSIS OF DISTANCE SAMPLING COUNTS RESULTS: EFFECTS OF ENVIRONMENTAL AND METHODOLOGYCAL VARIABLES

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ABSTRACT. Between 18 August and 4 September 1998, a census of frugivorous vertebrates was carried out in the Paranapiacaba fragment, one of the largest fragments of Atlantic rainforest (1400 km^2) that currently exists in Southeastern Brazil. The applied methodology was distance sampling using line transects. A total of 352.4 km were covered in 127 transects distributed across seven working areas. A total of 14 vertebrate species were censused and the global encounter rate was 1.53 groups per km. The effects of six environmental and methodological variables on the counts during the censuses have been analysed. Multivariate analyses techniques (correspondence analysis CA and canonical correspondence analysis CCA) shows that altitude is the variable that influences the most on the differential distribution of species in the whole of the censused area. Some other variables such as time of the day and walking speed of the observers have a significant quantitative effect on the encounter rate of the whole of the censused species.

KEY WORDS. Brazilian Atlantic rainforest, canonical correspondence analysis, census, frugivorous vertebrates.

INTRODUCTION

During the frugivorous vertebrates census carried out between 18 August and 4 September 1998 in the Paranapiacaba forest fragment, data were obtained on 14 bird and mammal species that allowed the estimation of population densities for each one of them. The applied methodology was distance sampling using line transects, which is based on covering routes by foot while recording data on distance, height and number of individuals for each group of animals that is sighted at both sides of the progression line.

From a methodological point of view, several factors can influence the data obtaining process during the coverage of the transects: topographic factors (altitudinal differences between the study areas, type of path and length of each transect), climatological factors (different climatological conditions during the days of census), daily factors (times at which censuses are performed) and human factors (walking speed of the observers). We will call these factors "census variables".

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The aim of this chapter is assessing the effect of census variables on the data obtaining process during the performance of frugivorous species censuses. The knowledge of this effect may be useful when interpreting the obtained results and also when planning new censuses in the same area or in similar ones.

MATERIAL AND METHODS

Censuses were performed in seven areas distributed across the three main protected areas of the Paranapiacaba fragment (see chapter 3 for a detailed description of the study areas). Overall, 352.4 km were covered in 127 transects, during which 483 contacts were made with the 14 censused vertebrate species (see chapter 4 for a detailed description of the census methodologies applied). Data used in the current work are the amount of groups of each species that were sighted per km covered in each transect (encounter rate).

Census variables

Census variables considered are described below:

1) Altitude: average altitude of the route of each transect.

The altitude range that was sampled during the censuses is very wide (between 60 and 1030 m). The possible effect of altitude on the encounter rate of the censused species could be due to the effect of altitude on plant fruition, which determines the availability of fruits for frugivorous species. The presence of ripe fruits of palmito palm (*Euterpe edulis*) has been used as an indicator of fruition along the altitudinal gradient (Guix, 1995). Two strata have been established, one below 400 m where no ripe fruit of palmito palm were observed, and another one above 500 m where they were found indeed. Based on this, two transect categories have been established: 1) lower stratum, below 400 m, with a low availability of fleshy fruits; 2) higher stratum, above 500 m, with a high availability of fleshy fruits.

2) Trail: kind of trail that was covered along each transect.

It is a categorical variable for which three classes have been established: 1) track; 2) easy path; 3) difficult path.

Tracks are wide paths with very little inclination (their layout tends to follow the contour lines) and vehicles to supply material or to carry technicians and scientists around sporadically use them. Easy paths are trails that can only be covered by foot, with a little inclination and without obstacles that interfere on the way. Difficult paths are trails with a more or less accused inclination that tend to cross water courses and where the presence of mud hinders in the way.

3) Weather: weather conditions during the coverage of each transect.

It is a categorical variable for which three classes have been established: 1) good - generally nice weather; 2) fair - cloudy sky, light rain; 3) bad - cloudy sky, with or without rain but windy.

Weather conditions during census performance have a direct effect on visibility. Generally, rain and wind are adverse since they make the detection of individuals a lot more difficult. The census was not performed on days of heavy rain or strong wind.

4) Time: time of the day at which each transect was carried out.

It is a categorical variable for which two classes have been established: 1) morning - transects performed between 7 h and 13 h; 2) afternoon - transects performed between 15 h and 18 h.

5) Length: total distance covered in each transect.

The length of the 127 transects performed during the census was not homogeneous. Different lengths were distributed in a random way depending on the other census variables, since there was not any previous design of any transect length based on any other particular variable. In order to compare transect groups, they have been grouped considering length ranges. Overall, six categories have been established: 1) less than 1 km; 2) between 1 and 2 km; 3) between 2 and 3 km; 4) between 3 and 4 km; 5) between 4 and 5 km; 6) more than 5 km.

6) Speed: average speed of the observers during the census.

In order to analyse the effect of the observers' walking speed during the coverage of the transect, five categories have been established: 1) less than 1 km/h; 2) between 1 and 1.5 km/h; 3) between 1.5 and 2 km/h; 4) between 2 and 2.5 km/h; 5) more than 2.5 km/h.

7) Area: each one of the areas where censuses were performed.

It is considered as a categorical variable and it has been divided into seven categories: 1) Núcleo Caboclos; 2) Alecrim; 3) Carmo; 4) Barra Grande; 5) São Pedro; 6) Saibadela; 7) Carlos Botelho. Areas are placed following the altitudinal gradient and therefore this variable is closely related to the altitudinal one. Since the possible effects of these two variables are not independent, the variable Area has not been included in the multivariate analyses.

The variables Altitude, Length and Speed can be codified either as numerical variables or as categorical variables depending on the type of analysis to be performed. In the first case, each transect has a particular value for each one of these variables (they are not grouped). In the second case, transects are grouped into the categories defined above (Table 1).

Data matrix and starting hypothesis

Census data can be ordered in a contingency table of 14x114 = 1596 boxes (species data matrix) where rows are the censused frugivorous species (14) and columns are each one of the transects during which at least one contact with one of the species has been made (114). In each box, the number of groups contacted per kilometre in each transect (encounter rate) is noted down. At the same time, census variables data can be placed in another contingency table of 6x114 = 684 boxes (census variables data matrix) where rows are the census variables (variables 1 to 6), columns are transects performed during which contacts were made, and where each box shows the value that each transect takes for each one of the census variables.

Table 1.- Census variables categories and global encounter rate values: n = number of transects, se = standard error, CV = coefficient of variation of the mean.

VARIABLE	global encounter rate			
	n	mean	se	CV
ALTITUDE				
< 400 m	40	2.075	0.295	92.3
> 500 m	71	1.324	0.171	108.6
TRAIL				
Track	30	1.939	0.350	101.9
Easy path	57	1.433	0.199	105.0
Difficult path	40	1.351	0.207	96.9
WEATHER				
Good	60	1.468	0.200	105.5
Fair	53	1.688	0.234	101.0
Bad	14	1.166	0.247	86.4
TIME				
Morning	86	1.804	0.187	97.2
Afternoon	41	0.944	0.138	93.8
LENGTH				
≤ 1 km	13	1.612	0.229	51.1
1 a 2 km	43	2.036	0.346	111.5
2 a 3 km	25	1.309	0.228	87.2
3 a 4 km	24	1.203	0.189	77.0
4 a 5 km	13	1.063	0.222	75.3
> 5 km	9	1.104	0.249	79.3
SPEED				
≤ 1 km/h	41	2.161	0.345	102.1
1 a 1.5 km/h	41	1.329	0.175	84.4
1.5 a 2 km/h	26	1.206	0.206	87.0
2 a 2.5 km/h	10	1.182	0.213	57.0
> 2.5 km/h	9	0.847	0.245	97.2
AREA				
N.Caboclos	6	0.747	0.238	78.0
Alecrim	25	1.168	0.292	91.1
Carmo	12	1.138	0.147	44.9
B.Grande	10	1.174	0.303	81.7
S.Pedro	15	0.884	0.208	91.3
Saibadela	27	2.182	0.361	86.0
C.Botelho	32	1.560	0.344	124.8
TOTAL	127	1.527	0.138	103.0

These two matrices allow a global analysis of the data through multivariate analysis techniques. The analysis can be summarised into determining whether the species data matrix presents a degree of inertia significantly different to that expected by hazard, related to the census variables data matrix. The null hypothesis is that the species data matrix does not present this inertia, while the alternative hypothesis is that it does present this inertia, in which case it can be determined which census variable or which group of census variables have an effect over the data and to what extent they have it. Moreover, this analysis allows the determination of the distribution of each one of the vertebrate species censused along the gradient created by each one of the census variables.

The quantitative effect of each census variable over the data obtained during the transects performance can be tested through univariate analysis techniques. The total amount of contacted groups of all accumulated species per km in each transect (global encounter rate) has been established as the dependent numerical variable. The problem is reduced to compare average values of the global encounter rate between the groups of transects established through each one of the census variables (Table 1). The null hypothesis in these analyses is that the groups of transects established through each census variable do not show differences between their average global encounter rate value. Statistical tests used are variance analysis (One-way ANOVA), Student Newman Keuls (SNK) *a posteriori* test and Student's *t* test.

Some of the census variables could be correlated, which would mean that the individual effect of each one of them would depend on the effect caused by a different one. In order to determine whether this relationship exists between some of the census variables, a Pearson product moment correlation analysis has been performed between pairs of variables.

RESULTS

Multivariate analysis

Two multivariate analyses have been performed to analyse the weight of each one of the census variables (except for the variable Area): Correspondence analysis (CA) and Canonical Correspondence Analysis (CCA). The CANOCO software (Ter Braak, 1985) has been used. In the variables data matrix, Altitude, Length and Speed have been considered as numerical variables while Trail, Weather and Time have been considered as categorical variables. The variable Area has not been included in the analyses and it only appears in the graphic representation of the CCA.

Monte Carlo permutation tests were performed in order to determine which ones of the variables have a significant effect (individually) on the data matrix. Making 9999 permutations, results of this test for each variable are: Altitude F=7.14 p=0.000; Trail F=1.73 p=0.055; Weather F=1.63 p=0.08; Time F=1.43 p=0.135; Length F=0.58 p=0.83; Speed F=0.74 p=0.69. Therefore, only the variable Altitude has an individually significant effect on the amount of contacts made per km with the whole of the species in the total of transects performed.

The total inertia of the data matrix is 4.707. The whole of the census variables explain up to 11.83% (trace = 0.557) of it. The rest of the inertia (88.17%) can be considered as background noise and it cannot be explained through the census variables used. Moreover, the eigenvalues of the first four canonical axes of the CCA are much lower than the eigenvalues of the first axes of the CA (Table 2), which shows that the census variables explain only a few of the directions of variation of the data matrix. Although the whole of the census variables explain only a fraction of the total inertia, this could nevertheless be the most important one (Ter Braak, 1986).

Table 2. Results of the Correspondence Analysis (CA) and Canonical Correspondence Analysis (CCA). sp-cens corr.= correlation coefficients between species data matrix and census variables data matrix. %var exp.= accumulated explained variance by each axis. Total inertia (sum of all eigenvalues) = 4.707, inertia explained by the environmental variables (sum of canonical eigenvalues) = 0.557.

	Axis1	Axis2	Axis3	Axis4
CA eigenvalues	0.756	0.578	0.476	0.440
CA sp-cens corr.	0.716	0.282	0.245	0.291
CA %var exp.	16.1	28.4	38.5	47.8
CCA eigenvalues	0.337	0.129	0.044	0.028
CCA sp-cens corr.	0.771	0.514	0.333	0.311
CCA %var exp.	7.2	9.9	10.8	11.4

Table 3. Interset-correlations between census variables and the first two CCA axes.

	axis 1	axis 2
Altitude	0.71	-0.08
Trail	-0.15	0.31
Weather	0.14	0.32
Time	0.18	0.18
Length	0.08	-0.05
Speed	-0.09	0.02

The two first axes of the CCA are the ones showing a lower diminishment of their eigenvalue relative to the CA and, moreover, they are the ones with a highest species-census veriables correlation (0.77 first axis and 0.51 second axis). The rest of the axes have very low eigenvalues and species-census variables correlations. A Monte Carlo permutation test (Ter Braak, 1985) shows that ordering along axis 1 is highly significant (999 permutations, eigenvalue of axis1 = 0.34, F-ratio = 7.94, p = 0.001); ordering along axis 2 is placed in the limit of statistical significance (999 permutations, eigenvalue of axis 2 = 0.13, F-ratio = 3.37, p = 0.050), and ordering along axis 3 (and next ones) is non-significant (999 permutations, eigenvalue of axis3 = 0.04, F-ratio = 1.71, p = 0.851). Therefore, space delimited by axes 1 and 2 offers an interpretable ordering of species-points and census variable-points. In this space, ordering along axis 1 is the one offering the best resolution, since it is the axis with highest significance values in the tests performed.

Census variables presenting a highest correlation with axis 1 of the CCA will be the ones best explaining the ordering along this axis (Table 3). The variable with the highest correlation with the first canonical axis is Altitude (0.71). The remaining variables have very low correlations with this axis. None of the census variables presents a high correlation with the second axis of the

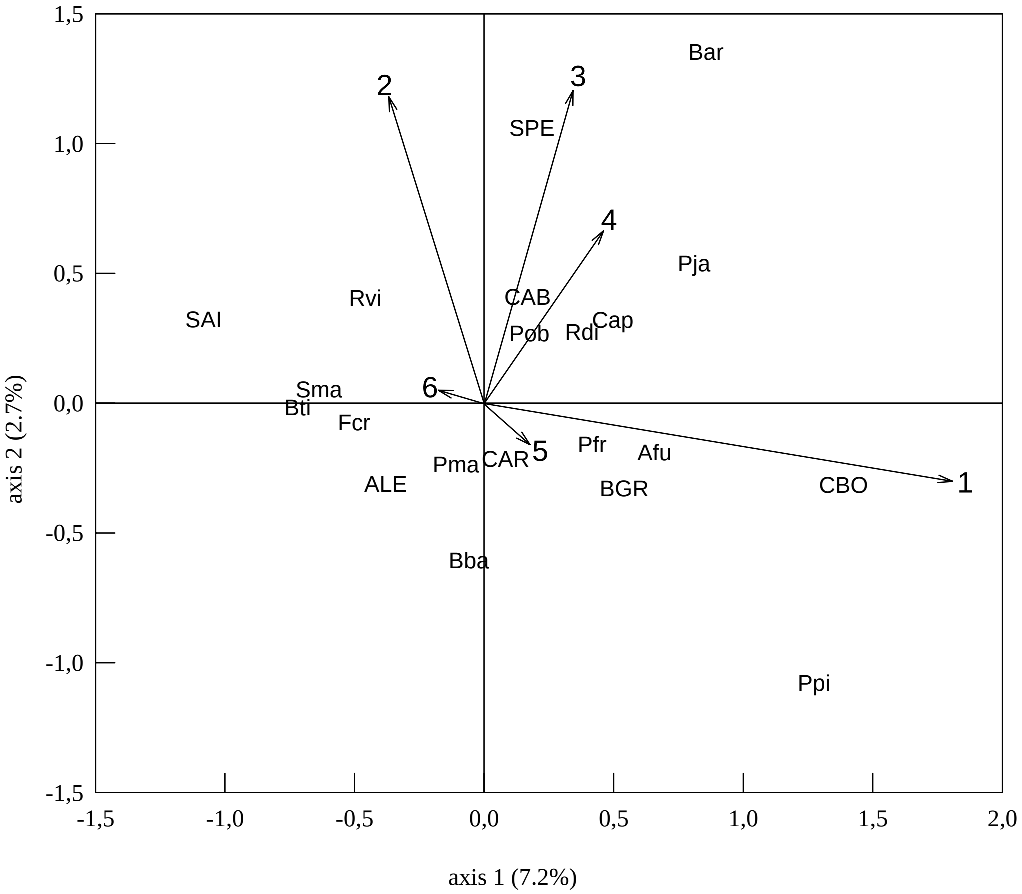
CCA. Variables Weather, Trail and Time are the ones showing the highest values (0.32, 0.31 and 0.18 respectively), so they are the ones best explaining the ordering along the second axis.

Figure 1. Canonical Correspondence Analysis. Representation of species-points (lower case), area-points (upper case) and census variables-points (numbers), into the space delimited by the first two CCA axes. The seven area-points are represented, but this variable has not been included in the analyses.

Bti = *Brotogeris tirica*, Sma = *Selenidera maculirostris*, Fcr = *Forpus crassirostris*, Rvi = *Ramphastos vitellinus*, Pma = *Pionus maximiliani*, Bba = *Baillonius bailloni*, Pob = *Penelope obscura*, Rdi = *Ramphastos dicolorus*, Pfr = *Pyrrhura frontalis*, Cap = *Cebus apella*, Agu = *Alouatta guariba*, Pja = *Pipile jacutinga*, Bar = *Brachyteles arachnoides*, Ppi = *Pionopsitta pileata*.

SAI = Saibadela, ALE = Alecrim, CAR = Carmo, CAB = Núcleo Caboclos, SPE = São Pedro, BGR = Barra Grande, CBO = Carlos Botelho.

1 = Altitude, 2 = Trail, 3 = Weather, 4 = Time, 5 = Length, 6 = Speed



The ordering of species-points and census variables-points in the space delimited by axes 1 and 2 of the CCA (that as a whole explain 9.9% of the total inertia in the species data matrix) are shown in Figure 1. The perpendicular projection on axis 1 of the arrows pointing towards the variables Altitude (1), Trail (2), Weather (3), Time (4), Length (5) and Speed (6), reflect the relative importance of each one of them. Therefore, and as mentioned above, axis 1 can be basically interpreted as an altitudinal gradient, while the remaining variables have little importance in this axis.

The variable Area has been represented in Figure 1 even though it was not included in the analysis. The seven area-points are placed occupying the gravity centre (centroid) of the transect-points cluster (which are not represented) performed in each area. These area-points are clearly ordered along axis 1 following an altitudinal gradient: areas placed at higher altitudes towards positive values of the axis, and areas placed at lower altitudes towards negative values of the axis. The extreme area-points are Carlos Botelho, in positive values, and Saibadela, in negative values. These two areas are the most contrasted in terms of transect altitude, since there is no altitudinal overlapping between any of them (see Figure 2 in chapter 4). Species-points are also ordered along axis 1 following and altitudinal preference gradient and they are therefore associated (by proximity) to the areas where they tended to be contacted.

Univariate analysis

For the whole of the 127 transects, the average global encounter rate was 1.53 ± 0.14 (group contacts per km). Through comparisons of means, it has been tested whether the average value of the global encounter rate shows differences or it does not between the different transect groupings that have been made based on the census variables (Table 1).

Transects distributed in the two altitudinal ranges considered (variable Altitude) show statistically significant differences in their global encounter rate values (Student's *t* test 109 d.f.; $t = 2.368$; $p = 0.020$). Below 400 m, 2.07 ± 0.29 contacts per km were made, while above 500 m the amount of contacts per km was 1.32 ± 0.17.

A variance analysis of the general encounter rate in the three categories of variable Trail does not yield any statistically significant differences ($F_{2,124} = 1.410$; $p = 0.248$). Therefore, the type of trail used in the census transects did not affect the number of contacts per km in the whole of the transects.

The three climatological categories (variable Weather) do not show statistically significant differences in their global encounter rate values (ANOVA: $F_{2,124} = 0.694$; $p = 0.502$). Therefore, the transects performed under supposedly adverse weather conditions (light rain and/or wind) were not less effective than the ones carried out under nicer conditions.

The time of the day at which censuses were performed have an obvious quantitative effect (variable Time). When performing a Student's *t* test, statistically significant differences appear between transects that were performed in the morning (86 transects) and the ones carried out in the afternoon (41 transects) (125 df; $t = 2.992$; $p = 0.003$). In the morning, the global encounter rate value (1.80 ± 0.19 contacts per km) is twice that of the afternoon (0.94 ± 0.14 contacts per km).

The average total length of the 127 transects was 2.8 ± 0.15 (s.e.) km, with a minimum value of 0.8 km and a maximum one of 13 km. Variance analysis on the six groups of transects based on variable Length shows that differences between their global encounter rate values are not statistically significant ($F_{5,121} = 1.627$; $p = 0.158$).

The average census speed (variable Speed) for the 127 transects was 1.4 ± 0.06 (s.e.) km/h., with a minimum value of 0.4 km/h and a maximum one of 3.9 km/h. Variance analysis on the five groups of transects based on this census variable shows that differences between their global encounter rate values are statistically significant ($F_{4,122} = 2.830$; $p = 0.028$). Through the SNK *a posteriori* test with a 0.05 significance level, no subgroups appear between the five categories. That means that the statistically significant differences exist between the two extreme groups of transects relative to the average global encounter rate value (Figure 2). These two groups are the ones that were censused at a speed equal to or below 1 km/h (with 2.16 ± 0.34 contacts per km), and the one censused at a speed averaging over 2.5 km/h (with 0.85 ± 0.24 contacts per km).

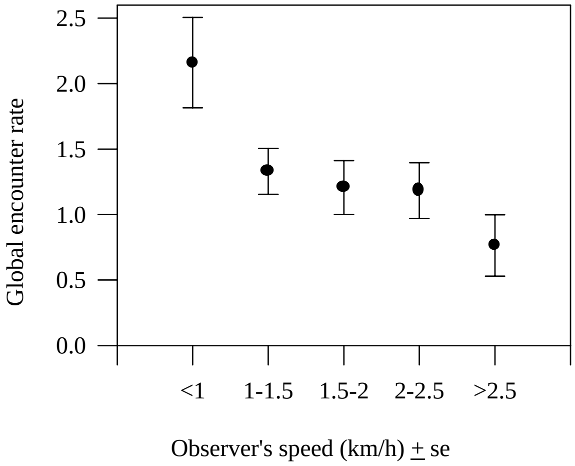


Figure 2. Relationship between global encounter rate and observer's speed.

Finally, it is interesting to test whether the different study areas (variable Area) yielded statistically significant global encounter rate values. Variance analysis shows that the values obtained in the different areas were similar ($F_{6,120} = 1.776$; $p=0.110$), with a maximum value in Saibadela (2.18 contacts per km) and a minimum one in Núcleo Caboclos (0.75 contacts per km).

Correlation analysis

Results obtained through correlation analysis between the census variables and the global encounter rate (Table 4) reinforce the results showed above.

The global encounter rate has a negative significant correlation with the variables Altitude, Time and Speed. Therefore, the global encounter rate was lower in transects performed at the lowest altitudinal range (< 400m) and in those carried out in the afternoon. Moreover, the tendency of the number of contacts per hour to decrease as the censusing speed increases is confirmed.

Table 4. Correlation matrix (Pearson product moment correlation) between census variables and global encounter rate (g. e. rate, in groups per km). n = 127 in all correlations. * p<0.05; ** p<0.01 (bilateral in both cases).

	Altitude	Trail	Weather	Time	Length	Speed
Trail	-0.14					
Weather	-0.00	-0.01				
Time	0.14	-0.03	-0.03			
Length	0.15	-0.34**	-0.02	-0.36**		
Speed	0.04	-0.43**	-0.07	-0.07	0.56**	
g. e. rate	-0.18*	-0.13	-0.01	-0.26**	-0.17	-0.24**

Censusing speed and transect length are positively correlated (Figure 3). This relationship might be due to a subjective factor in the observers: if they know in advance about the transect length, they tend to walk faster if they know that the transect is going to be long. This fact can have a negative effect on the effectiveness of the census since, as we said above, the higher the speed, the lower the global encounter rate (Figure 2). Specifically, if the census speed is higher than 2.5 km/h, the number of contacts per kilometre decreases significantly (Table 1).

Significant correlations between the pairs Trail-Length, Trail-Speed and Length-Time show that the more difficult the layout of the transects, the shorter the covered distance and the censusing speed, and also that transects performed in the afternoon were generally shorter.

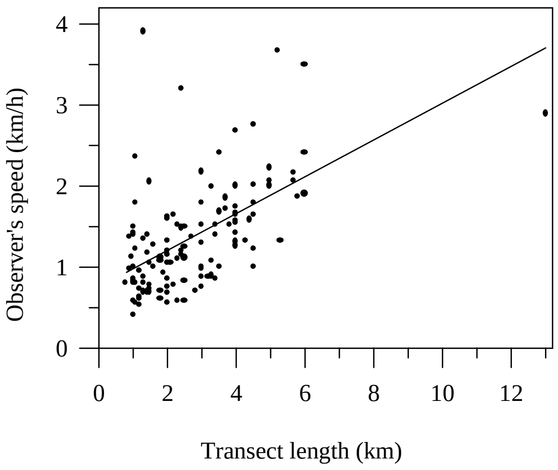


Figure 3. Relationship between transect length and observer's speed, showing the correlation line (r = 0.56, p < 0.01).

DISCUSSION

Multivariate analyses show that the variable Altitude has a significant influence on the global structure of the data, while the remaining census variables do not have a significant effect. This shows that altitudinal differences between sampled areas provoke the segregation of different species, which end up occupying their preferred altitudinal level.

According to CCA (Figure 1), *Brotogeris. tirica*, *Selenidera maculirostris*, *Ramphastos vitellinus* and *Forpus crassirostris* are the species showing a strongest preference for low altitude areas, while *Pionopsitta pileata*, *Brachyteles arachnoides*, *Pipile jacutinga*, *Alouatta guariba*, *Cebus apella*, *Pyrrhura frontalis* and *Ramphastos dicolorus* prefer higher areas. *Penelope obscura*, *Baillonius bailloni* and *Pionus maximiliani* seem indifferent to the altitudinal range that they inhabit.

These results, obtained through CCA, agree with those achieved (in the different chapters of the census of frugivorous species) through several univariate analyses for the different species in terms of preferences along the altitudinal gradient (see chapters 6, 7, 8 and 9). This shows how powerful this kind of global analysis of the data is in order to detect general tendencies in species data matrices confronted to environmental data matrices. CA and CCA have been used to determine general tendencies in data matrices belonging to a very wide range of organisms (Ter Braak, 1987; Wright & Samways, 1999; Peres & Dolman, 2000; Ribes *et al*., 2000), and they have proved to be a very powerful statistical tool in all cases.

Altitude has not only an important qualitative effect on the vertebrate community structure, but also a remarkable quantitative effect on it. Transects performed below 400 m yielded twice as many contacts as those that were carried out above 500 m (Table 1).

The time of the day at which transects are performed has a strong effect on the number of contacts with the different species. In the morning, the amount of contacts per km is twice that of the afternoon. This is directly related to activity periods of the species, which tend to be more active between dawn and noon.

The observer’s speed also has a quantitative effect on the number of contacts with the censused species. Generally, the faster the census, the lower the amount of contacts per km. This result seems reasonable when taking into account the sampling system (see chapter 4). If the speed is too high, the observer cannot detect all the objects within his field of vision. From the analyses performed, we determined that the most effective speed is not over 1 km/h. Chiarello (2000), in surveys that were similar to ours, carries out transects at a speed of 1 km/h. Since censusing speed and transect length are directly related, it is important to control this parameter also - when transects are long, observers tend to increase their speed.

From all these results, a few recommendations can be made in order to interpret the census results and also to design similar censuses in the future:

- Altitudinal strata: it is necessary to sample the whole range of altitudes available to get acceptable estimates of densities across the area. If sampling is reduced to a certain altitudinal range, estimates can be considerably biased.

- Kind of path: there are not statistically significant differences between the amount of contacts per km depending on the type of path (the highest value is achieved in tracks). Since it is easier to walk on tracks, using them is highly recommended (in case they are tracks that are not regularly used). Generally, steep paths should be avoided because it is difficult to keep on looking high when walking on them.
- Weather: Censuses should not be carried out under bad weather conditions (rain and/or wind).
- Time of the census: Censuses should preferably be performed in the morning, since it is the most active period of the day for most species.
- Transect length: Observers tend to walk faster on long trails, which can bring down sighting efficiency. Generally, transects longer than 4 km should be avoided.
- Censusing speed: The most effective speed seems to be 1 km/h. Nevertheless, speed should not be over 2.5 km/h.

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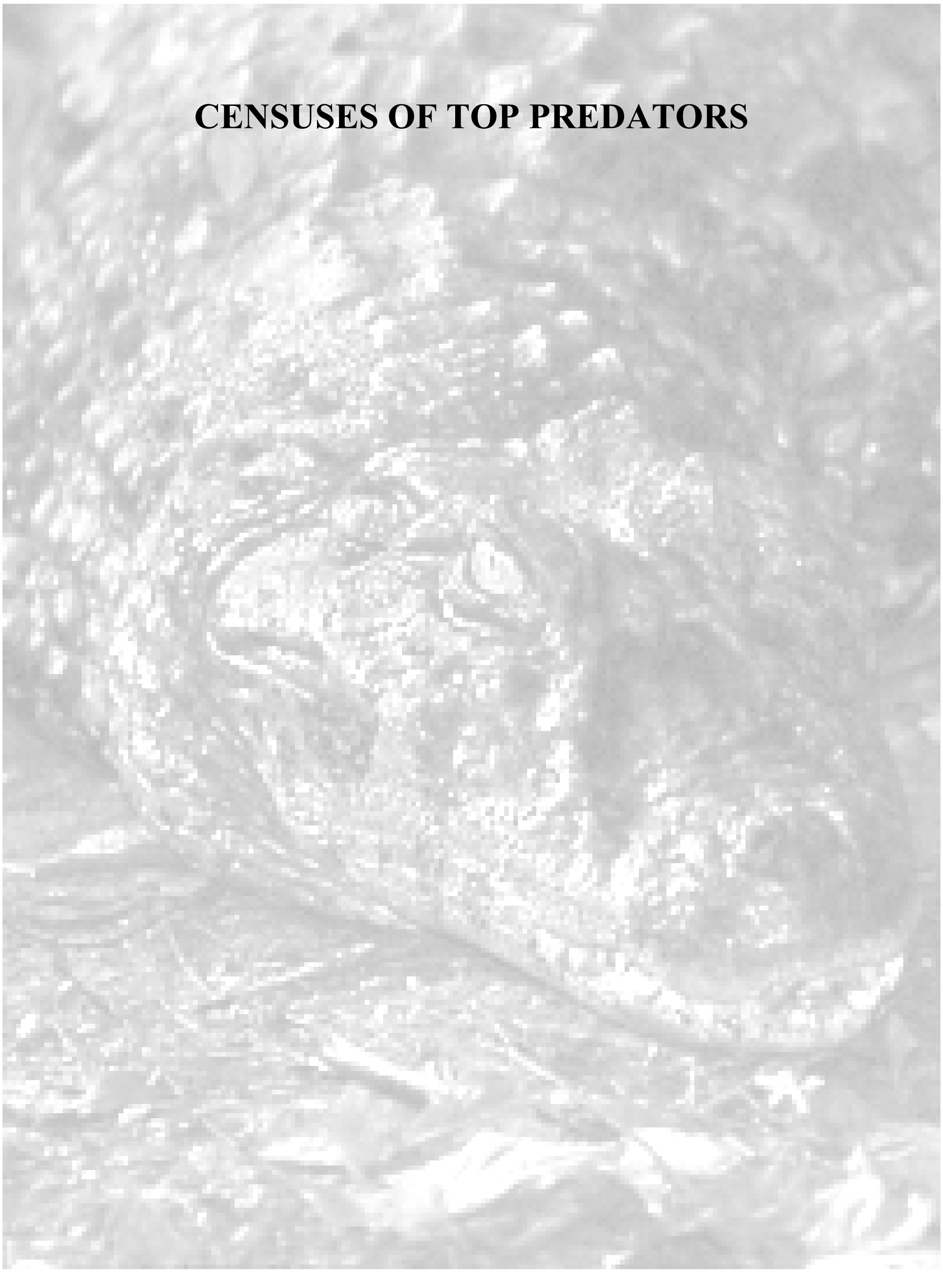
CENSUSES OF TOP PREDATORS



POPULATION STATUS OF THE BROAD-SNOUTED CAIMAN (*Caiman latirostris*; REPTILIA: CROCODYLIA)

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ABSTRACT. The Broad-snouted caiman (*Caiman latirostris*) is a threatened species that is not listed by IUCN. It was widely distributed throughout Eastern and Southeastern South America until the end of the 17th century. Although today it still occurs in most of its original distribution area, it survives in small and isolated populations. In general, these residual populations are composed by small size individuals and very few reproductive adults. Between 18 August and 4 September 1998 we performed surveys along 55 km of rivers and streams. We counted *C. latirostris* in places of the P.E. Intervales where the species has been reported since 1991 and we searched for new populations across all the Paranapiacaba forest fragment. No new populations or isolated specimens were found in 1998, in relation to the 1991 and 1994 expeditions. In the Alecrim lagoon (located at an altitude of 315 m) two adults (sizes: 120-150 cm), two possible sub-adults (80-100 cm) and 16 juveniles (25-30 cm) of *C. latirostris* were found. We emphasize the need of a management plan in the area that considers the possibility of rescuing specimens living beyond the limit of the P.E. Intervales and the translocation of specimens between populations living in other Atlantic rainforest protected areas.

KEY WORDS. Brazilian Atlantic rainforest, Broad-snouted caiman, *Caiman latirostris*, census, survey.

INTRODUCTION

At the end of the 17th century, the Broad-snouted caiman (*Caiman latirostris*) inhabited a wide region in Eastern and Southeastern South America. Its distribution included most of the basins of rivers São Francisco, Paraná, Paraguay and Uruguay, and the Eastern coasts of Brazil (from Pernambuco to Rio Grande do Sul) and Uruguay (Figure 1). Its favourite habitats are calmed waters such as estuaries, lakes and river pools, surrounded by low and dense vegetation, and mangroves of *Rhizophora mangle* and *Avicennia* spp. (Groombridge, 1982; Alderson, 1991; Steel, 1995). It is in fact the Crocodylia species that reaches the closest latitudes to the South Pole and probably the one that resist the lowest temperatures. Nevertheless, abrupt relieves and high altitudes seem to be a limiting factor in the species distribution, since it does not occur above 500 m (Anderson, 1991; Grenard, 1991).

It is a medium size caiman. When it becomes an adult, it reaches between 1.2 and 2.0 m of length. Its nesting period goes from October to February, when the female lays between 20 and 60 eggs (Steel, 1995). It feeds on little mammals, birds, fishes and reptiles (including chelonians), but gastropods have an outstanding position in its diet. When food is scarce, it probably feeds on little

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

individuals of its own species. Juveniles and young individuals feed almost exclusively on insects and other little invertebrates (Verdade *et al.* 1992).

Figure 1. *Caiman latirostris* distribution until the end of the 17th century based on data by Groombridge (1982) and Steel (1995).

Brazilian populations are listed in Appendix I of CITES (see UNEP-WCMC, 2001). Currently, the conservation status of the species in Brazil (see Lista Oficial de Espécies da Fauna Brasileira Ameaçadas de Extinção; Decree num. 1.522, of 19 December 1989 and Decree num. 45-N of 27 April 1992, of the Instituto Brasileiro de Meio Ambiente e Recursos Naturais-IBAMA) is mainly due to selective hunting for skin trade that has been being practiced for decades, and, in smaller measure, to habitat loss (Groombridge, 1982; Steel, 1995). Although it still occurs in most of its original distribution area, it generally survives in small and excessively isolated populations. In the State of São Paulo, the number of remaining populations is quite small (Figure 2), and most of them consist of small size individuals and very few reproductive adults.

Figure 2. Remaining populations of *Caiman latirostris* in the State of São Paulo. Localities and vegetal communities where adult specimens were found between 1982 and 1994, according to Carretero *et al.*, 1996. 1: Ilha do Cardoso, mangrove (C. Leonel, pers. comm.); 2: Ilha Comprida, mangrove (C. Yamashita, pers. comm.); 3: Una do Prelado river, mangrove (J.C. Guix, pers. obs.); 4: Cubatão, mangrove (J.C. Guix pers. obs.); 5: Perequê river, mangrove (C. Yamashita, pers. comm.); 6: Itatinga river, mangrove (J.C. Guix, pers. obs.); 7: Funil Area, P.E. Intervales, swap surrounded by Atlantic rainforest (Guix *et al.*, 1992); 8: Alecrim Area, P.E. Intervales, Atlantic rainforest (Guix *el al.*, 1997).

Populations in Parque Estadual Intervales

Between 1991 and 1994, two remaining populations of *C. latirostris* were found in the P.E. Intervales (Figure 3). One of them inhabited a flooded shallow near Base Funil at an altitude of 40 m, while the other one was in a 400 m^2 lagoon placed 1.5 km away from Base Alecrim (Guix *et al.* 1992, 1997).

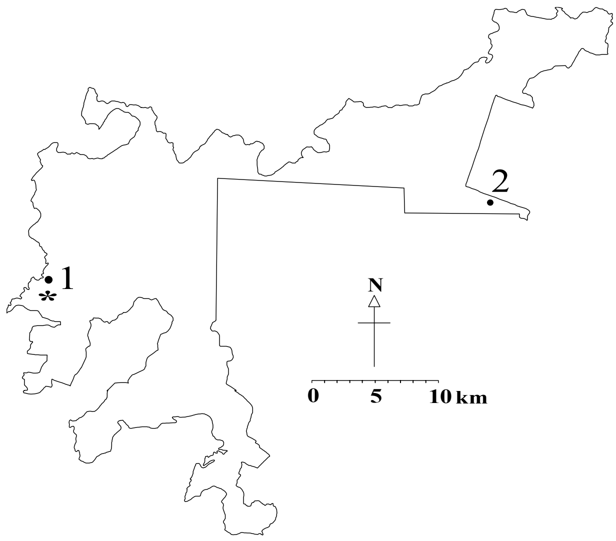

Figure 3. Parque Estadual Intervales. 1: Base Alecrim, 2: Base Funil. The * shows de position of the Alecrim lagoon.

Initially, the lagoon in Alecrim had been registered to be at an altitude of 200 m, but measurements taken in 1998 using altimeters that were more accurate indicated that the lake is at 315 m of height. It was also checked that one third of the lagoon was between 0.8 and 2 m deep, and the rest were shallow waters between 0.15 and 0.8 m. It must be pointed out that it is an artificial lagoon (Figure 4), created with the damming of a little brook after the construction of a dirt track.

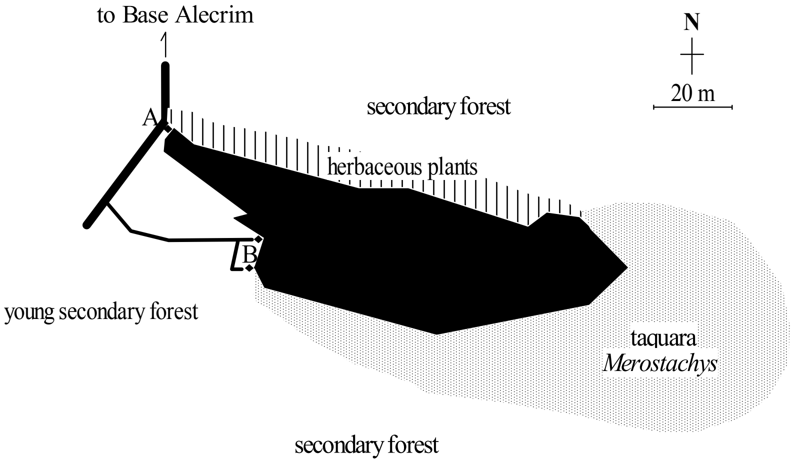

Figure 4. Lagoon in the Alecrim area where the Broad-snouted caiman was found. Black area: water mass. A and B: observation points. Thick black lines: paths.

Like most rivers in the P.E. Intervales, the Pilões (or Formoso) river, which is the main water body in the Alecrim area micro-basin, belongs to the Ribeira de Iguape water system that flows into the estuary-lagoon complex of Iguape-Cananéia-Paranaguá, one of the best preserved mangrove areas of Brazil (States of São Paulo and Paraná).

According to Mr. Donato Ursulino dos Santos, former guard living in Base Alecrim, an adult specimen appeared dead and floating on the water, a few days after a fight between two caimans was seen in the lagoon. The specimen was picked up by Mr. Donato and taxidermized by the environmental monitoring team of P.E. Intervales. It is now in the Sede museum in the park.

From that information, the aim of the searches of Broad-snouted caimans in 1998 was finding new populations in the ecological *continuum* and assessing the situation of the species in the area.

The population in the lagoon of Alecrim is particularly interesting from an ecological point of view, since it is a reproductive population that inhabit oligotrophic waters surrounded by hillsides Atlantic rainforest right on the Atlantic slope of the Serra de Paranapiacaba. This type of environment constitutes a new habitat for the species (Guix *et al*., 1997).

Specimens count in 1994

In the 1994 caiman census near Base Alecrim and Base Funil, it was checked that the old flooded shallow in Funil had dried out completely and that the native vegetation covering some of the environments used by the caimans had been almost entirely replaced by an African species of grass introduced in the area (*Brachiaria* cf. *mutica*). As mentioned above, a group of *C. latirostris* was detected in 1991; the caimans living there dispersed and they ended up leaving the P.E. Intervales. In August 1994, only five specimens were found in two flooded areas placed in farms and private lands neighbouring the park. In Alecrim, 13 specimens were counted, four of them being probably adults (Table 1).

Table 1. Number of *Caiman latirostris* specimens counted in the 1994 census.

Size categories (cm)	Funil	Alecrim
120 - 150	2	4
60 - 80	2	2
30 - 40	1	7
Total	5	13

Table 2. Number of *Caiman latirostris* specimens counted in the Alecrim lagoon in 1998.

Size categories (cm)	Alecrim
120 – 150	2
80 - 100	2
25 - 30	16
Total	20

MATERIAL AND METHODS

Surveys

Searches of new *C. latirostris* populations were performed between 18 August and 4 September 1998 in Saibadela, Alecrim, São Pedro (P.E. Intervales) and Lagoa Vermelha (Eastern P.E.T. Alto Ribeira). About 55 km of rivers and streams were surveyed during the day by the Caiman team and the

Otter team. Also, natural lagoons and flooded areas located below 500 m of height were surveyed in search of caimans and/or its traces.

Counts

In the 1998 census, places where water could accumulate and host caimans were located in the Alecrim area (valley of the river Pilões or Formoso) and the Saibadela area from cartography and information given by the guards and inhabitants of P. E. Intervales. Lakes, river pools and brooks, were examined on sunny days and some of them also at night. During daylight, searches were carried out in sandy "beaches" and in little steep canyons in river bends at times when those environments were hit by sunshine. At night, spotlights and lanterns were used to locate and count specimens.

Specimens from the lagoon in Alecrim were counted in several occasions, during the day and at night, by between two and seven people. Diurnal and nocturnal searches carried out by the team in the Saibadela area were unsuccessful.

RESULTS

Surveys

During the 1998 surveys, no new populations or isolated specimens were found in any new area. Searches in river margins in the Alecrim and Saibadela areas were fruitless. No caimans were found, and neither were nests, nor traces (tracks, tail marks) that indicated the presence of *C. latirostris* on the sand of the sunniest beaches. Only Southern river otter (*Lontra longicaudis*) traces were found in the rivers Pilões (Base Alecrim), Quilombo and Forquilha (Base Saibadela) and two South American snake-necked turtle (*Hydromedusa tectifera*) specimens were found, one of them in the Pilões river and the other one in the Saibadela river, at 160 and 80 m of altitude respectively.

Some guards from P.E. Intervales told us that they had found caiman nests in the Pilões river margins, about 10 km down from Base Alecrim, towards a locality in the South called Xiririca, that had been adjoined to the park in 1995. There was also news from a hunter that caught a 1.5 m long specimen in the Pilões river margin, in the same area where nests were found. On the other hand, we were also told about the sighting of a large specimen near the Claro river waterfall, a tributary of the Pilões river (Donato U. dos Santos, pers. comm.).

On the other hand, during the survey of the Caiman team in the Lagoa Vermelha in P.E.T. Alto Ribeira (a potential habitat for the species), near the border with P.E. Intervales, no caiman specimens were detected and there were no signals either that suggested that they may occur in that lagoon. Maybe the steep mountain slopes and the waterfalls in this region are natural barriers that stop this species reaching the area.

Counts

During the five days census in the lagoon in Alecrim, twenty specimens were detected (two adults, two possibly sub-adults and 16 juveniles; Table 2).

DISCUSSION

Even though there was recent news about the occurrence of Broad-snouted caimans in rivers near the Saibadela area (J. Sabino, pers. comm., 1997), this species was not found during the day or at night near Base Saibadela and its surroundings. The guards did not have any news on the presence of this species in the Saibadela area, although it is known that specimens are sometimes caught in parts of the river that are not under the protection of the park (J. Vieira, pers. comm., 1998).

Maybe the most outstanding facts of the current census in the lagoon in Alecrim were the sighting of a relatively high number of *C. latirostris* juveniles in August and the finding of introduced tilapia shoals (*Tilapia* sp.; Cichlidae), on which caimans probably fed. The existence of these tilapia shoals would explain how adult caimans could survive in a little lagoon fed by a very small oligotrophic brook (width of the brook: 30-40 cm; depth: 2-3 cm).

Apparently, there is only one dominant pair in the lagoon in Alecrim that breeds every year. During the breeding season, this pair must turn especially territorialist and it scares away sub-adult specimens that would share the space with the adults in other periods (see minimum adult size in Verdade & Sarkis, 1998).

In the August 1998 census, no specimens between 30 and 80 cm in length were found. The fact that juveniles and sub-adults up to 40 cm were nevertheless found in the 1994 census suggests that as young individuals grow they are either predated by other animals (possibly even by sub-adults and adults of the same species that inhabit the lagoon) or they disperse through the local water system getting maybe as far as the main river in the region, the Ribeira de Iguape.

It is obvious that such a small population as the one inhabiting the lagoon in Alecrim is not genetically sustainable in the medium and long terms. Consanguinity problems may arise between the young specimens that survive and that can eventually achieve the adult state. On the other hand, this lagoon – artificially created after the damming of a little brook with the construction of an unpaved track that follows the Pilões river valley – does not seem big enough to sustain any more adult specimens (either because of the lack of food or because of the lack of space for more than one pair to establish their territory to breed and nest).

It is important that a management plan is established for this species in the area. The possibility of rescuing specimens living beyond the limits of P.E. Intervales (where illegal hunting pressure is still high) should be considered, as well as the recovery of points below 300 m of height were water used to accumulate (such as the formerly flooded area in the Base Funil) and the translocation of specimens between populations living in protected areas.

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Chapter 12

SOME OBSERVATIONS ON THE SOUTHERN RIVER OTTER (*LONTRA LONGICAUDIS*, MAMMALIA: MUSTELIDAE): STATUS AND BIOLOGY

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ABSTRACT. Between 18 August and 4 September 1998, Southern river otter (*Lontra longicaudis*) surveys were performed along oligotrophic rivers and streams of seven zones of the Paranapiacaba Atlantic rainforest fragment, in Southeastern Brazil. The otters were detected through sightings and the presence on fresh scats and tracks at the entrance of their dens in all of these zones, covering an altitudinal profile of 60 - 850 m. A preliminary analysis of the scats found in five of the surveyed areas, showed fishes, crustaceans, mammals, birds and insects as the most common items in the diet of this species. Results obtained highlight the importance of the Paranapiacaba forest fragment in the conservation of the Southern river otter.

KEY WORDS. Brazilian Atlantic rainforest, conservation, diet, habitat use, *Lontra longicaudis*, survey.

INTRODUCTION

Medium and large size carnivorous mammals (Order Carnivora) have always been subject to the interest of researchers, not only because they are conspicuous species but also because they are key species; their disappearance would result into a chain reaction affecting drastically the equilibrium in the ecosystems where they occur (Glanz, 1982). These species tend to be placed at the top levels of trophic chains and, at the same time, they work as indicators of the conservation status of an environment. Because of this, describing where they occur and their conservation status can be basic to develop conservation strategies.

Although *Lontra longicaudis* is not a conspicuous species, which is obvious from the low number of sightings made by researchers (cf. Blacher, 1987; Quadros, 1998), it can act as an indicator of river conservation. Southern river otters do not tolerate polluted waters or deforested margins that cannot offer them proper food and refuge.

Lontra longicaudis taxonomy is currently under revision. Their synonymies include: *Lutra annectens, L. a. colombiana, L. platensis, L. incarum, L. enudris, L. e. mitis, L. insularis, L. repanda, L. latidens* (Foster-Turley *et al.*, 1990). Some authors (Hershkovitz, 1972; Davis, 1978 quoted by Foster-Turley *et al.*, 1990) consider it as belonging to *L. canadensis*. The name *Lontra longicaudis* (Van Zyll de Jong, 1972) is the most widely accepted now (Foster-Turley *et al.*, 1990; Waldemarin, 1997).

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

Needing to be protected by law, the Southern river otter was considered as an endangered species and it was included, together with 208 other species, in the list of threatened animals published by the Brazilian Government (Lista Oficial de Espécies da Fauna Brasileira Ameaçadas de Extinção; Decree num. 1522, of 19 December 1989 and Decree num. 45-N of 27 April 1992, of the Instituto Brasileiro de Meio Ambiente e Recursos Naturais-IBAMA). It was included also, together with 311 more species, in the list of threatened animals published by the State of São Paulo Government (Espécies da Fauna Silvestre Ameaçadas de Extinção do Estado de São Paulo; Decree num. 42838, of 4 February 1998 of the Secretaria do Meio Ambiente do Estado de São Paulo), being forbidden its hunting, use, chase or capture. In the U.S. Endangered Species Act (1973), it was catalogued as threatened (Foster-Turley *et al.*, 1990). Nevertheless, *L. longicaudis* is listed, at an international level, as *data deficient* (see UNEP-WCMC, 2001).

Blacher (1987) points out that very few things are known about Brazilian otters. Basic subjects such as taxonomy and distribution as well as questions on their biology, ecology and conservation must be resolved. Some works are that by Quadros (1998), on *Lontra longicaudis* ecology in the Município de Itapoá, State of Santa Catarina; the one by Waldemarin (1997) including a study on *L. longicaudis* ecology in the Parque Nacional da Lagoa do Peixe: management and conservation; finally the ones by Pardini (1996), including otter ecology studies in the Parque Estadual Turístico do Alto Ribeira, and Blacher (1987) considering occurrence and conservation of the species on the coast of Santa Catarina.

According to Cimardi (1996), *L. longicaudis* feeds on little mammals, birds, amphibians, fishes, molluscs and crustaceans. After analysing excrements collected in the Lagoa do Peri, in Santa Catarina, Blacher (1987) concluded that the basis of *L. longicaudis* diet are freshwater shrimps (*pitús*) and fishes, detected by the presence of exoskeletons, scales and otoliths. Bardier (1992), studying otters in Uruguay and after a preliminary analysis of 187 samples, suggested that the main components in otter diet are fishes and crustaceans. Pardini (1998), after analysing 569 excrement samples collected in the Betari river in P.E.T. Alto Ribeira, State of São Paulo, found the main items in *L. longicaudis* diet to be: fishes (mainly Fam. Loricariidae, occurring in 84.5% of the samples), crustaceans (mainly *Aegla shmitti*, in 68.3% of the samples), arthropods (found in 78,9% of the samples) and insects (*Corydalus* sp. larvae occurring in 20.7% of the samples); other items (mammals, amphibians, birds and reptiles) appear in less than 5% of the samples. In samples collected in the Reserva Volta Velha, Itapoá-SC, Quadros (1998) found two main types of prey in 202 excrement samples: fishes (mainly *Hoplias malabaricus* and *Geophagus brasiliensis*), occurring in 74.26% of the samples, and crustaceans (mainly *Trichodactylus fluviatilis*), in 62.87% of the samples); trophic opportunism was obvious from the presence of items such as fruits, birds, reptiles and mammals. Medina (1998) analysed 605 excrement samples from *Lutra provocax* in Chile, finding crustaceans (*Aegla rostrata*, *Aegla abtao abtao* and *Samastacus spinifrons*) and fishes (*Percilia gillisi*, *Percichthys trucha*, *Oncorhyncus mykiss*, *Salmo trutta* and *Galaxias* spp.) in decreasing order of importance within the otter diet; mussels (*Chilina* spp.) and birds (*Podilymbus podiceps*) appeared sometimes in the samples.

Many techniques have been developed to carry out animal censuses. Data obtained on populations have been: relative abundance, density, species diversity, biomass estimates, area use and some others. Depending on their aquatic habits, censusing techniques are not easy to apply in otters (Melquist & Hornocker, 1979). The same authors concluded that there is not such a thing as an easy method to census otters. Their occurrence in an area can be detected through scats, tracks, food remains and dens. Population estimates can be achieved through a combination of capture data, sighting of unmarked individuals, traces and the elements quoted above.

The aims of the current work can be summarised as follows: a- carrying out a preliminary evaluation on *Lontra longicaudis* occurrence in the Paranapiacaba forest fragment; b- identifying the main items in the diet of this species in the area.

MATERIAL AND METHODS

Data were collected in seven areas: Núcleo Caboclos (P.E.T. Alto Ribeira); Alecrim, Carmo, Barra Grande, São Pedro and Saibadela (P.E. Intervales); Sede (P.E. Carlos Botelho) (see chapter 3). Two surveys, averaging 5 hours in length each, were carried out in the São Pedro area (P.E. Intervales) between 18 August and 4 September 1998. Approximately 5 km along the São Pedro River were covered. This trail was considered from the affluents Xaxin and Tartaruga up, totalising 20 points where data were collected. Surveys were carried out between 9:00 h and 13:30 h. According to the method described in Pardini (1996), traces indicating the use of the area by the species (scats, tracks, dens, scratches, odours and/or food remains) were searched along the transect.

Scat samples collected were put in plastic bags and marked, indicating type of substratum on which it was found (dry tree trunk, stone or ground), age (recent or old), date, relapse or not, and river name and margin (Quadros, 1998). Relapse was tested using a white nail-varnish on the spots were scats were found.

Scat samples were dried at 50ºC for 48 hours. Sorting of the elements inside was carried out after. Since their composition was highly heterogeneous (fish spines, backbones, hairs, remains of crustacean exoskeletons, insect wings, little fish mandibles, little mammal bones and skulls), an electric shaker with four filters (0.21 mm, 0.50 mm, 1.19 mm and 2.00 mm) was used to obtain five grain sizes to help separating elements in otter diet. Otter tracks were photographed and measured.

The São Pedro River margins, made of dense woody and herbaceous vegetation, were carefully observed according to the methods suggested by Quadros (1998) and Pardini (1996) with the aim of finding dens that were being used by otters. Their use is detected by the presence of odours, tracks, platforms to enable access from the water and scratches at the entrance. These scratches are related to the widening or keeping of dens and platforms.

In order to complete data collection to verify the presence of the species in other areas of the Paranapiacaba forest fragment, observations were carried out in the following water systems: Triminina River (Núcleo Caboclos - P.E.T. Alto Ribeira); Pilões or Formoso River (Alecrim area - P.E. Intervales); Barra da Macaca River (Barra Grande area - P.E. Intervales); Carmo River (Carmo area - P.E. Intervales); Quilombo, Etá and Forquilha Rivers (Saibadela area - P.E. Intervales); Pedras and Taquaral Rivers (Sede - P.E. Carlos Botelho). Excepting in those from Saibadela, the following comments on dens were registered: probable or effective use by otters, river margin, entrance diameter, vertical and horizontal distances to the river and reference point (river or base).

RESULTS

Along the 5000 m of the São Pedro River (P.E. Intervales, São Pedro area), nine dens were detected. Only two of those were considered as being used by otters. In the remaining localities that were visited by other teams (Table 1), six dens were found along 300 m of the Taquaral River (P.E. Carlos Botelho) and only one of them was being used. Five dens were located along 500 m of the Barra da Macaca River (P.E. Intervales, Barra Grande area), but none of them had traces to show that it had been used recently. Finally, three of the fourteen dens found along 300 m of the Carmo River (P.E. Intervales, Carmo area) were being used by otters.

Table 1. Characteristics of the Southern river otter (*Lontra longicaudis*) dens located in the Carmo and Barra Grande areas (P.E. Intervales), and P.E. Carlos Botelho. (*) Presence of scats at the entrance. [1] Taquaral River (Sede - P.E. Carlos Botelho); Barra da Macaca River in Barra Grande area (P.E. Intervales); Carmo River in Carmo area (P.E. Intervales).

Den	River margin	Den entrance size (cm)	Vertical distance to the river (cm)	Horizontal distance to the river (cm)	River[1]
1	right	66/40	200	170	Taquaral
2	right	115/98	50	145	Taquaral
3	right	40/40	10	0	Taquaral
4	left	30/25	95	90	Taquaral
5	right	30/22	73	0	Taquaral
6	right	30/30	116	0	Taquaral
7	left	13/18	100	40	Barra Macaca
8	right	33/18	30	7	Barra Macaca
9	left	23/30	60	30	Barra Macaca
10	left	25/17	2	5	Barra Macaca
11	left	30/25	60	30	Barra Macaca
12	left	40/20 (*)	60	100	Carmo
13	left	40/20	85	110	Carmo
14	left	45/20	70	150	Carmo
15	left	15/20	90	400	Carmo
16	left	16/30	90	350	Carmo
17	left	25/27	100	300	Carmo
18	left	48/15	70	100	Carmo
19	left	18/35	50	130	Carmo
20	right	30/50	100	100	Carmo
21	right	16/20 (*)	60	110	Carmo
22	right	20/20	50	250	Carmo
23	left	16/20	50	250	Carmo
24	left	50/20 (*)	200	200	Carmo
25	left	25/45	100	110	Carmo

Even though the São Pedro River has sand banks along its margins, very few footprints were detected. Footprints were found near the entrance of two of the three dens being used by otters in the Carmo River, which confirmed their use. No footprints were found in the remaining localities.

During the sampling period, 40 scat samples were collected: 30 samples in the São Pedro River (locality where the highest sampling effort was applied), four samples in the Quilombo River, one sample in the Forquilha River, one sample in the Etá River (P.E. Intervales); three samples in the Taquaral River and one more in the Pedras River (P.E. Carlos Botelho). In the São Pedro River, stones were the favourite place for otters to defecate.

Considering that the sampling effort was higher in São Pedro area, results were analysed separately and then together with those data from other rivers. The main items in the diet of São Pedro River otters were fishes and crustaceans. In scats collected in 12 points of this river and its tributaries, preys appeared as follows: crustaceans in 92% of the collecting points, insects 33%, fishes 83%, birds 33% and mammals 42%. Results were similar in the remaining rivers although data relative to mammals, birds and insects could not be analysed because of the very few samples collected.

Three sightings occurred during the collecting period; one individual was seen on a rock by the Timinina River - Núcleo Caboclos in P.E.T. Alto Ribeira (João Dagoberto dos Santos, pers. comm.), another one in the Formoso River - Alecrim area in P.E. Intervales (Blanche Souza Pinto, pers. comm.) and two individuals were seen together at dusk in the waters of São Pedro River, São Pedro area in P.E. Intervales.

DISCUSSION

Natural History

The low number of sightings in the different observation areas in the Paranapiacaba fragment, as well as those made other authors in other regions, suggests that *L. longicaudis* is not very conspicuous. While working in Itapoá-SC, Quadros (1998) made four sightings in 19 surveys. Schweizer (1992), quoted by Quadros (1998), made 28 contacts in 392 days in the Negro River - MS, 82% of which corresponded to single individuals. Blacher (1987) made three contacts in 19 surveys in Santa Catarina Island.

Quadros (1998) points out that the morphofunctional dentition pattern of *L. longicaudis* is potentially adapted to the consumption of fishes as well as invertebrates. This preference was detected in this work and several others (Pardini, 1998; Medina, 1998; Bardier, 1992), which mention the high fish and crustacean consumption in a well diversified diet.

There is an interesting point regarding diet and amphibians: neither in the current work nor in Quadros (1998) were traces detected to indicate that amphibians were included in the diet. The author mentions that the methodology used to analyse diet composition (scat analysis) is not the most appropriate to identify amphibians. Amphibians do not have keratinised epidermic annexes that can resist digestion (e.g. hairs, feathers, carapaces, scales) and they do not have true teeth either. The author does not discard the possibility of amphibians being included in the diet of *L. longicaudis* and suggests that its consumption might be relatively low, like that detected by Pardini (1998) for mammals, birds, reptiles, arthropods and insects, or that it might be highly related to its availability in the environment.

Conservation

Huerta (1992) points out that more than a quarter (27%) of endangered carnivores are membres of the families Felidae and Mustelidae being in a similar proportion (23%) with 19 species of which eight are otter species. The relationship between size and vulnerability in carnivorous species has been explained through the following hypothesis: gestation length, weight at birth, offspring size, age at weaning, sexual maturity, age of independence, inter-reproductive interval and longevity are related through a positive correlation with body and brain weight in adult carnivores (Bekoff & Daniels, 1984 quoted by Huerta, 1992). Based on this, Huerta (1992) calculates potential capability of response to a population reduction in ideal conditions. The species with the lowest population growth rates would be the American black bear (*Ursus americanus*), the Sea otter (*Enhydra lutris*), the Southern river otter (*L. longicaudis*), the Kinkajou (*Potos flavus*), the Jaguar (*Panthera onca*), and the Puma (*Puma concolor*); having an intermediate population growth rate would be the Bobcat (*Lynx rufus*), the Cacomixtle (*Bassariscus astutus*) and the Coyote (*Canis latrans*). Because of its low capability of response to population reduction, national and international actions to enhance knowledge and protection of *L. longicaudis* as well as the conservation of its habitats are deeply needed. Due to the fragmentation process in tropical forests where the Atlantic rainforest is included, less than 7.16% of its original area in the State of São Paulo is preserved today (Fundação SOS Mata Atlântica & INPE, 1993).

The Paranapiacaba fragment is a continuous forest placed at the top of the Paranapiacaba mountain range (water divisor). It is of vital importance for the survival of aquatic and semiaquatic mammals of the Brazilian Atlantic rainforest such as *L. longicaudis*.

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Chapter 13

APPLICATION OF TREE CLIMBING TECHNIQUES TO BIRDS OF PREY SURVEYS IN THE ATLANTIC RAINFOREST

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INTRODUCTION

Trees are undoubtedly the most important elements in the rainforest. As main characters in the landscape, trees constitute the mainstay of the diversified biome of the Brazilian Atlantic rainforest. Their growth in height, in constant competition for light, originates different strata which determine the ecosystem's activity, structure and richness. Accessing arboreal strata may yield important information for several fields of research (Laman, 1994). The need to access trees in order to describe the vertical structure of the arboreal system, as well as to carry out censuses of birds of prey was raised during fieldtrips to the Atlantic rainforest in the State of São Paulo in 1991, 1994 and 1998 (Guix *et al*., 1992; Mateos & Mañosa, 1996). Experience acquired in these three trips enabled the development of a climbing technique to allow researchers to access tree tops when necessary. Basic matters considered to develop this method were security and efficiency, as well as simplicity and accessibility for people without an outstanding physical condition. Moreover, environmental impact had to be minimal. Based on that, the technique used by professional tree climbers was considered to be the most appropriate one.

GENERAL DESCRIPTION OF TREE CLIMBING TECHNIQUE

Equipment and specific methods used in tree climbing are different from those used in rock climbing or vertical works. In rock climbing, the rope and harness are only used to hold the climber in the event of a fall. The rope must be elastic in order to cushion the jerk and its surface must resist friction. The harness must be light enough to enable free movement. In tree climbing, rope and saddle constantly hold the climber to the tree and enable ascent. The rope must therefore be static and the saddle must be strong and comfortable.The climbing knot used is a prussik knot and it determines what type of rope must be used. This knot acts as a security and blocking system.

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Climbing a tree comprises three stages:

1.- Installation (Figures 1a, 1b). It consists of looping an access rope to the tree top, at a point above the one where observers shall be placed. This rope stays permanently fixed and it is used by anyone climbing the tree. Installation can be done in one or several stages. Once the rope is tied up, the installer goes back to the ground with the help of a descending rope, different from the former, and a prussik knot. The installation stage is the one that takes longest so it is best carried out prior to the day in which the census must be performed.

2.- Climb (Figures 1c, 1d). Once the access rope is installed, it stays fixed to enable the ascent of climbers with the help of mechanical ascenders. When the climbers reach their summit, they get positioned with the aid of a secondary rope which is also used for switching between rope settings, positioning, climbing short distances, as a back up measure and to enable descent.

Figure 1a-e. Different stages of tree climbing. a) The installer casts the throwing pear which is tied to a throw weight line to loop it over a branch. b) With the aid of the throw weight line, the climbing rope is looped over and fixed to the branch. If the rope needs to be placed at a higher level, installation is done thorugh several stages. c) When the rope is fixed, it can be used to climb. d) Once at the top, the climber secures himself to the branches with the descending rope and/or with the waist rope. e) When descending, the climbing rope has been released and dropped. The climber slides down his descending rope controlling speed with the help of the prussik knot.

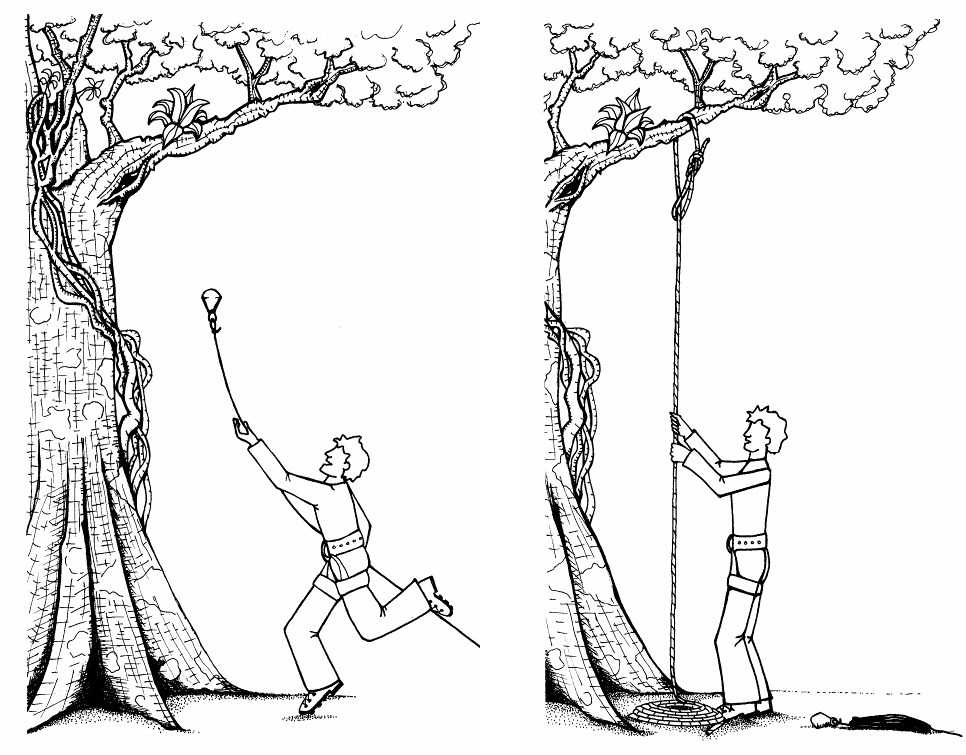


Figure 1a

Figure 1b

3.- Descent (Figure 1e). Each climber descends along their own secondary rope with the help of a prussik knot. Descent speed is controlled by grasping and gently pulling down the knot.

Figure 1c

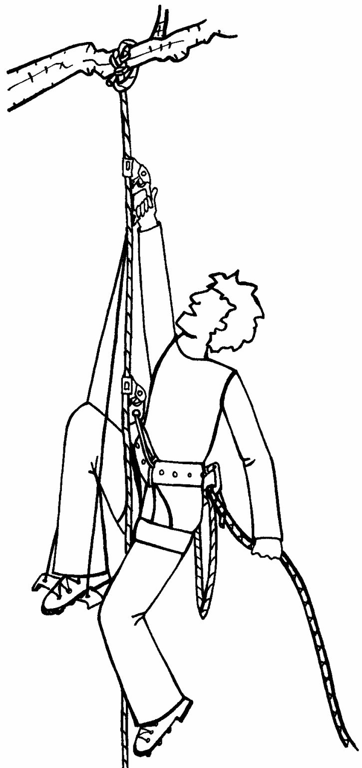
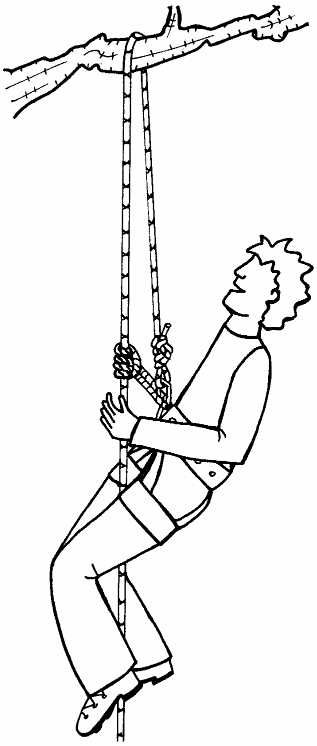


Figure 1d



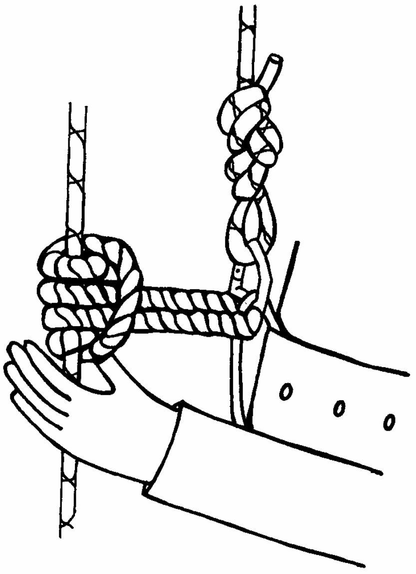


Figure 1e

Equipment

Although security and efficiency are basic when choosing equipment and methods to apply in tree climbing, minimising the impact of the climb on the tree is also extremely important. This was taken into account when picking up the equipment, which is listed below:

Saddle

It must be comfortable, with two wide padded straps to hold waist and legs. The waist strap has two lateral rings from where the climber is suspended.

Ropes

- Climbing rope. It is the one tied to the tree by the installer. It is a static rope made of polyester, polypropylene or nylon, twist constructed and 11 or 12 mm (1/2 inch) in diameter. It is about 50 m long.
- Descending rope. One for each climber. It is thicker and softer than the one above. One of the ends is fixed with a figure of eight and a carabiner to the saddle's central ring. A prussik knot is fixed to the rope through a line and it is secured to the saddle's central ring with a second carabiner which is placed above the first one. The prussik knot can be moved along the rope to control the length of the loop between the knot and the end of the rope which is fixed to the saddle.
- Waist security rope. It is between 6 and 8 m long, with a figure of eight in one end to which a carabiner is attached. This carabiner is used to hold the end of the rope to the saddle's left ring. A prussik knot is fixed to the rope through a line and it is secured to the saddle's right ring. The knot is moved along the rope to control its length. When this rope is not available, the loose end of the climbing rope can be used in stead, being fixed through a prussik knot to the saddle's waist rings.
- Two prussik knots. The prussik knot is easy to make and use. It enables climbers to be secured to the trees but it gives them a considerable freedom of movement. It is made with a 1 m long line twice twisted around itself and around a rope. The knot has the shape of a fist that can be moved along the rope when the line is not under tension but that throttles and stays jammed when the climber's weight is hanging from the knot. Preferably, either the same type of rope as the descending one or a slightly thinner one is used to make the knot. It is important that it is thick enough to be hold with the hand and to guarantee that it works smoothly.
- Throw weight line. It is about 50 m long and 2 mm in diameter. A weight is tied at the end to be lobbed over a branch in the tree. Once the line has been passed, its loose end is tied to the climbing rope and it is pulled up until both ends are hold by the person on the ground.

Throwing pear

It is a pear-shaped ball tied to the end of the throw line. It is a lead weight encased in foam rubber and it weights around 475 g.

Crampons

Metal grips hold to the installer’s boots through a leather strap. They facilitate the initial climbing in order to set up the ropes, but their use might be extremely damaging for the tree. This technique was used in the 1994 expedition but in 1998 it was decided that throwing pears and throw weight lines would be used in stead.

Fren

Metal device that is fixed to the saddle’s central ring with a carabiner and through which the ascending rope is passed. It incorporates a mechanism that stops it moving down the rope, which secures the climber and stop him falling down even if he releases his hand grip.

Mecanical ascenders

Metal handle that attaches to the rope. It incorporates a mechanism that enables it to only move up the rope. A foot stirrup is tied to the device. The climber attaches himself to the ascender and pushes it up as he stands up in the foot stirrup, then the stirrup is slided up while the climber hangs from the top ascender. Synchronised movements allow the climber to slide up the rope.

Technique

The climbing rope can be fixed to the tree in two different ways. The installer can either climb the tree using crampons and a security rope around his waist and around the tree trunk, or he can loop the rope over a strong branch with the help of a throw ball.

Climbers wearing their saddles access the tree through the rope that has previously been fixed by the installer, and they do so with the help of mechanical ascenders and foot stirrups. Each climber carries his waist rope and descent rope tied to the saddle with prussik knots. When the climber reaches the top he must loop the end of one of those two ropes over a higher branch and then fix it to his saddle. Prussik knots enable control of the resulting length, and the climber can then release himself from the climbing rope. From then on, he must secure himself with the waist rope and the descent rope alternatively until he reaches the position where he wants to stay. Tree climbing saddles are confortable enough to spend relatively long periods of time at tree tops.

When the climbers want to go down, they release the climbing rope and let it fall. Then they secure themselves with the descent rope, they tauten the prussik knot and smoothly slide down to the ground. The descent rope is recovered by pulling from one of its ends.

APPLICATION OF TREE-CLIMBIMG TO BIRDS OF PREY CENSUSES

The need of carrying out censuses of birds of prey had been considered during the 1994 and 1998 trips to the Atlantic rainforest in the State of São Paulo, since it holds some endemic species of this group of birds (see chapter 14). One of the easiest are most widely used techniques to estimate birds of prey abundances in a big area consists of placing a team of observers along and across the area; each observer stays in his location for a predetermined length of time while writing down the number of birds of prey that are spotted from his position as they fly or as they stand still. This procedure enables the calculation of an index of abundance for species which, because of their habits, are most frequently observed flying over the forest. The main problem that arises when planning a census of birds of prey is finding locations from which a wide vision of the setting can be obtained, since trees and the usually flat relief obstruct visibility above the canopy. Tree climbing has been used by several researchers to overcome such difficulty, since it allows observers to be placed in emerging points of the rainforest (Whitacre & Burnham 1992). We also chose this technique to execute censuses of birds of prey in the Brazilian Atlantic rainforest whenever those censuses could not be carried out from the ground. This way, census points could be chosen in a more random way which was less dependent from the availability of good points on the ground. Two expeditions have given us a valuable experience in terms of choosing trees in order to optimise the sampling effort.

Tree height

Emerging trees were chosen in most cases in which tree climbing technique was used to carry out censuses of birds of prey, since they gave a good vision above the canopy in flat areas. The marked relief of the Brazilian Atlantic rainforest provides good observation points without the need of climbing emerging trees which are quite difficult to find. Election is made based on the situation of the tree relative to the slope and their neighbours rather than on their height. Higher trees take more time to climb and therefore it is better choosing shorter trees placed in a good location in order to reduce the installation time and the effort needed. The fact that the point up to which the tree can be climbed is above the highest level of the surrounding trees is far more important than the tree height itself.

Tree location relative to relief

Trees placed on hills or on the highest points of slopes are generally prefered, since they enable a good visibility. Also, those placed on strong slopes give a better visibility down the slope.

Tree orientation

Since censuses are carried out in the morning, it is impoortant that census points have a good view to the West to stop the blinding effect of the sun, which makes bird detection and identification extremely difficult.

Accessibility to the base of the tree

Tree climbing gear is heavy and carrying it around the forest in the absence of tracks or paths becomes difficult, as difficult as orientating in the forest to reach the chosen spots. It is therefore preferable choosing trees near tracks or paths since they can be easily accessed.

Presence of epiphytes

The presence of a big quantity of epiphytes hinders the installation of the climbing system, it slows down the climbers on their way up and it increases the risk of accidents and injuries provoqued by vegetation or associated fauna. Moreover, epiphytes are disturbed by the climbing process, and therefore avoiding trees covered by a big quantity of epiphytes is highly recomended.

Arboreal species

Although species is not a factor that is taken into account when choosing a tree, large *Cecropia* are trees with a structure and a type of growth that are quite appropriate for climbing. They are also associated to forest clearings and they grow fast and straight up so they usually offer a good visibility.

CONCLUSIONS

After three expeditions to the Brazilian Atlantic rainforest, tree climbing technique has proved to be highly useful as a tool to study different aspects of forest ecology. To start with, it is simple and safe, it requires minimal equipment and a short time to learn and just a little bit of practice. The technique was shown not only to the researchers involved in studies concerning forest structure and birds of prey, but also to guards and supervisors of the P. E. Intervales. This way, one of the main objectives of the expeditions was achieved: giving to the parks' employees the minimum knowledge so that they can use tree climbing technique in monitoring programs that might be developped in the future. A tree climbing set has been kept in the P. E. Intervales from 1994.

Carrying out censuses of birds of prey has been the main application of tree climbing in the expeditions. Tree climbing has proved to be a helpful tool since it enables visibility in places where it would be impossible to get it from the ground. It is necessary, though, dedicating an important initial effort to find good trees and to install the climbing equipment in places previously chosen according to the census needs. Since birds of prey censuses are preferably carried out between 9:00 a.m. and noon and since finding, approaching, preparing and climbing a tree can take between 1 and 4 hours, it is important that points of count are located and equipped prior to the census so that observers can be in their places on time. Ideally, a team of two or three people should dedicate its time to find and equip trees according to the census needs while one or more teams should be carrying out counts from the locations set by that first team. A trained team can find and equip two trees per day. It is recommended that points of count are clearly located and labelled on the map and in the field so that they can easily be located by observers and in later ocasions; that way, the enormous effort that locating and climbing implies is highly rewarded.

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Chapter 14

BIRDS OF PREY SURVEY (AVES: CATHARTIFORMES AND ACCIPITRIFORMES) IN THE PARANAPIACABA FOREST FRAGMENT

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ABSTRACT.- A total of 23 point-counts were conducted between 18 August and 4 September 1998 in an Atlantic rainforest area of the State of São Paulo (Southeastern Brazil), to obtain data on bird of prey abundance in two adjacent protected areas from the Parque Estadual Intervales and the Parque Estadual Turístico do Alto Ribeira. A total of 88.17 h were devoted to observation, during which 334 contacts with birds of prey, involving 719 individuals of 9 especies, were obtained. The Black vulture *Coragyps atratus* was observed in 91% of the counts, followed by the Mantled hawk *Leucopternis polionota* (78%), the Black hawk-eagle *Spizaetus tyrannus* (43%), the Turkey vulture *Cathartes aura* (22%), the Ornate hawk-eagle *Spizaetus ornatus* (17%), the Roadside hawk *Buteo magnirostris* (9%), the Short-tailed hawk *Buteo brachyurus* (9%), the Crested caracara *Polyborus plancus* (9%), and the Tiny hawk *Accipiter superciliosus* (4%). The presence of open patches in P.E.T. Alto Ribeira favoured higher scavenger abundance than in P.E. Intervales, but abundance of other non-scavenger species was similar in both areas. Mapping of simultaneous observations of individuals of *Spizaetus tyrannus* and of *Leucopternis polionota* indicated that average territory length for these species was 5 km and 2.4 km respectively.

KEY WORDS. Brazilian Atlantic rainforest, birds of prey, count, territories, relative abundance.

INTRODUCTION

The Brazilian Atlantic rainforest hosts several species or subspecies of diurnal birds of prey which are endemic to the region and that are currently threatened, i.e.: *Leptodon forbesi, Leucopternis lacernulata, Leucopternis polionota* and *Spizaetus tyrannus tyrannus* (Collar *et al.*,1992; del Hoyo *et al.*, 1994; Bildstein *et al.*, 1998; Bierregaard, 1998*)*. It hosts as well other species of widely distributed birds of prey which are, however, endangered or under threat in Brazil, such as *Harpia harpyja*, *Leptodon cayanensis*, or *Spizaetus ornatus* (Bernardes *et al.*, 1990). As predators placed at the top of trophic chains, forest birds of prey need wide areas of woodland to ensure subsistence and they are therefore very sensitive to deforestation and habitat fragmentation. Generally, birds of prey are good ecological indicators of the degree of conservation of the forest spots that they inhabit, since some species require wide and well preserved rainforest areas, while some others appear as soon as anthropic alterations occur

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(Mañosa & Pedrocchi, 1997; Bierregaard, 1998).

Approximately 111 of the 296 known species of diurnal birds of prey live in tropical forests. Fortyone of these 111 species are considered as endangered in the Red Book of the International Committee for Bird Conservation, and the situation of many more is unknown (Thiollay, 1994). More than 50% of the species of tropical birds of prey are threatened by destruction or fragmentation of habitats, by the presence of environmental pollutants, by hunting pressure, or by a combination of all those factors (Thiollay, 1985; Bildstein *et al.*, 1998). These facts justify the start of scientific and conservation programs to preserve this taxon as a significant and quite often key element of the world's biodiversity, that is currently disappearing (Burnham *et al.*, 1994).

The situation of the populations of forest birds of prey in the Neotropical regions and particularly in the Brazil area, is quite unknown (Albuquerque, 1986). One of the reasons to explain the lack of information on the subject is the fact that methods commonly used to count terrestrial birds are not applicable to estimate population sizes of birds of prey (Forsman & Solonen, 1984). Additional difficulties associated with the characteristics of the habitat appear in tropical forests to complicate the study of birds of prey (Thiollay, 1989). These methodological difficulties mean that the basic information needed to design conservation strategies to preserve those species is lacking. Several research and monitoring programs on birds of prey are currently being developed in the Neotropical region in order to fill these gaps (Thiollay, 1989; Vannini, 1989; Whitacre & Thorstrom, 1992), but little attention has been paid so far to the Atlantic rainforest.

The purpouse of our work was obtaining new information on the conservation status of some species of birds of prey which are endangered or endemic to the Atlantic rainforests in Brazil. With that objective in mind, a census was designed to estimate the abundance of the species that had been detected in two previous expeditions to the Parque Estadual Intervales, during which the interest of this area for the conservation of birds of prey became apparent (Guix *et al.*, 1992; Mateos & Mañosa, 1996; Mañosa & Pedrocchi, 1997). Determining population sizes in large birds of prey is basic for their conservation, since genetic and demographic viability is only guaranteed above certain population value (Frankel & Soulé, 1981), and is therefore crucial to establish their degree of vulnerability and resilience (Bierregaard, 1998), as well as to set management and conservation strategies.

METHODOLOGY AND AREA OF STUDY

Based on the results of a preliminary study (Mañosa & Pedrocchi, 1997), point-counts were chosen to estimate abundances of the most common species of birds of prey in Atlantic rainforest area. The method consists on selecting counting points spread across the area under study and devoting several hours to observation from each location. Positions must be placed on elevations or on top of emergent trees in order to guarantee a good visibility of the aerial space (see chapter 13). During the observation period, all birds of prey that are spotted, either flying or still, must be recorded.

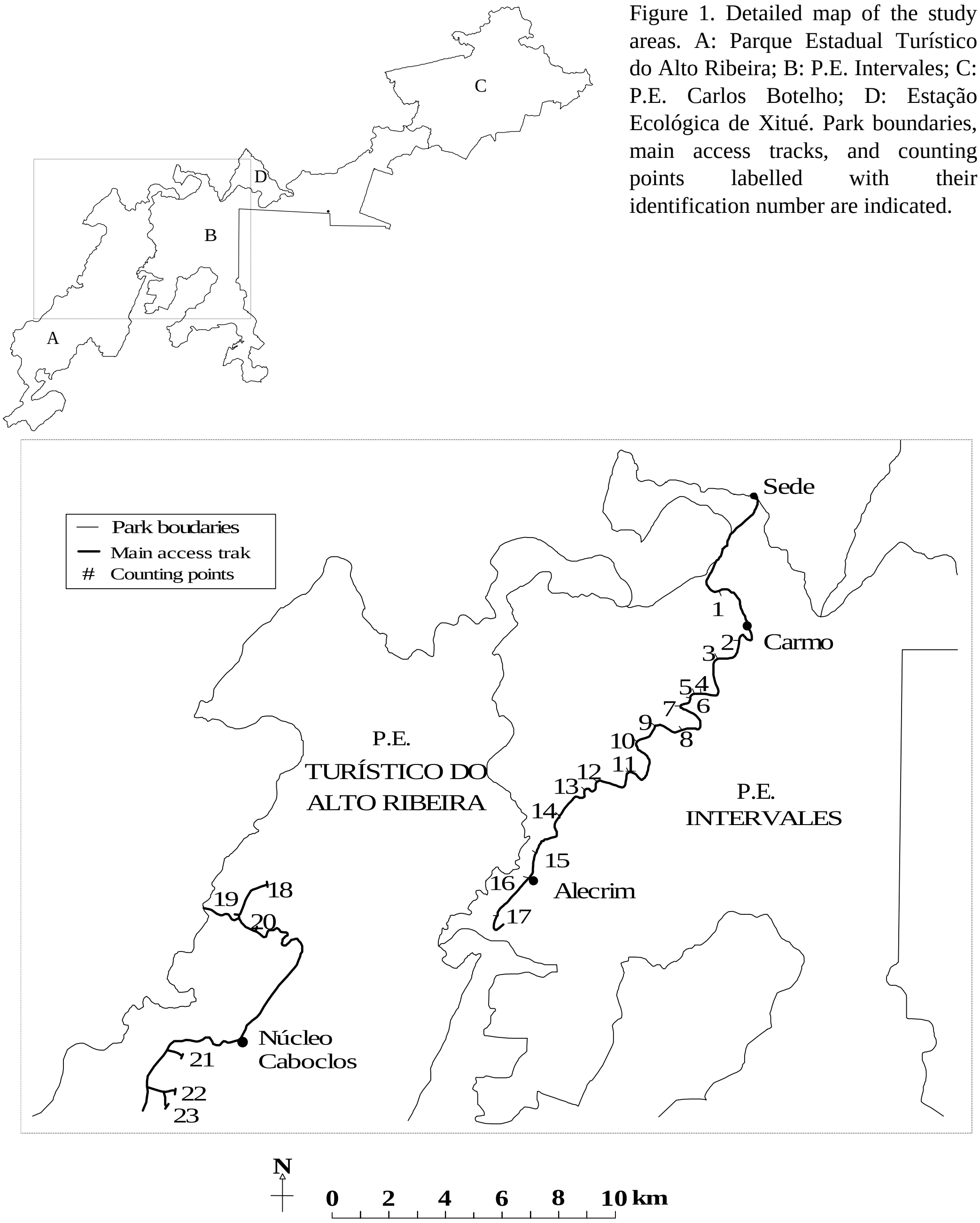


Figure 1. Detailed map of the study areas. A: Parque Estadual Turístico do Alto Ribeira; B: P.E. Intervales; C: P.E. Carlos Botelho; D: Estação Ecológica de Xitué. Park boundaries, main access tracks, and counting points labelled with their identification number are indicated.

Counts were carried out in two adjacent areas in the P.E. Intervales and the P.E.T. Alto Ribeira (Figure 1, see chapter 3). In P.E. Intervales 17 points were selected (see Appendix). Points were distributed along the track that joins Sede and Base Alecrim following the Formoso River valley, from the confluence of the Córrego de Agua Comprida with the Córrego Lobrego, 2.3 km above the Base Carmo, to 2.6 km beyond the Base Alecrim. In P.E.T. Alto Ribeira, 6 points were chosen, all of them located around Núcleo Caboclos (Figure 1). The P.E. Intervales area is covered by mature and advanced secondary forests. The P.E.T. Alto Ribeira area is on an abrupt terrain of karstic origin, which had once been used for farming and grazing. The rainforest is much less tall, and open areas and active or abandoned farms are common.

Point-counts were conducted following Whitacre *et al.* (1992). They were carried out by one or two observers placed in elevated locations, with an angle of vision of 80º - 294º and a minimum radium of vision of 1000 m, in fair or slightly rainy weather. The 23 points were selected along paths to allow good visibility. Some counting points were only 300 m apart, but they offered views to completelly different section of the study area. Most counts started 2.5 - 4.5 h after sun rise and lasted between 1.75 and 4 h (see Appendix). Each counting period was divided into 5 minutes intervals. For each interval, all birds of prey spotted were recorded, as well as the amount of time that each individual had been observed. A list of species and minimum numbers of individuals and groups spotted in each count was obtained, along with the number of intervals and total amount of time during which each species had been observed. Based on these data, several indexes of abundance were calculated for each species and park: group size (average number of individuals ± sd), average contact length (average length of contact in minutes ± sd), contacts/h (number of contacts divided by observation hours ± 95% ci), % of presence (percentage of counts in which the species occurs ± 95% ci), efficiency-%minutes (percentage of minutes of observation in which the species is detected ± 95% ci), and efficiency-%intervals (percentage of observation intervals in which the species is spotted ± 95% ci). Confidence intervals (ci) were calculated using bootstrap techniques, with 10^4 iterations of sample size equal to the original sample size in each case.

The territory mapping method (Thiollay, 1989; Bibby *et al*, 1992) was used to determine the spacing between different pairs of *Leucopternis polionota* or *Spizaetus tyrannus* along the Carmo River valley (P.E. Intervales). Plots of all the observations conducted, either during the counts or outside them, result on clusters of points that reveal the presence of several territories. Results are shown as number of pairs per km of prospected valley and as average territory length (distance between the most distant contact points for a given species divided by the number of territories between those two points).

RESULTS

The 23 counts totalised 5290 min (88.17 h) of observation, equivalent to 1058 five minutes intervals. The average length of the counts (± sd) was 3.83 ± 0.37 h. Only in one count (number 3, see Appendix) no birds of prey were spotted.

In total 719 individuals belonging to 9 different species of diurnal birds of prey were observed during the counts, grouped in 334 contacts (3.79 contacts/hours) (Table 1). Most species were spotted in both parks except for *Buteo brachyurus,* which was only seen in P.E.T. Alto Ribeira but that had been previously reported in P.E. Intervales (Mañosa & Pedrocchi, 1997), and *Accipiter* *superciliosus,* which apperared only in P.E. Intervales. *Polyborus plancus* was seen in both parks, but at very low frequence. Count efficiency, measured as number of contacts per hour or percentage of positive intervals, was higher in P.E.T. Alto Ribeira than in P.E. Intervales. This difference can be explained by the larger abundance of scavenger species at the P.E.T. Alto Ribeira area (Table 2), which turned out to be statistically significant.

Outside the counts, one specimen of *Falco rufigullaris* was seen in Alecrim. This species was not reported in previous expeditions to the same regions (Willis & Oniki, 1981; Mañosa & Pedrocchi, 1997). One specimen of *Buteo albicaudatus* was spotted in P.E.T. Alto Ribeira, near Núcleo Caboclos. At the Carmo-Formoso River valley, in P.E. Intervales, some birds were spotted that could correspond to *Leucopternis lacernulata,* an endemic species of the atlantic brazilian rainforest, but this identification could not be guaranteed for certain.

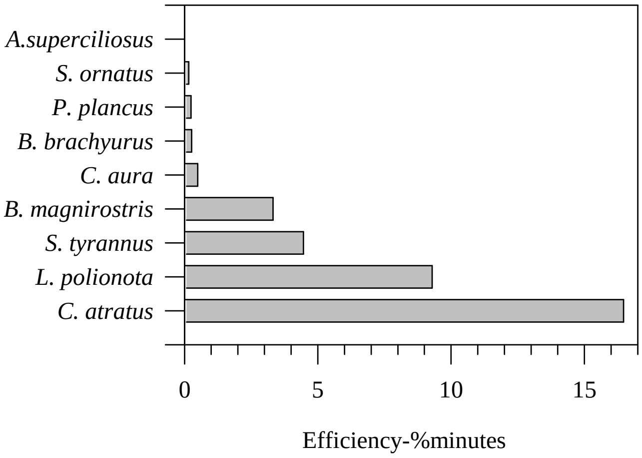


Figure 2. The percentage of minutes of observation during which each species is detected (efficiency-%minutes) is one of the indexes that best indicates their abundance. Some other useful indexes are summarised in Table 1.

The species most frequently observed in the area was *Coragyps atratus,* which constituted 63% of all observations (Table 1). It was spotted in 91.3% of the counts and in 16.5% of time (Figure 2), generally in groups of 2 to 12 individuals (only 26% of the observations corresponded to a single indivual), usually flying over the forest or open areas.

Cathartes aura was far more scarce than its relative, since it represented only 3% of observations. It was spotted in 21.7% of the counts (Table 1) and during 0.5% of observation time (Figure 2), possibly due to the fact that it is less associated to the human habitats surrounding the parks. This species is less inclined than *C. atratus* to form groups, 9 observations were of single individuals and only 2 corresponded to groups of 3 and 4 individuals.

Leucopternis polionota was the second most frequently observed species, corresponding to 15% of all observations (Table 1). It was spotted in 78.3% of the counts and 9.3% of observation time (Figure 2), both in forest or near open areas. In P.E. Intervales, it was seen twice while capturing a snake and once capturing a dove. It was spotted in 18 occasions, of which 10 corresponded to a single individual, 7 corresponded to a pair, and 1 to a threesome.

Table 1. Global results of birds of prey counts for different species based on 23 point-counts (5290 observation minutes or 1058 intervals of 5 minutes), which yielded 334 contacts. Average values and 95% confidence intervals are shown. Confidence Intervals have been determined through bootstrap, except for group size and contact length, where standard deviation has been used. Species have been ordered from the one with highest abundance to the one with the lowest.

Coragyps atratus	
Contact number (% of total)	210 (63%)
Positive intervals	276
Positive minutes	871
Group Size (± sd)	2.68 ± 1.79
Contact length (± sd)	4.15 ± 6.19
Contacts/h	2.35 (1.66 - 3.06)
% of presence	91.30 (78.26 - 100.00)
efficiency (% minutes)	16.47 (10.69 - 22.50)
efficiency (% intervals)	25.92 (18.24 - 34.08)
Leucopternis polionota	
Contact number (% of total)	51 (15%)
Positive intervals	133
Positive minutes	458
Group Size (± sd)	1.20 ± 0.40
Contact length (± sd)	8.98 ± 15.68
Contacts/h	0.58 (0.38 - 0.79)
% of presence	78.26 (60.87 - 95.65)
efficiency (% minutes)	9.29 (4.93 - 14.57)
efficiency (% intervals)	13.18 (8.12 - 18.81)
Spizaetus tyrannus	
Contact number (% of total)	45 (13%)
Positive intervals	79
Positive minutes	246
Group Size (± sd)	1.29 ± 0.59
Contact length (± sd)	5.47 ± 5.10
Contacts/h	0.49 (0.23 - 0.77)
% of presence	43.48 (21.74 - 65.22)
efficiency (% minutes)	4.46 (2.07 - 7.19)
efficiency (% intervals)	7.16 (3.44 - 11.23)
Cathartes aura	
Contact number (% of total)	11 (3%)
Positive intervals	13
Positive minutes	24
Group Size (± sd)	1.45 ± 1.04
Contact length (± sd)	2.18 ± 2.18
Contacts/h	0.13 (0.02 - 0.26)
% of presence	21.74 (8.70 - 39.13)
efficiency (% minutes)	0.49 (0.11 - 1.02)
efficiency (% intervals)	1.28 (0.27 - 2.54)

Table 1 (cont)

Buteo magnirostris	
Contact number (% of total)	7 (2%)
Positive intervals	38
Positive minutes	183
Group Size (± sd)	1.29 ± 0.49
Contact length (± sd)	26.14 ± 28.78
Contacts/h	0.08 (0.00 - 0.22)
% of presence	8.70 (0.00 - 21.74)
efficiency (% minutes)	3.32 (0.00 - 9.93)
efficiency (% intervals)	3.44 (0.00 - 10.24)
Spizaetus ornatus	
Contact number (% of total)	4 (1%)
Positive intervals	5
Positive minutes	8
Group Size (± sd)	1.50 ± 0.58
Contact length (± sd)	2.00 ± 1.41
Contacts/h	0.05 (0.01 - 0.10)
% of presence	17.39 (4.35 - 34.78)
Efficiency (% minutes)	0.16 (0.02 - 0.35)
Efficiency (% intervals)	0.49 (0.09 - 0.99)
Buteo brachyurus	
Contact number (% of total)	3 (<1%)
Positive intervals	4
Positive minutes	15
Group Size (± sd)	1.00 ± 0.00
Contact length (± sd)	5.00 ± 4.58
Contacts/h	0.03 (0.00 - 0.09)
% of presence	8.70 (0.00 - 21.74)
Efficiency (% minutes)	0.27 (0.00 - 0.72)
Efficiency (% intervals)	0.36 (0.00 - 0.91)
Polyborus plancus	
Contact number (% of total)	2 (<1%)
Positive intervals	4
Positive minutes	13
Group Size (± sd)	1.00 ± 0.00
Contact length (± sd)	6.50 ± 2.12
Contacts/h	0.02 (0.00 - 0.05)
% of presence	8.70 (0.00 - 21.74)
Efficiency (% minutes)	0.24 (0.00 - 0.62)
Efficiency (% intervals)	0.36 (0.00 - 0.91)
Accipiter superciliosus	
Contact number (% of total)	1 (<1%)
Positive intervals	1
Positive minutes	1
Group Size (± sd)	1 ± ----
Contact length (± sd)	1 ± ----
Contacts/h	0.01 (0.00 - 0.03)
% of presence	4.35 (0.00 - 13.04)
Efficiency (% minutes)	0.02 (0.00 - 0.05)
Efficiency (% intervals)	0.09 (0.00 - 0.27)

Table 2. Comparison between several abundance parameters for bird of prey species in the two natural parks studied. Average value and the 95% confidence intervals are shown. The star * indicates significant differences between the two parks at p < 0.05.

	P.E. Intervales	P.E.T. Alto Ribeira
Number of counts	17	6
Observation time (h)	65.5	22.7
Number of total intervals	786	272
Number of observed species	8	8
Number of positive intervals	391	160
Number of contacts	225	109
Number of contacts/h	3.43	4.80
% of positive intervals	49.7	58.8
Contacts per hour		
Coragyps atratus	2.10 (1.23-3.00)	3.06 (2.46-3.67)
*Cathartes aura**	0.01 (0.00-0.04)	0.45 (0.13-0.83)
Leucopternis polionota	0.57 (0.35-0.82)	0.58 (0.20-0.95)
Spizaetus tyrannus	0.50(0.19-0.84)	0.46 (0.04-0.96)
Spizaetus ornatus	0.03 (0.00-0.07)	0.10 (0.00-0.21)
Buteo magnirostris	0.09 (0.00-0.26)	0.04 (0.00-0.13)
Buteo brachyurus	0.00 ---	0.13 (0.00-0.29)
Polyborus plancus	0.01 (0.00-0.04)	0.04 (0.00-0.13)
Accipiter sp.	0.01 (0.00-0.04)	0.00 ---
Percentage of presence		
*Coragyps atratus**	88.2 (70.6-100.0)	100.0 (100.0-100.0)
*Cathartes aura**	5.9 (0.0-17.6)	66.6 (33.3-100.0)
Leucopternis polionota	82.3 (64.7-100.0)	66.6 (33.3-100.0)
Spizaetus tyrannus	41.2 (17.6-64.7)	50.0 (16.7-83.3)
Spizaetus ornatus	11.8 (0.0-29.4)	33.0 (0.0-66.7)
Buteo magnirostris	5.9 (0.0-17.6)	16.7 (0.0-50.0)
Buteo brachyurus	0.0 ---	33.3 (0.0-66.7)
Polyborus plancus	5.9 (0.00-17.6)	16.7 (0.0-50.0)
Accipiter sp.	5.9 (0.00-17.6)	0.0 ---
Percentage of positive intervals		
Coragyps atratus	22.2 (13.1-32.2)	36.4 (27.1-46.4)
*Cathartes aura**	0.2 (0.0-0.7)	4.2 (1.1-7.5)
Leucopternis polionota	14.6 (8.4-21.7)	9.2 (2.5-18.2)
Spizaetus tyrannus	7.4 (3.1-12.4)	6.6 (0.3-12.9)
Spizaetus ornatus	0.4 (0.0-1.0)	0.8 (0.0-1.8)
Buteo magnirostris	4.5 (0.0-13.6)	0.3 (0.0-1.0)
Buteo brachyurus	0.0 ---	1.4 (0.0-2.8)
Polyborus plancus	0.2 (0.0-0.7)	0.7 (0.0-2.1)
Accipiter sp.	0.1 (0.0-0.4)	0.0 ---

Spizaetus tyrannus is a large eagle that appeared in almost half the counts (43.5%), with a 13% of all observations (Table 1) and during 4.5% of observation time (Figure 2). It was generally seen alone or in pairs, flying over the forest or near open areas, as well as still. In one occasion, 4 specimens were seen together, probably corresponding to two neighbour pairs. Chases occurred between two of the individuals. *Spizaetus ornatus* was observed far less frequently, either as single individuals or in pairs. It represented about 1% of all observations, appeared only in 17.4% of counts (Table 1) and involved 0.2% of observation time (Figure 2), as single individuals or in pairs.

Two buzzard species belonging to the genus *Buteo* were spotted during the counts. *Buteo magnirostris* always appeared near humanised areas. It corresponded to 2% of all observations, was spotted in 8.7% of the counts and during 3.3% of observation time. *Buteo brachyurus* represented less than 1% of observations and it was only spotted in 8.7% of counts and in 0.3% of observation minutes (Table 1, Figure 2).

The counting points 1 to 16 were systematically distributed along the the Carmo River valley (in P.E. Intervales), so that the area in between was homogeneously prospected. *S. tyrannus* occured in the lower area of the valley, at count points number 7, 8, 9, 13, 14, 15 and 16, but not at points 1,2,3,4,5,6,10, 11 and 12. These facts, combined with mapping and behaviour of the specimens observed during and outside the counts, suggests that the section of valley considered was used by 2 or 3 pairs of *S. tyrannus.* One possible pair used the area between Rio das Mortes and Rio Monjolo, where three adult specimens were simultaneously observed. A second pair used an area which partially overlaps the former, from Rio das Mortes to Rio Novo, although it could occasionally reach the Corrego da Anta. The third pair inhabited the section between Corrego de Anta and Alecrim, but it could also reach Corrego Feixo. The two central pairs exploited a length of 16 km in the valley, 8 km each. Average territory length of these two pairs, measured as a projection on the map, was 5 km (Figure 3). Observations undertaken from point 17, 2.5 km SW from Alecrim and beyond the homogeneously prospected area, could correspond to a fourth pair located near the Claro River valley.

Concerning *S. ornatus*, only two observations occured in the Carmo River valley, on different days but more than 7 km apart: one of them at the confluence between Rio das Mortes with Rio Carmo, and the other one between Alecrim and the Corrego do Inferno. This suggests that the valley was inhabited by at least one, and maybe two, pairs of this species between Carmo and Alecrim.

L. polionota occured at medium and low heights of the valley like the two species previously considered, but it also appeared at higher heights. Between points 1 and 16, it was spotted in counts 1, 2, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15 and 16. The distribution of observations suggests at least 6 pairs along the 22 km of valley considered (3.7 km per pair), and there might be a 7th one near point 17. The average territory length of the 6 pairs as a projection on the map was 2.4 km (Figure 4).

Figure 3. Observations of *Spizaetus tyrannus* along the Carmo River valley (P.E. Intervales) can be grouped in 2-4 clusters, which indicates the presence of a minimum of two pairs. This species was not observed at the top of the valley.

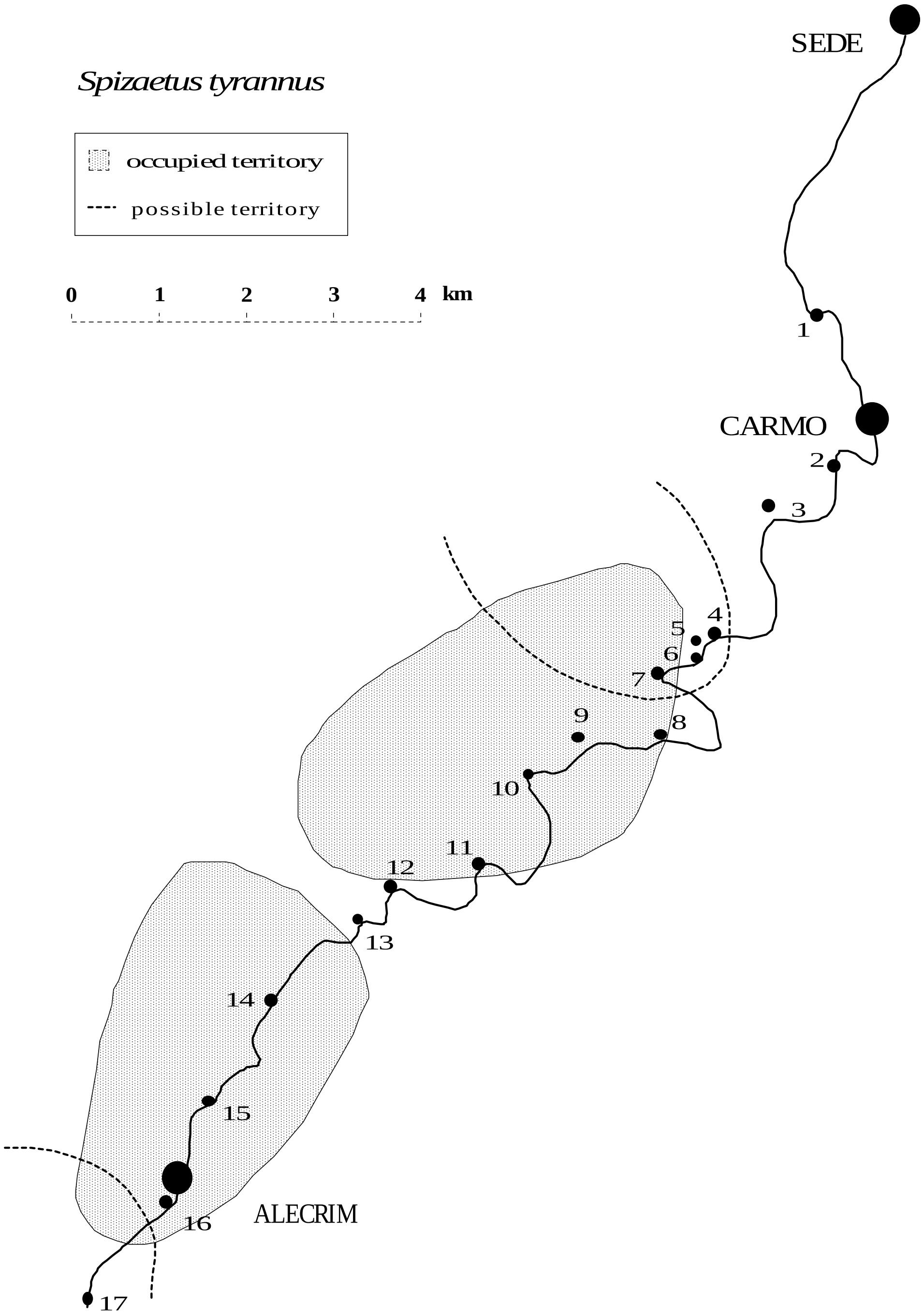
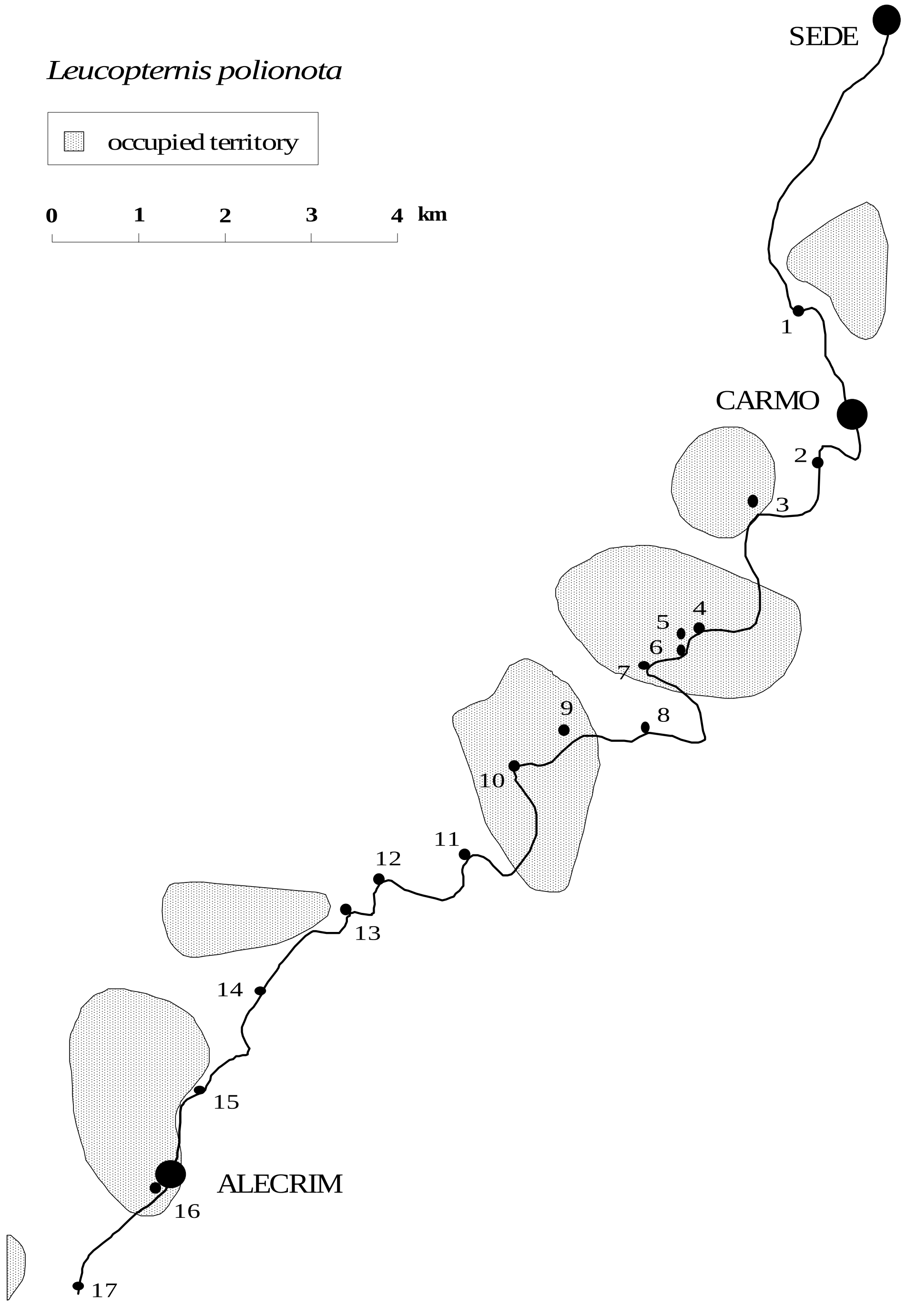


Figure 4. Observations of *Leucopternis polionota* along the Carmo River valley (P.E. Intervales) can be grouped in 6-7 clusters, which indicates the presence of at least 6 pairs along the river valley.



DISCUSSION

General characteristics of the birds of prey community in the study area

The most frequently observed species in the area was *C. atratus.* It is a scavenger bird, very ubiquitous and widely spread across the american continent, which exploits open and humanised zones as well as dense forest areas. In forest areas, though, it needs the presence of *C. aura*, which can smell carrion. Relative abundance of *C. atratus* might be overestimated in comparison to the other species since, being a large glider and scavenger bird, it remains for hours flying in circles and prospecting the territory and it can be easily spotted from large distances. Its high abundance is possibly related to the existence of open humanised areas surrounding the study areas. *C. aura* is also a scavenger bird that feeds on carrion, but unlike *C. atratus*, it has a sharp sense of smell to detect carrion in the forest. It is also widely distributed in the american continent and therefore not endemic to the Atlantic rainforest. It seems far less abundant than *C. atratus* in the study area, maybe because it is less associated to humanised habitats. Abundances observed in the P.E. Intervales-P.E.T. Alto Ribeira would correspond to a population basically sustained by the ressources that can be obtained from the forest.

L. polionota is one of the most interesting species in the area, since it is endemic to the Atlantic rainforest. According to our results, it seems to be relatively abundant in the study area, inhabiting primary or advanced secondary forest areas but frequently hunting in open areas, as suggested by the fact that it was repeatedly spotted waiting on the edge of clearings.

Unlike suggested by previous counts, *S. tyrannus* was found to be relatively abundant in the study area. *S. ornatus*, though, seems to be less common. Apparently, the latter needs bigger and better preserved primary forest areas. The lower abundance indexes for this species could indicate that it is less frequent, but they could also refer to its shy behaviour, since it tends to stand still waiting for preys instead of flying. *B. magnirostris* appeared associated to points next to open areas, while *B. brachyurus* was spotted in forest zones.

Comparison between abundances of birds of prey in P.E. Intervales and P.E.T. Alto Ribeira

Different species of birds of prey can coexist because they are adapted to the use of different ressources or habitats. It would be expected then that differences in vegetation and management between the two preserved areas considered in this study would translate into differences in composition between the communities of birds of prey that they host. Particularly, considering the higher abundance of more or less active farms in P.E.T. Alto Ribeira and the closeness to open areas, it is not surprising that this area holds higher abundances of scavenger birds of prey. Concerning the remaining species, abundances were alike in both parks, although *B. brachyurus* was only spotted in P.E.T. Alto Ribeira. Abundances tended to be higher for most species in P.E.T. Alto Ribeira, but no definitive conclusions could be achieved due to the fact that the number of counts which were held there was relatively low.

Space distribution of *Leucopternis polionota* and *Spizaetus tyrannus* territories along the Carmo River valley (P.E. Intervales)

Birds of prey are territorial animals that usually split the space in an homogeneous way. Agonistic interactions can occur in the contact areas between territories. When birds of prey counts are carried out homogeneously spread in a particular space and observations and interactions are represented in a map, distinct clusters of points appear representing the most visited areas in the territory and zones where most conflicts take place. This clusters of points represent the sharing out of the space among the different pairs inhabiting the area under study, which depends on the ecological needs of each species, and allows the distance between adjacent pairs to be estimated. Our data suggest that *L. polionota* occurs both in lowland and highlands of the study area, while *S. tyrannus* does not seem to reach the highest areas of the valley. There is no obvious spatial exclusion between the three species considered and their territories largely overlaped.

Importance of the study area for the conservation of birds of prey

Results yielded by this count, together with those obtained in 1994 (Mañosa & Pedrocchi, 1997) confirm the importance of P.E. Intervales and P.E.T. Alto Ribeira for the conservation of several endemic or endangered species of birds of prey in the Brazilian Atlantic rainforest. Particularly *L. polionota*, which had been considered by several authors as *very little known* (Thiollay, 1985; IUCN, 1990), *endangered* (Thiollay, 1994), *threatened* (Collar *et al.*, 1992; del Hoyo *et al.*, 1994) or recently as *lower risk/near threatened* (see UNEP-WCMC, 2001), seems to have a large and stable populations in the area, although it is not possible to determine accurately the problems related to these populations due to the lack of data regarding demographic parameters. Equally, *S. ornatus* and *S. tyrannus*, two large eagles which are not globally threatened (Bildstein *et al.*, 1998; UNEP-WCMC, 2001), have remarkable populations in the area under study. Particularly interesting are the apparently healthy populations of the later, belonging to the subspecies *S. tyrannus tyrannus,* which is endemic to the Brazilian Atlantic rainforests (Bierregaard, 1998). Unfortunately, the presence of *L. lacernulata* in the area could not be confirmed. Progressive reduction or fragmentation of the protected area that has been studied would involve an important impact on these two endemisms of the Brazilian Atlantic rainforest.

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Appendix: Description of the counting points. For counts at the P.E. Intervales (from 1 to 17), the DIST column shows distance (in meters) from Sede to the point. These distances were measured by car and point 0 was placed at Sede. Within this reference system, Base Carmo is placed at a distance of 9100 m, and Base Alecrim at 29100 m. Counting points (column POINT) are numbered as in Figure 1.

POINT	DIST	DATE	TIME	LENGTH	TYPE	ANGLE (left-right)	FOREST
01	6800	980823	11:00	3.50 h	Tree	40º- 160º	Mature
02	10900	980825	08:00	4.00 h	Tree	160º- 270º	Mature
03	11700	980824	12:00	4.00 h	Tree	210º- 325º	Mature
04	13400	980825	11:30	2.50 h	Land	64º- 130º	Mature
05	13500	980825	08:00	3.75 h	Land	327º- 82º	Mature
06	13600	980825	08:00	3.75 h	Land	250º- 350º	Mature
07	16100	980828	09:45	4.00 h	Land	160º- 310º	Mature
08	17200	980828	09:25	4.00 h	Land	240º- 360º	Mature
09	18100	980828	09:00	4.00 h	Land	210º-330º	Mature
10	20600	980828	08:30	4.00 h	Land	295º- 145º	Secondary
11	21800	980827	08:20	4.00 h	Land	240º- 320º	Secondary
12	23100	980827	08:15	4.00 h	Land	270º- 30º	Secondary
13	23800	980827	08:00	4.00 h	Land	270º- 110º	Secondary
14	26800	980830	09:05	4.00 h	Land	300º- 60º	Mature
15	27800	980830	08:40	4.00 h	Land	247º- 40º	Mature
16	29100	980829	08:00	4.00 h	Land	207º- 48º	Secondary
17	31700	980830	09:00	4.00 h	Land	240º- 360º	Secondary
18	-------	980901	09:50	4.00 h	Land	290º- 100º	Secondary
19	-------	980902	08:40	4.00 h	Land	100º- 305º	Secondary
20	-------	980902	08:45	4.00 h	Land	170º- 340º	Secondary
21	-------	980901	09:00	4.00 h	Land	110º- 270º	Secondary
22	-------	980903	08:20	3.66 h	Land	300º- 100º	Secondary
23	-------	980903	09:00	3.00 h	Tree	120º- 220º	Secondary

CHECK LIST OF VERTEBRATE SPECIES

Chapter 15

CHECK LIST OF BIRDS AND MAMMALS IN THE PARANAPIACABA FOREST FRAGMENT

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ABSTRACT. The check list of bird and mammal species found during the vertebrate census performed in the Paranapiacaba fragment (Brazil) between the 18 August and 4 September 1998 is presented. A total of 241 bird species and 26 mammal species were detected. Up to 35.7% of birds are endemic to the Atlantic rainforest. Several species of birds are threatened or have a precarious conservation status: *Pipile jacutinga*, *Touit surda / T. melanonota, Amazona vinacea, Triclaria malachitacea, Pionopsitta pileata, Dryocopus galeatus, Phylloscartes paulistus, Carpornis malanocephalus, Lipaugus lanioides*, *Biatas nigropectus, Macropsalis forcipata, Tinamus solitarius*, *Crypturellus noctivagus noctivagus*, *Penelope obscura bronzina*, *Pyroderus scutatus scutatus*, *Procnias nudicollis*, *Slerurus scansor*, *Leucopternis polionota*, *Leucopternis lacernulata*, *Spizaetus ornatus* and *Spizaetus tyrannus tyrannus*. Among protected mammals in the state of São Paulo we found *Brachyteles arachnoides*, *Alouatta guariba clamitans, Speothos venaticus, Procyon cancrivorus, Lontra longicaudis, Panthera onca, Puma concolor, Herpailurus yaguarundi, Leopardus wiedi / tigrina, Leopardus pardalis, Tapirus terrestris, Pecari tajacu, Tayassu pecari* and *Agouti paca*. A comparative analysis with other check lists shows that some birds live in certain altitudinal ranges and that some move across different heights depending on the time of the year, probably in association with food availability. Mammals are generally more difficult to see, and indirect methods are needed to detect them and identify them. The amount of detected species shows that the studied rainforest fragment has a good conservation status as well as a high ecological value.

KEY WORDS. Brazilian Atlantic rainforest, birds, check list, conservation, endemisms, mammals.

INTRODUCTION

The list of birds and mammals detected during the 1998 census in the Paranapiacaba forest fragment gives an idea about the conservation status of the studied rainforest areas. Detection of species that are endemic to the mountain rainforests is particularly significant, since they only survive in large and mature enough forest areas. There are a lot of threatened and/or endangered species because of the reduction of the Brazilian Atlantic rainforest (which has been calculated to be now about 8% of its original size) and because a large proportion of the species that it hosts are endemic. The origin of these endemisms is the geographic isolation of the Atlantic rainforest from the Amazonian rainforest and the Andean forests through a barrier of dry habitats (Haffer, 1974; Willis, 1992).

Organising such a large census in this kind of area is not a common practice. All the information on local fauna that was obtained is extremely interesting due to the lack of knowledge about many of the species typically found in the Atlantic rainforest.

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona.

The current data complement the ones obtained during the 1991 survey trip and the 1994 census in the Parque Estadual Intervales (Guix *et al.*, 1992; Pedrocchi & Souza, 1996), as well as several studies carried out in the 1980's and 1990's (Willis & Oniki, 1981; Scott & Brooke, 1985; Vivo *et al.*, 1992; Aleixo & Galetti, 1997; Silva & Vielliard, 1997; Vielliard & Silva, 2001).

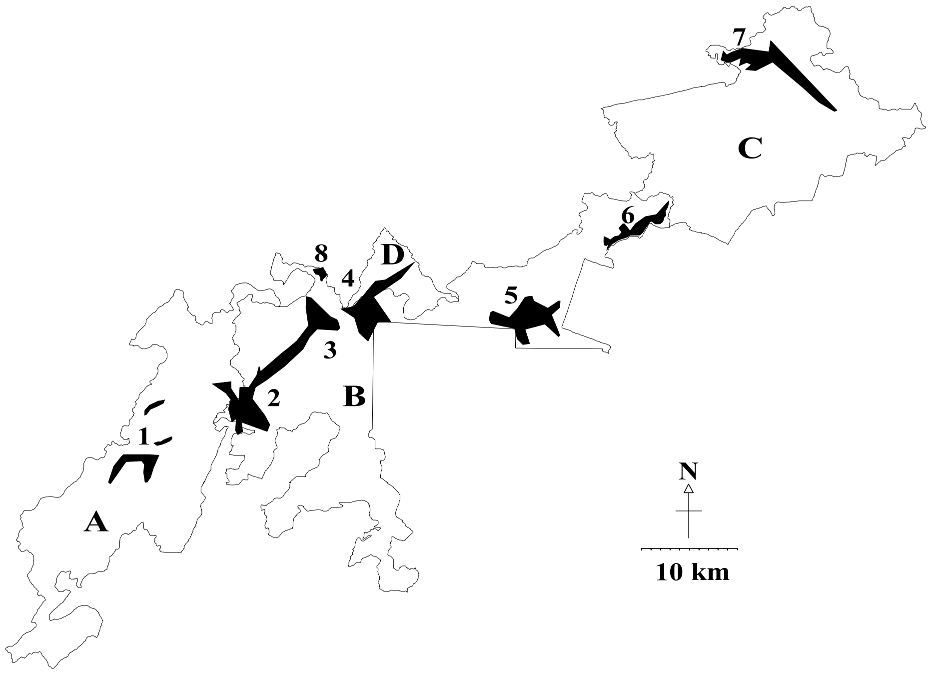
Records of birds at different altitudes have allowed an analysis on the altitudinal distribution of different species depending on the time of the year by comparing winter data (current census) with summer ones (Scott & Brooke, 1985).

MATERIAL AND METHODS

Compared to previous surveys and censuses (Guix *et al.*, 1992; Mateos & Mañosa, 1996), the 1998 census was performed in more areas (seven of them, see chapters 3 and 4) that were spread across P.E.T. Alto Ribeira, P.E. Intervales and P.E. Carlos Botellho. The altitude ranges sampled during the census were: Núcleo Caboclos (330-785 m), Alecrim (195-700 m), Carmo (485-750 m), Barra Grande (550-1030 m), São Pedro (410-580 m), Saibadela (60-610 m), Sede of P.E. Intervales (700-850) and Sede P.E. Carlos Botelho (650-825 m).

All the observations were made between the 18 August and 4 September 1998, within the winter period of the Southern hemisphere.

Figure 1. Location of the observation areas. 1: Núcleo Caboclos, 2: Alecrim, 3: Carmo, 4: Barra Grande, 5: São Pedro, 6: Saibadela, 7: Sede P.E. Carlos Botelho, 8: Sede P.E. Intervales, A: P.E. Turístico do Alto Ribeira, B: P.E. Intervales, C: P.E. Carlos Botelho, D: Estação Ecológica de Xitué.



At each area, the research teams observed and identified all the vertebrate species that they sighted. They used binoculars (between 7 and 20 enlargements) and cameras provided with 200, 300 and 400 mm zooms. Some bird species were identified *a posteriori* from the photographs obtained, and some others had to be identified *in situ* through their vocalisations. In the case of mammals, which are more difficult to observe, footprints, depositions and other traces were identified. Amphibians and reptiles were observed *in situ* or identified *a posteriori* from photographs, and some frog was detected through vocalisations; nevertheless, this group was not expressely prospected, and only the most remarkable findings are mentioned in this study. Species were identified using conventional guidebooks and more or less specialised books dealing with the study area (Dunning, 1987; Grantsau, 1988; Emmons, 1990; Dubs, 1992; del Hoyo *et al*., 1992, 1994, 1996, 1997, 1999; Sick, 1993; Ridgely & Tudor, 1989, 1994; de la Peña & Rumboll, 1998).

For each species, it has been indicated whether it is included in the list of threatened fauna from the State of São Paulo (Espécies da Fauna Silvestre Ameaçadas de Extinção do Estado de São Paulo; Decree num. 42838, of 4 February 1998 of the Secretaria do Meio Ambiente do Estado de São Paulo) and whether it is endemic to the Atlantic rainforest (Willis & Oniki, 1981; Dunning, 1987; del Hoyo *et al*., 1992, 1994, 1996, 1997, 1999; Ridgely & Tudor, 1989, 1994).

RESULTS

Results from the bird and mammal census performed in the Atlantic rainforest in 1998 are shown in Annex I.

Biatas nigropectus, endemic to the Atlantic rainforest, does not appear in the check list although a vocalisation was heard in E.E. Xitué, near the Sede of the P.E. Intervales. In a previous survey, it was also detected in P.E. Intervales (Silva & Vielliard, 1997).

Regarding birds of prey, the occurrence of *Leucopternis lacernulata* in the lower Carmo-Formoso river valley (Alecrim area, P.E. Intervales) was not totally confirmed and it should be checked in the future. It has never been detected in the P.E. Intervales area before (Willis & Oniki, 1981; Guix *et al*., 1992; Pedrocchi & Souza, 1996; Aleixo & Galetti, 1997; Silva & Vielliard, 1997; Vielliard & Silva, 2001). This species seems to inhabit low altitudes, below 300m, while *L. polionota* occupies a higher range, up to 1500 m (Scott & Brooke, 1985).

DISCUSSION

Birds

The amount of species observed in the 1998 census is 241 belonging to 50 families. About 14.5% of them (35 species) are endemic to the Atlantic rainforest *sensu stricto* (following the criteria established by Hueck, 1972a,b); if we follow a *sensu lato* criteria of the Atlantic forests potential distribution (which includes the coastal Atlantic rainforest and the inland subtropical forests in a same "morphoclimatic domine"; cf. Ab'Saber, 1977), the percentage of endemic species is 35.7% (86 species). These numbers are clearly higher than those obtained in 1991 and 1994 (Guix *et al*., 1992; Pedrocchi & Souza, 1996), due to a more intensive sampling effort, a larger amount of prospected areas and a bigger observer's team.

The amount of birds detected is remarkable if we take into account that 300 species were observed in a wide study involving six isolated Atlantic rainforest fragments (Willis & Oniki, 1981).

In order to compare the current results with those obtained in the 1991 survey trip (Guix *et al*., 1992) and the 1994 census (Pedrocchi & Souza, 1996), only data referring to P.E. Intervales can be considered (Saibadela, Carmo, Barra Grande, Alecrim, São Pedro and Sede areas). The amount of bird species observed in the P.E. Intervales during the 1998 census is 217, belonging to 48 families (see Annex I). This amount is much higher than the ones obtained in previous censuses, even though the 1991 one was performed over the reproductive season, when bird plumages and behaviours are most conspicuous and they vocalise, which makes them easier to be detected. This larger amount of species detected is due to the big amount of observers collaborating in the 1998 census, which allowed having more fixed bases over the prospecting period (two more areas than in the previous years) and a bigger amount of experienced observers.

Considering surveys performed in the Paranapiacaba forest fragment (Guix *et al*., 1992; Pedrocchi & Souza, 1996; Aleixo & Galetti, 1997; Silva & Vielliard, 1997; current survey), 386 bird species have been detected overall in an Atlantic rainforest area covering 1400 km^2; up to 123 (31.9%) species are endemic to this type of Southeastern Brazil forest with the exception of *Ramphocelus bresilius*, which is endemic to open and semi-open spaces. These numbers are still an underestimation of the real ones: the amount of species increases considerably with every new census (Table 1) and the peak registered for the Southeastern Brazil Atlantic rainforest is still quite far (Goerck, 1997; see the following paragraphs).

Table 1. Global results of the bird censuses performed so far in the Paranapiacaba fragment. Censuses that were carried out in 15 days periods (years 1991, 1994 and 1998, see Guix *et al*., 1992; Pedrocchi & Souza, 1996; current work) are separated from those exhaustive ones made in Saibadela (P.E. Intervales) between 1993 and 1996 (Aleixo & Galetti, 1997, in the table see 1997a) and in Sede-Carmo, P.E. Intervales (Silva & Vielliard, 1997, in the table see 1997b).

Year	Total birds	Birds detected for the 1st time	Total accum.	Increase percentage (%)
1991	163	163	163	-
1994	147	46	209	28.2
1998	241	73	282	34.9
1997a	234	47	329	16.7
1997b	312	57	386	17.3

A total of 940 bird species inhabit Eastern Brazil, and 214 of them are endemisms (Scott & Brooke, 1985). Up to 660 of those species breed in the Atlantic forests and 30% of them (200 species) are endemics to this type of forest (Goerck, 1997). About a hundred species in the region are considered to be threatened or endangered, and 64 of them are endemic to the Atlantic forests, according to the ICPB/IUCN *Red Data Book,* Brazil area (Collar *et al*., 1992). This list is considerably longer than it was ten years ago (King, 1981), which showed 41 species and 30 endemisms. A recent study shows that 68% of birds in the Atlantic rainforest can be considered as "rare" (Goerck, 1997), because of their scarce populations, habitat restrictions and/or narrow distribution range. According to this author, there would be still 43 highly vulnerable endemisms missing from the ICPB/IUCN lists, which shows the conservative tendency of these lists.

Only in the State of São Paulo there are 136 of the Atlantic forests (*sensu lato*) endemisms, of which 123 (90.4%) have been registered in the Paranapiacaba mountain range, and 86 (63.2%) were observed during the 1998 census. These amounts show the good ecological status of the study area and its importance as a reserve of the world's biodiversity. The main threat on this habitat is deforestation (Goerck, 1997).

In the state of São Paulo, 162 bird species are threatened and 31 more are probably threatened (overall 193 species, according to the Decree number 42838, from 4 February 1998, State of São Paulo). In the 1998 census, 27 of these species were sighted, up to 41 in the whole of the Paranapiacaba fragment - they are marked with an asterisk in Annex I. Eight of the birds observed are listed as "vulnerable" (VU) or "endangered" (EN), according to IUCN red list categories (BirdLife International, 1998; UNEP-WCMC, 2001), where the most threatened species of the world are included: *Pipile jacutinga* (VU), *Touit surda / T. melanonota* (EN), *Amazona vinacea* (EN), *Triclaria malachitacea* (VU), *Dryocopus galeatus* (VU), *Phylloscartes paulistus* (VU), *Carpornis malanocephalus* (VU) and *Lipaugus lanioides* (VU). *Leucopternis lacernulata* and *Biatas nigropectus* are also included as "vulnerable". Otherwise, 13 of the observed species are considered "near threatened" (NT): *Tinamus solitarius, Crypturellus noctivagus, Leucopternis polionota, Ramphodon naevius, Baillonius bailloni, Piculus aurulentus, Drymophila ochropyga, Scytalopus indigoticus, Phyllomyias griseocapilla, Carpornis cucullatus, Procnias nudicollis, Thraupis cyanoptera* and *Orchesticus abellei*. Other four species were included in the IUCN list in 1996 as "near threatened" but they were not considered in the most recent revision for the year 2000 (UNEP-WCMC, 2001): *Spizastur melanoleucus, Pionopsitta pileata, Macropsalis forcipata* and *Muscipipra vetula*.

According to Collar *et al*. (1992), two of the species observed are seriously threatened: *Pipile jacutinga* and *Lipaugus lanioides*. *Leucopternis polionota* and *Macropsalis forcipata* are not included in the list but they are normally considered as "near threatened" (del Hoyo *et al*., 1994, 1999; UNEP-WCMC, 2001). Some other sighted species are endangered: *Crypturellus noctivagus noctivagus*, *Penelope obscura bronzina* and *Pyroderus scutatus scutatus*. Moreover, species such as *Tinamus solitarius* and *Procnias nudicollis*, are in a delicate conservation status. The occurrence of *Tinamus solitarius* in the Atlantic rainforest is almost as delicate as that of *Crypturellus noctivagus noctivagus*, which has disappeared from many lowland forests and it is only surviving in areas without a strong hunting pressure (Sick, 1993). On the contrary, the number of *Crypturellus obsoletus* specimens has increased in Brazil during the last century, possibly due to the diminishment of *T. solitarius* populations (Cabot, 1992). *Spizaetus ornatus* and *Spizaetus tyrannus tyrannus* were not considered as globally threatened (Thiollay, 1994), although the most up to date revisions are including them in the lists of threatened birds (Mañosa & Pedrocchi, 1997).

The subspecies of *Penelope obscura* from the Atlantic rainforest (ssp. *bronzina*) is endangered because of its restricted distribution area (Guix, 1997) and it was classified in 1990 by the ICPB/IUCN as vulnerable. In fact, *P. obscura bronzina* and *Pipile jacutinga*, as some other Cracidae species, are considered as threatened because their populations have diminished a lot in the last 50 years due to habitat reduction and hunting pressure derived from human activities (Sick & Texeira, 1979). Regarding very rare species, according to the categorization made by Goerck (1997), *Sclerurus scansor* must be considered; it is especially affected by habitat fragmentation and prone to extinction (Willis, 1979). The same happens with frugivorous birds and particularly with big size ones: they depend on the availability of ripe fruits and need wider areas to survive all through the different seasons (Willis, 1979). Psitacidae and Cotingidae are among the most vulnerable ones: four species within the genus *Amazona*, *Touit surda*, *Pionopsitta pileata* and the genus *Carpornis* (Goerck, 1997). Some other birds qualified as rare are *Myrmotherula gularis*, *Cichlocolaptes leucophrus*, *Anabazenops fuscus*, *Mackenziaena severa* and the genus *Phylloscartes* (Goerck, 1997).

Some species, typical from open spaces or forest boundaries, were found in the open areas around the bases. They are common in humanised habitats: *Troglodytes aedon*, *Buteo magnirostris*, *Falco sparverius*, *Zonotrichia capensis*, *Crotophaga ani*, *Tapera naevia*, *Pardirallus nigricans*, *Columba cayennensis*, *Ramphocelus bresileus*, *Sporophila caerulescens*, *Pitangus sulphuratus*, etc. According to Goerck (1997), only one third of Atlantic rainforest species can take highly humanised environments (i.e. *Pitangus sulphuratus*, *Brotogeris tirica* and *Pyrrhura frontalis*). In the surrounding areas of the headquarters of each park (Sede areas), highly humanised and with plenty of open spaces, many species were observed: *Vanellus chilensis*, *Milvago chimachina*, *Columbina talpacoti*, *Nyctidromus albicollis*, *Notiochelidon cyanoleuca*, *Mionectes rufiventris*, *Mimus saturninus*, *Spinus magellanicus*, etc. Even *Cariama cristata* was sighted in open areas in P.E. Carlos Botelho. *Myiozetetes similis* tends to occur in open spaces also, and so does *M. cayanensis*, although in the winter it is only seen in low altitude areas such as Saibadela.

The sighting of *Caprimulgus sericocaudatus* is remarkable, since it is a quite rare and unknown species (Dunning, 1987, Silva & Vielliard, 1997). A female went into Carmo base, and it was identified from the photographs taken because of the brown endings of the three external feathers at each side of the tail. It has a peculiar distribution; it appears in different isolated points widespread in South America, which suggests that available data are incomplete or even that different species could be being mixed up. In fact, the Southeastern Brazil species is currently catalogued as a different subspecies (*C. s. sericocaudatus*) (Cleere, 1999).

Regarding hummingbirds, *Heliothrix aurita auriculata* was recorded. It had never been registered in the area but it had been sighted in neighbouring areas. It seems to be endemic to the Atlantic rainforests (Grantsau, 1988) and quite rare (Scott & Brooke, 1985), but with a wide distribution range according to Schuchmann (1999). Many of the hummingbird genera sighted have been recently reorganised and modified (Schuchmann, 1999).

Chaetura andrei is a summer species that can be observed in Southeastern Brazil between the end of August and January (Chantler, 1999). It was sighted during the current census, but it was not registered in the 1994 winter survey performed at the beginning of August.

A group of 15 individuals of *Orchesticus abellei* was sighted in São Pedro, probably a migrating group (J.C. Guix, pers. comm.) even though this species was observed in the same place during the 1994 census (Pedrocchi & Souza, 1996).

Stephanophorus diadematus is a not very common migrator that appears in the high areas of

Intervales in the winter (Guix, 1988). It has also been quoted by Silva & Vielliard (1997).

Birds of prey, as in the 1994 census (see Mañosa *et al.*, 1996 and Mañosa & Pedrocchi, 1997), have been studied in depth through specifical censuses (see chapter 14).

Table 2. Bird species distribution according to different altitudinal ranges and different seasons. Regarding altitudinal ranges, species are splitted into low altitude species (<500 m), high altitude species (>500 m) and species living all over (0-1000 m), separating summer (rows, Scott & Brooke, 1985) from winter (columns, current work). This way, it is easy to see that there are 25 species inhabiting low altitudes (< 500 m) in both summer and winter, 13 species inhabiting high altitudes (>500 m) in the summer and low altitudes (< 500 m) in the winter, etc. In order to check each species, see column "range" in Annex I.

	WINTER			
SUMMER	<500 m	>500 m	0-1000 m	Total
<500 m	25 (12.4%)	7 (3.5%)	14 (7.0%)	46
>500 m	13 (6.4%)	10 (5.0%)	16 (8.0%)	39
0-1000 m	12 (6.0%)	19 (9.4%)	85 (42.3%)	116
Total	50	36	115	201

Bird species distribution according to their seasonality and altitudinal range

One of the most interesting contributions of the current survey is the simultaneous study of different forest areas placed at different heights, since it has allowed the study of species distribution across an altitudinal range. The fact that the 1998 survey has been performed during the winter allows a comparison with the altitudinal ranges found by Scott & Brooke (1985) during the summer. Ranges offered by these authors have been enlarged with 1998 data in 40.3% of the cases (81 cases out of 201, only species occurring in both lists were considered, see Table 2). To facilitate the analysis, observations were grouped into 500 m intervals. Species detected by Scott & Brooke (1985) were surveyed between October and January, during the summer reproductive season (and so was the 1991 survey, carried out in October (Guix *et al.*, 1992)). On the other hand, the 1998 survey has been performed in August, in the winter, as the 1994 survey. Some other surveys exist for the P.E. Intervales, but they mix summer and winter data and they have been discarded from the analysis (Aleixo & Galetti, 1997; Silva & Vielliard, 1997). In 1994, most surveyed areas where placed below 500 m, apart from some observations in the Sede area of P.E. Intervales. In those areas where heights belonged to two different altitude ranges, observations were considered individually depending on the place where the species was sighted. Based on these premises, Table 2 allows the assumptions of the results that follow:

- Most bird species in the Atlantic rainforest are distributed all across the forest regardless of the time of the year or altitude (85 species, 42.3%). Mild temperatures in tropical and subtropical latitudes allow this, because fruition occurs at different heights all through the year and even though in the winter temperatures may drop at high altitudes and sporadical frosts may occur.

- There are also species that are characteristic and exclusive from low altitudes (25 species, 12.4 %). They can be considered as sedentary from low altitude ranges since they were never detected at higher heights. They are thermophilic species that avoid high altitude ranges probably in association to their nourishing source, whatever fruits, flowers or insects.

- The occurrence of species that move down to lower altitude ranges in the winter, where average temperatures are higher, is interesting also (12.4%). Both, species distributed all over in the summer that go below 500 m in the winter (12 species, 6.0%) and species living in the highest mountain range areas moving below 500 m in the winter (13 species, 6.4%) are grouped into this category. With the same aim, searching for milder temperatures (which can be associated to food availability), there are species with partial population movements: they are only detected at high ranges in the summer and they widen their distribution range in the winter (16 species, 8.0%). These data show that within the Brazilian Atlantic rainforest ecosystem (*sensu stricto*) there are altitudinal migrations of certain birds to avoid cold and/or low food availability in the winter. This affects 20.4% of the species (see Annex I). It must be taken into account that the highest areas of the Paranapiacaba mountain range can get frozen in the winter (it happened in 1994 and 1999) or they can have sleet (J.C. Guix, pers. comm.), and very few plants flower there in the middle of winter.

- At the same time, there are species that are exclusively restricted to the highest areas in the mountain range (10 species, 5.0%).

- Finally, some species are distributed across low altitudes in the summer and they can move over 500 m in the winter (10.5%). Some of them are only found above 500 m in the winter (7 species, 3.5%), while some others widen their distribution range in the winter across all possible heights (14 species, 7.0%). Considering the high diversity found in the Atlantic rainforest, they could be birds that move up in order to use certain resources (fruits) that are finished in low altitude ranges but still available in higher areas.

The fact that birds with highly specialised feeding strategies (frugivores, nectarivores...) are found in an environment as complex as the Paranapiacaba fragment might provoke altitudinal migratory movements in all directions: some fruits and flowers may appear only at high altitudes in the winter while some others always occur in lower areas (Guix, 1995). In the summer, a high energetic investment in reproduction can influence the search of a habitat with high food availability.

Crypturellus noctivagus noctivagus is restricted to the lowest areas in the Atlantic rainforest, in previous years (Guix *et al.*, 1992; Pedrocchi & Souza, 1996) and in the current survey it has always been detected below 150 m, as quoted by Scott & Brooke (1985). Probably seeds, ants and beetles on which it feeds (Cabot, 1992) are restricted to those low altitude ranges.

Some species that are restricted to low altitude ranges are typical wetland birds or birds that tend to live in the lowest river sections. These ecosystems never occur on top of the hills but at the bottom of the valleys, and also a milder climate favours the development of invertebrates and amphibians. That is the case of *Bubulcus ibis*, *Egretta alba*, *Pardirallus nigricans*, *Porzana albicollis*, etc.

The Hirundinidae, which feed on insects, and certain Tyraniidae prefer low altitudes all through the year, or at least in the winter. On the contrary, some other insectivores can occur in any altitude range, that is the case of the Apodidae species. The Atlantic rainforest climate allows this duality, which depends on the requirements and capability of each species.

Some hummingbirds (Trochilidae) prefer low altitude ranges (*Ramphodon naevius*, *Heliotrix aurita*, as pointed out by Schuchmann (1999)) while some others shelter there in the winter (*Chlorostilbon aureoventris*, *Hylocharis cyanus* and *Florisuga fusca*) but can be sighted all around in the summer - they are possibly associated to the flowering of certain plants.

In the case of frugivorous birds, some Traupidae species always appear at low altitude ranges: *Euphonia violacea*, *Hemithraupis ruficapilla*, *Ramphocelus bresileus* and *Tersina viridis*.

In Psitacidae, the altitudinal distribution showed by *Amazona amazonica* confirms that it occurs below 600 m (Collar, 1997). The summer range showed by *Triclaria malachitacea* fits the 300-1000 m interval defined by Collar (1997).

Myiozetetes similis is typical from open spaces as *M. cayanensis*, but the latter can only be seen at low altitude ranges in the winter.

In the case of little conspicuous birds such as forest birds of prey (i.e. *Falco rufigularis* and *Accipiter superciliosus*) that were detected only once during the 1998 census, their altitudinal range might depend on the hazard associated to the observation event, since they can occur above 1500 m of height (del Hoyo *et al*., 1994). That might also be the case of some nocturnal species belonging to the families Tytonidae, Strigidae, Caprimulgidae and Nyctibiidae.

Procnias nudicollis appeared in 1998 across a wide range of altitudes, as it did in the 1991 census (Guix *et al*., 1992), but unlike in 1994, when it was only sighted at low altitudes (Pedrocchi & Souza, 1996). This suggests that this species might have a migratory behaviour and it moves across different altitudinal ranges in the mountain range (Sick, 1993; Pedrocchi & Souza, 1996) depending on the ecological conditions of each year (fruit production depending on interseasonal and intraseasonal climatological differences). Scott & Brooke (1985) consider that its range is 0-1150 m. *Ramphocelus bresileus* is associated to low altitudes (Scott & Brooke, 1985), and it was only sighted at Saibadela.

The wide sampling area considered in the current census and that of Scott & Brooke (1985), together with the large amount of sightings, has allowed a first balance on the seasonal altitudinal preferences of birds in the Atlantic rainforest. It is shown that even though it is a tropical rainforest, different altitudes in the Paranapiacaba mountain range result on different temperature feelings and different food availabilities that are reinforced by seasonal differences (winter/summer). All this results on sedentary behaviours and vertical migrations of birds depending on their preferences. These episodes remain almost unknown nowadays because they are less apparent in a tropical area than they are in a temperate region, where climatical changes are much more noticeable.

Mammals

Elaborating check lists of mammal species in wet tropical forests implies using a set of different detection and sampling techniques that must be specific for each group, considering their body size and their behavioural and habitat preferences (Voss & Emmons, 1996). The fact that many mammal species show nocturnal habits and discreet behaviours might result into considerably incomplete faunal check lists.

In order to compile data on the occurrence of mammal species in the Paranapiacaba fragment, at the same time as censuses were being performed there was an effort to sight as many individuals and species as possible, as well as to detect traces related to their presence in certain habitats, altitude ranges or fragment areas.

P.E. Intervales is the only park that was sampled in this study for which a preliminary check list exists (Vivo & Gregorim, *in press*). In it, 84 mammal species were detected without taking into account small ones or bats.

The use of traces or indirect signs to identify mammals (i.e. prints, vocalisations) is a common and reliable practice widely used by mastozoologists (Dirzo & Miranda, 1990; Emmons, 1990; Becker & Dalponte, 1991; Dirzo & Miranda, 1991).

During the 1998 censuses, a total of 26 mammal species belonging to 16 different families were detected. Some of them are indicators of the good conservation status of the sampled forests and the Paranapiacaba fragment as a whole: the Woolly spider monkey (*Brachyteles arachnoides*), the Southern river otter (*Lontra longicaudis*) and several feline species (Annex I).

According to IUCN red lists (UNEP-WCMC, 2001), two of the mammals observed are threatened: *Brachyteles arachnoides*, who has changed from the “endangered” (EN) category in 1996 to the highest category “critically endangered” (CR) in 2000, and *Speothos venaticus* qualified as “vulnerable” (VU). A taxon is “critically endangered” when it is facing an extremely high risk of extinction in the wild in the immediate future (UNEP-WCMC, 2001), so the *Brachyteles arachnoides* is in a very delicate conservation status and its presence in the Paranapiacaba forest is very important (see chapter 9). Otherwise *Lontra longicaudis* is qualified as “data deficient” (DD) and two other species are considered as “near threatened” (NT): *Panthera onca* and *Tapirus terrestris*.

Most big cat species use tracks and paths as quick access routes or as marking and watching areas. Finding many prints on the different kinds of surfaces (i.e. sand, earth, mud) is very common. These prints are a good indirect method to identify adult and subadult individuals belonging to the largest species (Crawshaw Jr, 1996). Depositions can also be used to certify the occurrence of a certain species. During the census period, prints were found belonging to Jaguars (*Panthera onca*), Pumas (*Puma concolor*), Ocelots (*Leopardus pardalis*) and Jaguarundies (*Herpailurus yaguarundi*). Prints from two little felines belonging to one or two species of the genus *Leopardus* (*L. wiedii* and *L. tigrina*) were also found, but they could not be identified with certainty.

The Brazilian tapir (*Tapirus terrestris*) was frequently detected through prints left in tracks, paths and canyons and also through depositions and deposition aggregates.

The Collared peccary (*Pecari tajacu*) and the White-lipped peccary (*Tayassu pecari*) were identified by their prints. A group of collared peccaries was sighted in the P.E. Intervales.

The Coati (*Nasua nasua*) was detected only through visual contacts. It is quite an active species during the day and at dusk and sighting groups is relatively common.

An adult paca specimen (*Agouti paca*) frequented assiduously at night a manger kept by guards in the São Pedro area (P.E. Intervales). This species was also detected through prints in other areas of the Paranapiacaba fragment. The Red-rumped agouti (*Dasyprocta leporina*), the Tayra (*Eira barbara*) and the Crab-eating fox (*Cerdocyon thous*) were both sighted and identified through prints.

The Crab-eating fox (*Cerdocyon thous*) and the Bush dog (*Speothos venaticus*) can be told apart from the different size of their prints (Becker & Dalponte, 1991). During a previous specific survey of *Speothos venaticus* carried out in the Paranapiacaba fragment (M. Martin, pers. comm.), no certain trace of its occurrence was found over two years of sampling. It is an endangered species that has become quite rare: there are only news about one sighting made in P.E. Carlos Botelho before the census by park staff.

Since the priority of the survey carried out in 1998 was obtaining density estimates of certain vertebrate species, including little mammals and bats in the check list was impossible. Nevertheless, the occurrence of the Brown four-eyed oposum (*Metachirus nudicaudatus*) in P.E. Carlos Botelho was detected through the finding of jaw fragments and hairs.

Herpetofauna

No special survey of amphibians or reptiles was carried out during the 1998 census although several species have been detected since 1991 (Guix *et al.*, 1992; Guix *et al.*, 1994; Carretero *et al.* 1996; Guix *et al.*, 2000). Only the findings of two freshwater tortoise species belonging to the family Chelidae are worth mentioning: *Hydromedusa tectifera* was found in Saibadela and Alecrim (low altitude areas), and *Hydromedusa maximiliani* was found in P.E. Carlos Botelho, at a higher altitude. The latter is qualified as "vulnerable" (VU) in the threatened species categories established by the IUCN red list (UNEP-WCMC, 2001).

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Annex I. Check list of bird and mammal species detected in the Paranapiacaba forest fragment during the 1998 census.

Abbreviations used and sampled altitude ranges: SA = Saibadela (60-610 m). AL = Alecrim (195-700 m). SPE = São Pedro (410-580 m). PETAR = Núcleo Caboclos (330-785). CA = Carmo (485-750 m). BG = Barra Grande (550-1030 m). SE = Sede P.E. Intervales (700-850 m). CB = Sede P.E. Carlos Botelho (650-825 m).

Birds

Family classification of each species has been done according to the terminology currently accepted as it appears in Nores, 1991.

* Species that are included in the list of threatened or possibly threatened species in the state of São Paulo, according to Decree number 42838, of 4th of February 1998.

Species that are endemic to the Atlantic forests: ^{E} Endemisms *sensu stricto* (only includes the coastal edge of the Atlantic rainforest), ^{L} Endemisms *sensu lato* (including inland fragments).

Habitat where they were observed for areas that included different types of environments: 1. Closed forest; 2. Open areas, x. Unspecified.

Range: Altitudinal range, 1: < 500 m, 2: >500 m, 3: 0-1000 m. The first number corresponds to summer - Scott & Brooke (1985) and the second one to winter (current work and Pedrocchi & Souza 1996). When only data from winter are available, one number is shown.

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	CB	Range
Tinamidae:									
*Tinamus solitarius** ^{L}	1	1	x		1	x		x	33
*Crypturellus n. noctivagus** ^{E}	1								11
Crypturellus tataupa	1	x							31
Crypturellus obsoletus obsoletus	1	x	x	x	x	x	1	x	23
Ardeidae:									
Bubulcus ibis	x								11
Egretta alba			x						11
Egretta thula	x							x	13
Syrigma sibilatrix								x	2
Cathartidae:									
Coragyps atratus	1,2	1,2	x	1,2	x		2	x	33
Cathartes aura	1	2		2					33
Accipitridae:									
*Leptodon cayanensis**							2		13
Accipiter superciliosus		2							21
*Leucopternis polionota** ^{E}	1,2	1,2	x	1,2	1			x	23
Buteo magnirostris	2	2		2			2	x	33
Buteo brachyurus				2				x	33
Buteo albicaudatus				x			2		33
*Spizastur melanoleucus**								x	33
*Spizaetus ornatus**	1	1		1					3
*Spizaetus tyrannus tyrannus** ^{E}	1	1	x	1,2					33
Falconidae:									
Polyborus plancus		2		2	1		2	x	33
Milvago chimachina							2		12
Falco sparverius								2	12
Falco rufigularis		1							11
Cracidae:									
*Penelope obscura bronzina** ^{E}	1	1	x	1			1	x	23
*Pipile jacutinga**	1	1	x	1	1	x		x	3

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	CB	Range
Phasianidae:									
Odontophorus capueira^{L}	1	x	x	x	x		1	x	33
Rallidae:									
Aramides saracura^{L}	1	x	x				x		33
Aramides cajanea			x	2				x	13
Pardirallus nigricans	2								11
Porzana albicollis	2								11
Cariamidae:									
Cariama cristata								2	2
Charadriidae:									
Vanellus chilensis	2			2			2	2	13
Columbidae:									
Columba cayennensis		x						x	13
Columba picazuro	1	x		x	x	x	x		3
Columba plumbea		x	x	x		x		x	23
Columbina talpacoti							2		12
Leptotila verreauxi								2	12
Leptotila rufaxilla	1,2	x	x		x				33
Geotrygon montana	1				x				33
Zenaida auriculata							2		2
Psittacidae:									
Pyrrhura frontalis^{L}	1,2	1	x	x	1	x	1	x	33
Forpus crassirostris	1	1	1		1	1		1	33
Brotogeris tirica^{E}	1,2	x	x	x	x		1	x	33
*Pionopsitta pileata**^{L}			x	x		x		x	33
Pionus maximiliani	1,2	x	x	x	x		x	x	33
*Amazona amazonica**				2					11
*Amazona vinacea**^{L}		x		x					3
*Touit surda**^{E}			x						1
*Triclaria malachitacea**^{E}	1	x	x			x		x	23
Cuculidae:									
Piaya cayana	1,2	1	x	x	1	x	1	x	33
Guira guira		2		2			2		13
Crotophaga ani	2			2			2		33
Tapera naevia			2				2		33
Tytonidae:									
Tyto alba				2				2	12
Strigidae:									
Athene cunicularia	2						2	2	13
Bubo virginianus				2					22
Caprimulgidae:									
*Caprimulgus s. sericocaudatus**^{L}					1				2
*Macropsalis forcipata**^{L}							2		2
Hydropsalis torquata								x	2
Nyctidromus albicollis							2	2	12
Nyctibiidae:									
Nyctibius griseus							2		12
Apodidae:									
Streptoprogne zonaris	1	x		x	x				33

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	CB	Range
Chaetura cinereiventris			x						33
Chaetura andrei	1	1			1				33
Trochilidae:									
Phaethornis eurynome^{L}	1	x	x		x	x	x	x	23
Agyrtria versicolor versicolor					x			x	32
Polyerata fimbriata								x	32
Thalurania glaucopis^{L}	1,2	1,2	x	2			1	x	33
Chlorostilbon aureoventris	1								31
Hylocharis cyanus cyanus		x							31
Clytolaema rubricauda^{E}								x	22
Florisuga fusca^{L}		x							31
Lophornis chalybeus chalybeus^{E}		x		2					3
Leucochloris albicollis^{L}				2			x	x	32
Ramphodon naevius^{E}		x							11
*Heliothrix aurita auriculata**^{E}		2							11
Trogonidae:									
Trogon surrucura^{L}	1	1	x	1			1	x	33
Trogon viridis	1	1	x		1		1	x	13
Trogon rufus		1		1	1	x	1	x	33
Momotidae:									
Baryphthengus ruficapillus^{L}	1		x	x	x			x	33
Alcedinidae:									
Ceryle torquata	1								13
*Chloroceryle aenae**	1								31
Chloroceryle americana	1	1	x						11
Bucconidae:									
Nystalus chacuru							2		12
Malacoptila striata^{E}	2		x	x				x	33
Ramphastidae:									
Selenidera maculirostris	1	1	1		x	x		x	33
Baillonius bailloni^{L}	1	1	1					x	23
*Ramphastos vitellinus**	1	1	1					x	33
Ramphastos dicolorus^{L}	1	1	1	x	x	x		x	13
Picidae:									
Picumnus temnickii^{L}		x	x		x		x		3
Picumnus minutissimus				x					2
Piculus aurulentus^{L}							x		22
Melanerpes flavifrons^{L}		x	x	x	x		2	x	33
Colaptes campestris	2						x	x	33
Colaptes melanochloros	1,2								31
Cichlocolaptes leucophrys^{E}							x		2
Celeus flavescens	1	x	x	x					11
Dryocopus lineatus	1,2	x		x			x	x	3
*Dryocopus galeatus**^{L}								x	2
*Campephilus robustus**^{L}		x				x			3
Veniliornis spilogaster^{L}			x	x	x	x	x		3
Dendrocolaptidae:									
Dendrocincla turdina		x	x	x					3
Sittasomus griseicapillus	1	x	x	x	x	x	x	x	33

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	CB	Range
Lepidocolaptes fuscus ^{L}	1	x	x	x				x	33
Lepidocolaptes squamatus ^{L}		x				x	1	x	33
Furnariidae:									
Furnarius rufus		x		x			x		33
Xenops minutus				x					32
Xenops sp.			x						
Philydor atricapillus ^{L}		x		x			x		33
Philydor rufus		x	x			x			33
Anabazenops fuscus ^{E}			x		x	x	x		33
Synallaxis ruficapilla ^{L}		x	x			x	x	x	23
Synallaxis spixi ^{L}	x	x							31
Synallaxis cinerascens ^{L}							x		22
Sclerurus scansor ^{L}	1		x					x	23
Lochmias nematura	1	x	x			x	x	x	33
Formicariidae:									
Batara cinerea			x			x	x		23
Mackenziana severa ^{E}		x							23
Grallaria varia		x	x				x	x	33
Thamnophilus caerulescens			x				x	x	23
Thamnophilus ruficapillus	1								21
Dysithamnus mentalis			x	x	x		x		33
Myrmotherula gularis ^{E}		x	x			x			33
Drymophila ferruginea ^{L}		x	x		x	x	x	x	33
Drymophila malura ^{L}						x	x		22
Drymophila ochropyga ^{E}							x		22
Pyriglena leucoptera ^{L}		x	x		x	x		x	33
Myrmeciza squamosa ^{E}						x			2
Myrmeciza loricata ^{E}								x	12
Chamaeza campanisoma	1	x	x		x	x	x	x	33
Chamaeza meruloides ^{E}	1	x	x			x			3
Formicarius colma			x						31
Rhinocryptidae:									
Scytalopus indigoticus ^{E}						x			2
Conopophagidae:									
Conopophaga melanops ^{E}	1		x	x					33
Conopophaga lineata ^{L}						x		x	22
Tyrannidae Elaeniinae:									
Phyllomyias virescens ^{L}				x					-
Phyllomyias griseocapilla ^{E}		1							21
Camptostoma obsoletum						x			32
Elaenia flavogaster		x		x					33
Elaenia obscura	2								21
Mionectes rufiventris ^{L}						x			31
*Phylloscartes paulistus** ^{L}					x				12
Myiornis auricularis					x				33
Todirostrum poliocephalum ^{L}			x		x		x		33
Todirostrum plumbeiceps			x						21
Tolmomyias sulphurescens		x			x		x		33
Platyrinchus mystaceus		x	x	x	x	x		x	33

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	CB	Range
Tyrannidae Fluvicolinae:									
Myiophobus fasciatus					x				32
Contopus cinereus		x							11
Pyrocephalus rubinus		x							1
Muscipipra vetula ^{L}				x					22
Colonia colonus	1	x	x		x				33
Hirundinea ferruginea							x		32
Machetornis rixosus				x					11
Tyrannidae Tyranninae:									
Attila rufus ^{E}			x				x		33
Pseudoattila phoenicurus							x		2
Sirystes sibilator		x			x				1
Myiarchus swainsoni		x		x					11
Myiarchus cf. ferox							x		32
Pitangus sulphuratus	1,2	x	x	x	x		2	x	33
Megarhynchus pitangua								x	32
Myiozetetes similis		2					2	x	33
Myiozetetes cf. cayanensis	2								31
Myiodynastes maculatus	1								31
Tyrannus melancholicus	2	x		x			x		33
Onychorhynchus coronatus				x	x				2
Muscivora tyrannus		x							11
Tyrannidae Tityrinae:									
Tityra cayana				x					32
Pachyramphus castaneus		x	x	x	x		x		33
Pachyramphus polychopterus					x				32
Cotingidae:									
Carpornis cucullatus ^{E}		x	x		x	x	x	x	23
*Carpornis melanocephalus** ^{E}	1								1
*Procnias nudicollis** ^{L}	1,2	x	x	x	x		x	x	33
*Pyroderus scutatus scutatus** ^{L}	1		x			x		x	3
*Lipaugus lanioides** ^{E}		x	x			x			13
Oxyruncidae:									
Oxyruncus cristatus						x	x		22
Pipridae:									
Chiroxiphia caudata ^{L}	1	x	x	x	1	x	x	x	33
Ilicura militaris ^{E}	1								21
Manacus manacus	1								11
Schiffornis virescens ^{L}			x	x	x	x	x		23
Hirundinidae:									
Progne chalybea	1	2		2					11
Phaeprogne tapera	2								11
Stelgidopteryx ruficollis			x						31
Notiochelidon cyanoleuca		2	x	x	x	2	x		33
Hirundo rustica				2					11
Troglodytidae:									
Troglodytes aedon	2	2	x				x	x	33
Thryothorus longirostris ^{E}	1		x						11

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	CB	Range
Muscicapidae Sylviinae:									
Ramphocaenus melanurus		1	x		1				11
Muscicapidae Turdinae:									
Platycichla flavipes				x	x	x	x	x	32
Turdus amaurochalinus	1,2			x	x				33
Turdus rufiventris	1,2	x	x	2		x	2	x	33
Turdus leucomelas	2			2			2	2	13
Turdus albicollis	1		x	x				x	33
Mimidae:									
Mimus saturninus	2			2			2		33
Vireonidae:									
Cyclarhis gujanensis	1		x		x	x	x	x	33
Hylophilus poicilotis			x				x		23
Vireo olivaceus				x	x		x		32
Emberizidae Icterinae:									
Cacicus chrysopterus				x	x	x	2	x	2
Cacicus haemorrhous	1,2	1,2	x	x	1				33
Gnorimopsar chopi								2	12
Molothrus bonariensis							2	2	32
Emberizidae Parulinae:									
Parula pitiayumi					x				12
Basileuterus culicivorus		x	x	x	x		x	x	33
Basileuterus leucoblepharus ^{L}		x			x		x	x	23
Basileuterus flaveolus					x				2
Basileuterus hypoleucus						x			2
Basileuterus rivularis			x				x		3
Basileuterus sp.	1								-
Geothlypis aequinoctialis	1,2						x		33
Emberizidae Coerebinae:									
Coereba flaveola	1			x		x	x	x	33
Emberizidae Thraupinae:									
Dacnis cayana	1	1,2		x	x		2		33
Chlorophanes spiza	2								1
Euphonia chlorotica	1,2								31
Euphonia pectoralis ^{L}	1		x		x	x		x	33
Euphonia violacea	1	1,2	x	x					11
Habia rubica	1		x				2	x	33
Cissopis leveriana		x	x	x	1		x		3
Tangara cayana		x							31
Tangara seledon ^{L}	1	1,2	x	1,2			2		33
Tangara cyanocephala ^{L}	1,2	1,2	x	x	1		x	x	33
Hemithraupis ruficapilla ^{E}	1	1,2	x		1				11
Tachyphonus coronatus ^{L}	1	x	x	x	1	x	2	x	33
Stephanophorus diadematus ^{L}						x	1		22
Orthogonys chloricterus ^{E}						x	x		32
Thraupis sayaca	1,2		x	x			2	x	33
Thraupis cyanoptera ^{E}			x	x				x	23
Thraupis ornata ^{E}		1,2	x	x	1		2		33
Thraupis palmarum	1,2	1,2							31

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	CB	Range
Trichothraupis melanops	1	x	x	x	1	x	2	x	33
Ramphocelus bresileus E	2								11
Ramphocelus carbo				x			x		2
Pipraeidea melanonota					x				23
Tersina viridis	1	1,2							11
Orchesticus abellei E			x						21
Emberizidae Cardinalinae:									
Saltator similis L	2		x		x	x	2		23
Pitylus fuliginosus L		x	x	x	x				33
Emberizidae Emberizinae:									
Zonotrichia capensis	2	2	x	2			2	x	33
Sporophila caerulescens		2		x					33
Haplospiza unicolor L			x						21
*Embernagra platensis**		x							1
Sicalis flaveola	2							2	3
Volatinia jacarina		2					2		33
Emberizidae Carduelinae:									
Spinus magellanicus							2		2

Mammals

* Species that are included in the list of threatened or possibly threatened species in the state of São Paulo. Type of trace: S=Sighting, P=Prints, E=Depositions, B=Bones, F=Food remains, D=Den, H=Heard, S=Scratches on tree trunks, I=Interviews to park staff, they can refer to up to 3 years before the census, x=unspecified

SPECIES	SA	AL	SPE	PETAR	CA	BG	SE	PECB
Marmosidae:								
Metachirus nudicaudatus			S					B
Didelphis aurita		P					P	
Dasypodidae:								
Dasypus novemcinctus	S	S	D, P					
Euphractus sexcinctus			D, P					
Cebidae:								
*Brachyteles arachnoides** ^{E}	S		S,E		S			S
Cebus apella nigritus	S	S	S,H		S			S,E
*Alouatta guariba clamitans** ^{E}	H	S,H	S,H,E	S,H	S			S
Canidae:								
Cerdocyon thous	P			P			S,P	P,E
*Speothos venaticus**								I
Procyonidae:								
*Procyon cancrivorus**	P	P	P					P
Nasua nasua								P,S
Mustelidae:								
*Lontra longicaudis**	E,P	S,D	E,P,S			x		E,P
Eira barbara	P		S	S	S			P
Felidae:								
*Panthera onca**	I	P	x					P,I
*Puma concolor**	I	P,T	P,E		P			P,I
*Herpailurus yaguarundi**		P						
*Leopardus sp. (wiedii / tigrina)**								
*Leopardus pardalis**	P	P	x	P	P			S
Tapiridae:								
*Tapirus terrestris**	E,P	P,H	P,E		P			P,S
Tayassuidae:								
*Pecari tajacu**	S,P	P	x					P
*Tayassu pecari**	S							
Cervidae:								
Mazama sp.	P	P	P					P,E
Sciuridae:								
Sciurus ingrami	S	S	S,F		S			S
Muridae:								
Akodon sp.					S			
Cassiidae.								
Cavia aperea								S
Hydrochaeridae:								
Hydrochaeris hydrochaeris			P				x	E,P
Agoutidae:								
*Agouti paca**	P	S	S,P					P,B
Dasyproctidae:								
Dasyprocta leporina	S		P,H					S

CONSERVATION

Chapter 16

THE PARANAPIACABA FRAGMENT AS A KEY AREA IN THE CONSERVATION OF THE BRAZILIAN ATLANTIC RAINFOREST

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INTRODUCTION

In the last few decades, conservation biology has experienced a huge development. Science has been getting progressively involved in the need to preserve the environment until it has definitely assumed its role in modern society (see Kohm *et al.*, 2000; Morris, 2000; Noss, 2000). One of the consequences has been a real boom of publications on conservation covering all sorts of fields, from different ways to face environmental problems to environmental management techniques or texts for the general audience (Flaspohler *et al.*, 2000). Nevertheless, the growing relationship between science and conservation is particularly perceptible when evaluating the exponential increase of scientific journals on this subject that have been appearing since the 1980's.

All this effort has led into a better understanding of conservation issues. In just over three decades, there has been a jump from the species-by-species conservation concept to the ideas of ecosystem conservation and biological community conservation and sustainability at different levels and spatial scales (see for example Soulé 1980; Soulé & Wilcox, 1980; Wilson, 1988, 2000; Solbrig *et al.*, 1992; Gaston, 1994; Miller, 1994; Huston, 1996; Reaka-Kudla *et al.*, 1997, Raven, 1997; Ghilarov, 2000; Loreau, 2000). Nowadays, the subject of discussions is not only the importance to the environment of species richness and ecosystem diversity, but also that of genetic diversity in animal and plant populations.

The particular features of the Paranapiacaba forest fragment, in comparison to other forest fragments placed in Eastern Brazil (i.e.: its location, large size, degree of isolation from surrounding forests, considerable discontinuities in its relief) turn it into a very significant portion of what the Brazilian Atlantic rainforest biome looked like before the European colonisation of the New World.

One of the most surprising features of the Paranapiacaba fragment is that, in wide zones placed

2002. In: *Censuses of vertebrates in a Brazilian Atlantic rainforest area: the Paranapiacaba fragment*. (Mateos, E.; Guix, J.C.; Serra, A. & Pisciotta, K., eds.). Centre de Recursos de Biodiversitat Animal. Universitat de Barcelona. Barcelona

near the limits of protected areas, the forest suddenly turns into a highly simplified environment created by human action (pastures, single-crop farms), without an interface or buffer zone between the forest ecosystems and farming areas. This is particularly noticeable in the highest fringe of the fragment, placed on the edge of the plateau, where domestic cattle replace the highly diversified forest communities.

On the other hand, the social conditions of human populations living in areas surrounding the fragment and interacting daily with it are issues that cannot be ignored. The whole of these ecological and social features will determine, in the medium and long terms, the future of the pristine forest portion so-called Paranapiacaba fragment; they all must be taken into account when managing the area.

SOCIOLOGICAL CONSIDERATIONS

People and forest

Nowadays, the human communities sharing part of the coast and coastal mountain ranges of Eastern Brazil must be taken into account when considering the Brazilian Atlantic rainforest biome.

The communities of caiçaras, ribeirinhos, caboclos, guaranis and quilombos keep quite integrated with the forests and they are the so-called "people of the forest". There are other populations scattered around the forest that are also using its resources. In the Paranapiacaba fragment area, the forest and human settlements mix and interact. Some of the inhabitants from the Vale do Ribeira or the adjacent plateau work on forest protection as guards or environmental instructors. Some other inhabitants are essentially extractors: they collect palmito and other vegetal species and they hunt medium and large size vertebrates for their own consumption or as quick and complementary source of income.

People worrying about the future of the remaining Atlantic rainforest areas must consider the precarious social conditions of life of many of the surrounding communities. In a generalist way, human pressure on the Paranapiacaba fragment is directly proportional to the bad social conditions in each area. The Vale do Ribeira has been considered for decades as one of the most socially depressed areas in the State of São Paulo. In fact, sociologists know the whole of the Southeastern region of the State as the "ramal da fome" (i.e. the hungry zone).

The rate of infant mortality is quite worrying and shows the direct consequences of the high degree of poverty prevailing in the area. According to 1998 data, the rate of infant mortality in the whole of the State of São Paulo was 18.6 children per 1000 births, while it was as high as 42.5 in some towns of the Vale do Ribera (Fundação SEADE, 1998).

Another fact that indicates the low quality of life of the human population in the area is the amount of connexions to drinking and sewage waters: only 40% of houses have drinking water and less than 20% of them are connected to sewage networks.

In 1991, 21.8% of the population over 18 years old was illiterate. In the towns of Barra do Turvo and Iporanga, the illiteracy rate was higher than 30%. In the State of São Paulo, the rate was 13.6% (Fundação SEADE, 1991).

In the whole of the areas surrounding the Paranapiacaba fragment there are also serious problems related to land use and ownership. The Censo Agropecuário made by the FIBGE (1995) showed that 44.9 % of the farms were smaller than 10 ha. Nevertheless, 70.1% of the farming land available was occupied by only 8.5% of farms that were larger than 100 ha.

This inequality in land distribution is a source of serious social problems. To start with, land-related conflicts result from tensions regarding land ownership between the landless (called "posseiros") and the local landowners (owners of large estates at a regional scale). In second place, there is a phenomenon of rural depopulation that generates unemployment or subemployment and therefore an increase of the conditions of extreme poverty in big cities such as São Paulo (which has about 20 million inhabitants). In third place, there is a slow phenomenon of progressive occupation of several protected areas by landless farmers.

In terms of basic health services offer, several towns have no hospitals and outpatients departments are the only option at reach for the population lacking economic resources.

The area is also lacking schools. According to the Fundação SEADE (1995), the head of the household in more than 50% of the families in the region had not been through the four years of minimum schooling period. On the other hand, the level of absenteeism from primary schools is significantly higher than the average of the State of São Paulo.

In such a scenario, very unfavourable to environmental conservation, environmental education programs are important, but they are not effective enough to make conservation objectives viable. In order to keep the remaining forests or to get them to increase in the future, it is necessary that human communities that are interacting with them get to not only value them but also to aim for their perpetuation.

Governmental institutions and non-governmental organisations (NGOs) have been developing different projects for several years. For instance, two of the projects developed by the Fundação Florestal in the Vale do Ribeira were the Management program for the exploitation of oysters in the Cananéia river estuary, and the Program for the sustainable exploitation of natural resources (such as palmito and medicinal and decorative plants). They were developed with the communities formed by descendants from former slaves that had been working in the old coffee and sugar cane plantations during the colonial period ("quilombos").

The aim of these projects is generating job opportunities and richness based on the basic principle of sustainable development. Many of the products offered by the forest can be legally obtained since the areas became protected. These legally obtained products can revert as new possibilities for the community - i.e.: the sustainable extraction of palmito and several vegetal species with therapeutical properties. In the same manner, forest regeneration can turn into an indirect source of richness for populations living by protected areas. In these areas, one of the ways of showing the importance of the Atlantic rainforest and generating resources is favouring the affluence of general visitors to very particular areas under the supervision of qualified staff.

TECHNICAL CONSIDERATIONS

Isolation degree of animal populations in the Paranapiacaba fragment

Several vertebrate species such as arboreal primates (Cebidae), guans (Cracidae) and toucans (Ramphastidae) are restricted to typically forestal environments. Nevertheless, some animal populations or species (especially those inhabiting the peripheral fringes of the Paranapiacaba fragment) are in the habit of periodically abandoning the Paranapiacaba fragment to feed in smaller fragments placed in the surroundings or even in other regions.

Some birds of prey (e.g. *Buteo brachyurus*) that nest in the Paranapiacaba fragment feed in neighbouring residual forest areas or even in areas that are currently covered by semiopen or open vegetation. The same happens with several parrot species (maybe most of them) inhabiting the study area. Among frugivorous species probably frequenting smaller fragments placed by or near the Paranapiacaba fragment, there is *Pyroderus scuttatus*, *Procnias nudicollis* (Cotingidae), *Turdus* spp. (Muscicapidae), *Euphonia* spp., *Tangara* spp., *Thraupis* spp. (Emberizidae, Thraupinae).

These frugivorous species are capable of taking vegetal diaspores (seeds) belonging to native species from the Paranapiacaba fragment into other fragments. In the same manner, they can transport seeds of alien species planted in neighbouring properties into the Paranapiacaba fragment and other smaller fragments in the area (Guix, 1995).

Apart from species moving at a little scale all through the year, some species or populations of migrant or wandering frugivores come from distant regions into the Paranapiacaba fragment in autumn and winter (e.g. *Stephanophorus diadematus* in the highest areas of the Paranapiacaba mountain range and *Turdus albicollis* in lower areas).

Among terrestrial mammals, there are also species restricted to the fragment and some others that get out of it sporadically or regularly. The fact that fresh traces belonging to *Puma concolor*, *Leopardus pardalis*, *Herpailurus yaguaroundi* and *Cerdocyon thous* are frequently found in open and semi-open areas shows that they go through those environments, particularly at night and dawn.

Finally, some of the animal populations restricted to habitats placed in the less elevated areas that are covered by Lowland Atlantic rainforest, can also be isolated from each other (that is, within the Paranapiacaba fragment) (see Figure 1). This makes its management even more complicated within this protected forest area.

Is the Paranapiacaba fragment area big enough to sustain, in the long term, the animal and plant populations that live in it?

The animal and plant populations inhabiting the Paranapiacaba forest fragment are under the effect of two important factors: 1) the factor surface - minimum area; 2) the factor isolation from other populations inhabiting the Atlantic mountain range rainforest areas.

In most vertebrate species, the effects of those factors in the medium and long term are not known yet. Nevertheless, at least for some large size vertebrate species (because they need large forest areas to survive or because they live in very low densities or both), it seems that the Paranapiacaba fragment is not big enough to sustain steady populations in the long term. The scarce populations of Jaguars and Broad-snouted caimans would be good examples.

In fact, several anthropic interferences, such as the selective hunting that is now occuring in the lowest areas of the Paranapiacaba mountain range and the Vale do Ribeira, probably also caused the extinction processes of the Harpy eagle (*Harpia harpyja*) and the Giant otter (*Pteronura brasiliensis*) in other areas of the Atlantic rainforest (Ihering, 1897; Sick, 1985, 1993; Emmons, 1990; Thiollay, 1994).

Figure 1: Protected areas in the Paranapiacaba fragment (A: P.E.T. Alto Ribeira; B: P.E. Intervales; C: P.E. Carlos Botelho; D: E.E. Xitué); areas below 200 m of altitude, covered by Lowland Atlantic rainforest, are shown in black. Ideal profile of the Paranapiacaba fragment; areas over and below 200 m of height are indicated..

Nevertheless, the fragment is topographically and ecologically very diversified, which means that many of the inhabiting animal species are not uniformly distributed across its area (see chapter 15). This is the case of *Bufo margaritifer*, *Crypturellus noctivagus noctivagus* and

Carpornis melanocephalus. To the species that inhabit forests placed in low areas only (< 200 m of height), the Paranapiacaba fragment is much smaller than to some others (Figure 1).

Top predators: conservation problems and suggestions

The four parks that form the ecological *continuum* are subject to a wide set of anthropic interferences from the neighbouring areas, such as illegal hunting and extraction (i.e.: palmito and timber extraction as combustible or building material, hunting of tinamous, guans, monkeys, big cats, tapirs, peccaries, etc).

The selective hunting of the Jaguar (*Panthera onca*) is a serious problem to the conservation of the reduced populations inhabiting the Brazilian Atlantic rainforest. Although this species has never been censused in the Paranapiacaba fragment, estimates based on studies that have been carried out in other areas of dense tropical forest suggest that the theoretical amount of jaguar specimens left in the fragment would be around 20 adults (cf. Guix, 1992, 2001). That is a very low amount of specimens to sustain a genetically steady population in the medium or long term. Many of the news arriving on Jaguar capture around the Atlantic rainforest fragments refer to "punitive expeditions" organised by farmers to catch or injure specimens that attack large size cattle (i.e.: cows, horses, mules and pigs). In order to diminish the pressure against big cat populations, not only a management plan that considered the translocation of specimens between Atlantic rainforest fragments and subtropical forests should be set, but also a pilot program giving economical compensations to farmers for the loss of cattle after the attack of jaguars and pumas should be established (Guix, 1997).

On the other hand, the survival of the remaining populations of the Broad-snouted caiman (*Caiman latirostris*) in the Paranapiacaba fragment depends on the introduction of a specific management program. This management program should consider the recovering of old water accumulation areas (i.e.: lagoons, flooding areas) under 300 m of height and the rescue and translocation of specimens inhabiting protected areas in the P.E. Intervales and private properties.

As it has been shown, the studied areas are highly important for the conservation of birds of prey. Generally, the knowledge on the species of this group in the Brazilian Atlantic rainforest is very limited, and more data on demographic parameters would be needed in order to analyse the problems that are related to their populations. In the valley of the Rio Carmo (P.E. Intervales) and in the P.E.T. Alto Ribeira central region there are steady populations of *Leucopternis polionota* (a threatened species), *Spizaetus tyrannus tyrannus* (a subspecies that is endemic to the Brazilian Atlantic rainforest) and other species of birds of prey. The population status of these species in the rest of the Paranapiacaba fragment and in the whole of the Brazilian Atlantic rainforest is nevertheless unknown. Considering the fragmentation of this ecosystem, determining the degree of isolation of the animal populations would be necessary - some of them are probably very restricted to forest environments (e.g. *L. polionota*) while some others prefer open or semi-open areas (e.g. *Buteo brachyurus*, *Cathartes aura* and *Coragyps atratus*).

Finally, it must be pointed out that the Southern river otter (*Lontra longicaudis*) occurred in all the prospected areas of the Paranapiacaba fragment. Considering the orographical conditions of the fragment, the external influence of polluting factors in the watercourses is very low. This means that, if there are not any direct interferences affecting Southern river otter populations (e.g. illegal hunting, mining), this species has a big habitat potential in the area.

Biomass concentration and hunting

Animal and plant biomass estimates are very useful because they allow theoretical approaches to the productivity and loading capacity of an ecosystem and they can be important management tools.

One of the main difficulties when estimating animal biomasses in large rainforest areas such as the Paranapiacaba fragment is having access to population density estimates. In this sense, we think that the density estimates included in this publication are reliable enough to allow calculations that are more general.

One of the simplest calculations to obtain a biomass estimate is multiplying the average number of individuals/km^2 of a certain species and its associated standard error by the average weight of an adult individual of this species. In order to estimate biomasses for each species (kg/km^2), we used the population density values found in 1998 (individuals/km^2; in this publication) and the adult weight values published by other authors (Sick, 1985, 1993; Emmons, 1990, del Hoyo *et al.*, 1994, 1997; Guix, 1995).

Available biomass estimates are shown in Table 1. Among the censused groups of frugivores (Cracidae, Ramphastidae, Psittacidae and Cebidae), biomasses are concentrated in monkeys (Cebidae) and, among them, in *Brachyteles arachnoides* and *Cebus apella nigritus* individuals. On second place, regarding biomass per individual and total available biomass per square kilometre of arboreal frugivores, there are *Alouatta guariba clamitans* (Cebidae) and the two Cracidae species inhabiting the area (*Penelope obscura* and *Pipile jacutinga*).

The phenomenon of biomass concentration in some faunal groups has been observed in other rainforest areas such as Cocha Cashu (Peru), located in Southwestern Amazonia. Cocha Cashu is a protected area of mature and old secondary Amazonian rainforest inhabited by over 100 mammal species, including most of the top predators expected in this kind of forest (Terborgh *et al.*, 1983). Terborgh (1986) estimated that nearly half of the mammal biomass in Cocha Cashu (approximately 1780 kg/km^2) was concentrated in only six species: *Alouatta seniculus*, 180 kg/km^2; *Ateles paniscus*, 175 kg/km^2; *Tapirus terrestris*; 150 kg/km^2; *Agouti paca*, 140 kg/km^2; *Pecari tajacu*, 125 kg/km^2 and *Tayassu pecari*, 105 kg/km^2. Frugivorous mammals (nearly 1400 kg/km^2) concentrate 78.7% of mammal biomass, while frugivorous birds (158 kg/km^2) represent only 11.3% of the estimated frugivorous mammal biomass (Terborgh, 1986).

The high biomass concentrations in each monkey and guan individual of the Paranapiacaba fragment can have indirect ecological implications for the predators of these animals in areas with a lot of illegal hunting (i.e.: the lowest areas in Saibadela and Alecrim). Illegal hunters usually look for arboreal species (easier to catch than terrestrial ones) that provide a higher proportion of biomass per specimen. Among them, frugivorous Cebidae monkeys and Cracidae are very appreciated.

When a group of illegal hunters gets into an area, and even if they just catch a few specimens, there is a strong diminishment in the available biomass of arboreal frugivorous animals. This diminishment not only has effects on the populations of each frugivore species, but it also affects negatively the predator populations that feed on them (i.e.: big cats and birds of prey).

On the other hand, the effect of biomass concentration in just a few individuals complicates the recovery of the populations of the most threatened frugivorous species. The forest loading capacity is limited and these species cannot survive in high densities in the isolated forest fragments.

Table 1. Contributions to biomass made by monkey species (Cebidae), guans (Cracidae), toucans (Ramphastidae) and parrots (Psittacidae) in the Paranapiacaba fragment. Means ± standard error are indicated.

	species weight (kg/ind)	density (ind/km^2)	biomass (kg/km^2)
CRACIDAE			
Pipile jacutinga	1.25 (Sick, 1985, 1993)	2.67 ± 0.93	3.34 ± 1.16
Penelope obscura	1.080 (del Hoyo, 1994)	3.52 ± 1.59	3.8 ± 1.72
RAMPHASTIDAE			
Ramphastos vitellinus	0.490 (Guix, per. obs.)	2.81 ± 1.46	1.38 ± 0.72
Ramphastos dicolorus	0.486 (Guix, 1995)	3.23 ± 1.25	1.57 ± 0.61
PSITTACIDAE			
Pionus maximiliani	0.263 (Collar, 1997)	2.59	0.68
Pionopsitta pileata	0.109 (Collar, 1997)	0.895	0.09
Pyrrhura frontalis	0.083 (Collar, 1997)	8.80	0.73
Brotogeris tirica	0.063 (Collar, 1997)	10.53	0.66
Forpus crassirostris	0.030 (Collar, 1997)	3.08	0.09
CEBIDAE			
Brachyteles arachnoides	13.5 (Emmons, 1990)	2.33 ± 1.37	31.46 ± 18.50
Alouatta guariba clamitans	5.65 (Emmons, 1990)	0.79 ± 0.40	4.46 ± 2.26
Cebus apella nigritus	3.1 (Emmons, 1990)	5.31 ± 2.05	16.46 ± 6.36

GENERAL CONCLUSIONS

All the chapters in this book talk about the importance of the Paranapiacaba fragment in the conservation of several threatened vertebrate species in Eastern Brazil. From a conservationist point of view, this is the most important Brazilian Atlantic rainforest fragment because of its large size, the excellent degree of conservation of its forest and the complex animal and plant communities that it hosts.

Considering the scenario of drastic reduction experienced by the Brazilian Atlantic rainforest biome, the long term future of several species of large vertebrates living in Eastern and Southeastern Brazil is strongly linked to the future of the largest remnant forests of the States of

São Paulo, Rio de Janeiro and Paraná, and, very especially, to that of the Paranapiacaba forest fragment.

In spite of the importance of the Paranapiacaba fragment, several kinds of threats (illegal hunting and extraction, mining) hang over the peripheral forest areas owned by private owners as much as over the protected areas of the woods. On the other hand, and in spite of its large size, Paranapiacaba is still an isolated forest fragment for most of the species that it hosts.

From a strictly conservationist point of view, it is obvious that the Paranapiacaba fragment needs protecting measures to banish illegal hunting and extractions, and better connections with the forest and lowland ecosystems to which it was connected in the past.

In order to fulfil these two needs, current protecting measures made by park's managers should be reinforced through the creation of new income sources. In this sense, apart from a deeper implication of national and international conservation organisations (Balmford *et al*., 2000; Wilson, 2000), the creation of a Trust composed by several counties ("municipios") could be useful. Economical funds could be provided by the townhalls of neighbouring villages (São Miguel Arcanjo, Apiaí, Guapiara, Sete Barras...). This Trust should consider the purchase of surrounding lands covered by native secondary forests in order to minimise the impact on mature forest margins (especially in the Vale do Ribeira region and near the Barra Grande and Xitué areas) and to create forest corridors connecting the ecological *continuum* to neighbouring forest fragments (Guix, 2001). Apart from public funds investments, the purchase of small fragments and woodlots by private Trusts should be promoted, as well as giving economical support (e.g. tax reductions) to private owners preserving areas covered by native forests (Langholz *et al*., 2000; Norton, 2000).

In the next few years, the strongest anthropic pressures over the Paranapiacaba fragment are going to come from the lower areas of Vale do Ribeira, where illegal hunting and extractions have grown a lot in the last ten years. Together with a more effective vigilance, internationally funded and continuous environmental education programs should be established in the populations around the fragment, especially in the Vale do Ribeira.

Nevertheless, speaking only about the intrinsical importance of tropical forests to children and adults that have such limited future expectations is a vain work. A wider project supporting socially depressed areas around the fragment is needed in order to provide landless farmers with better future perspectives that are compatible with the conservation and management of such an important natural heritage as the Paranapiacaba fragment.

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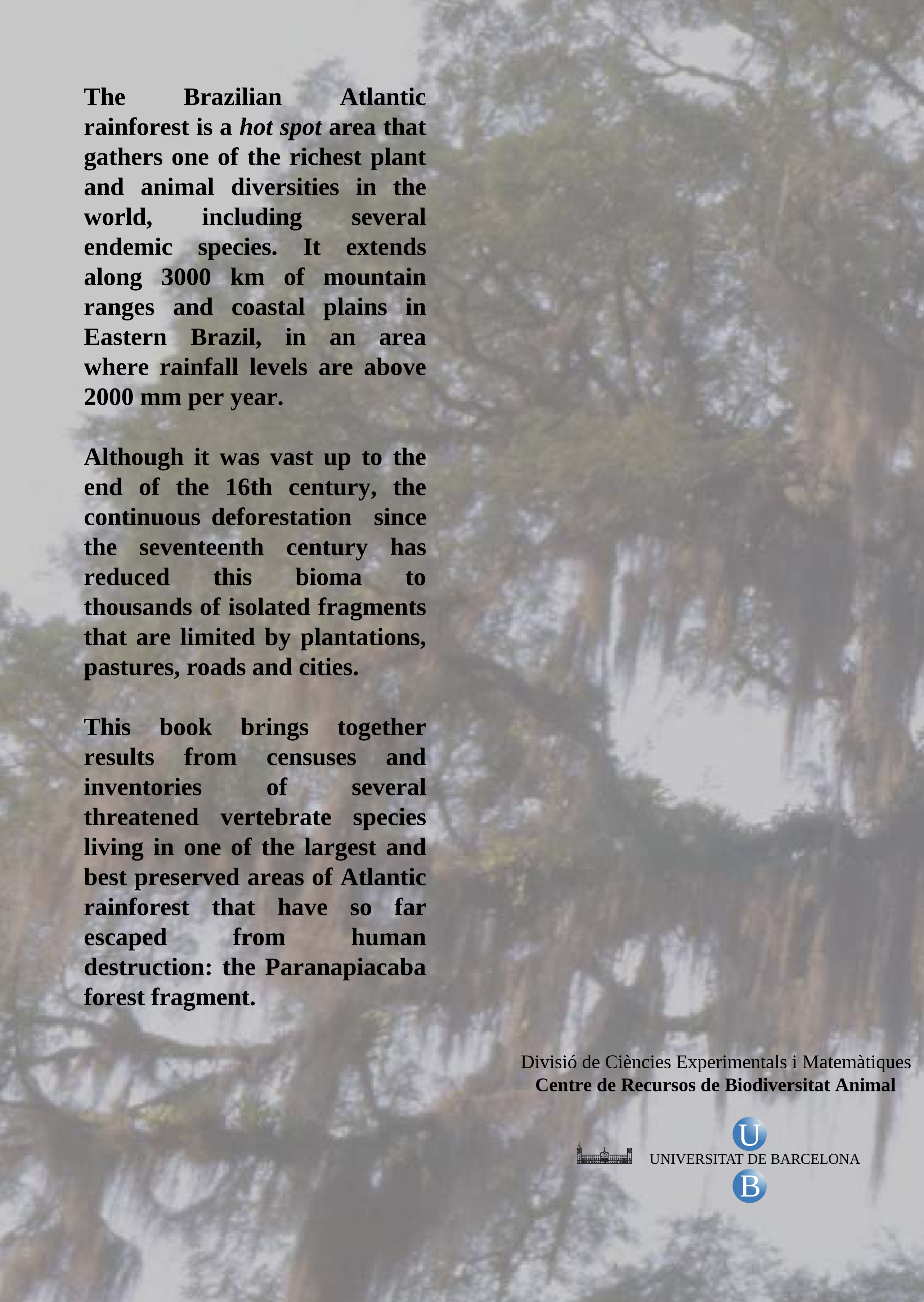

The Brazilian Atlantic rainforest is a *hot spot* area that gathers one of the richest plant and animal diversities in the world, including several endemic species. It extends along 3000 km of mountain ranges and coastal plains in Eastern Brazil, in an area where rainfall levels are above 2000 mm per year.

Although it was vast up to the end of the 16th century, the continuous deforestation since the seventeenth century has reduced this bioma to thousands of isolated fragments that are limited by plantations, pastures, roads and cities.

This book brings together results from censuses and inventories of several threatened vertebrate species living in one of the largest and best preserved areas of Atlantic rainforest that have so far escaped from human destruction: the Paranapiacaba forest fragment.

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