CONSERVATION VALUE OF A NATIVE FOREST FRAGMENT IN A REGION OF EXTENSIVE AGRICULTURE

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(With 1 figure)

ABSTRACT

A survey of mammals and birds was carried out in a semi-deciduous forest fragment of 150 ha located in a zone of intensive agriculture in Ribeirão Preto, State of São Paulo, south-eastern Brazil. Line transect sampling was used to census mammals and birds during six days, totalling 27.8 km of trails and 27.8 hours of observation. Twenty mammal species were confirmed in the area (except bats and small mammals), including rare or endangered species, such as the mountain lion (*Puma concolor*), the maned wolf (*Chrysocyon brachyurus*), and the ocelot (*Leopardus pardalis*). The brown capuchin monkey (*Cebus apella*) and the black-tufted-ear marmoset (*Callithrix penicillata*) were found frequently, suggesting high population density in the fragment. Regarding the avifauna, 49 bird species were recorded, most of them typical of open areas or forest edges. Some confirmed species, however, are becoming increasingly rare in the region, as for example the muscovy duck (*Cairina moschata*) and the toco toucan (*Ramphastos toco*). The results demonstrate that forest fragment of this size are refuges for native fauna in a region dominated almost exclusively by sugar-cane plantations. Besides faunal aspects, the conservation of these fragments is of great importance for the establishment of studies related to species preservation in the long term, including reintroduction and translocation projects, as well as studies related to genetic health of isolated populations.

Key words: avifauna, conservation, fragmentation, mammals, São Paulo.

RESUMO

Valor conservacionista de um fragmento de mata nativa em região de agricultura intensiva

Um levantamento da fauna de mamíferos e aves foi realizado em um fragmento de mata mesófila semi decídua com cerca de 150 ha de área localizado na zona de agricultura intensiva da região de Ribeirão Preto, Estado de São Paulo. O levantamento foi feito por meio de censos em trilhas durante seis dias, totalizando 27,8 km de trilhas e 27,8 horas de observacão. Foram confirmadas 20 espécies de mamíferos (exceto quirópteros e pequenos mamíferos), incluindo espécies ameaçadas ou raras na região, como a onça-parda (*Puma concolor*), o lobo-guará (*Chrysocyon brachyurus*) e a jaguatirica (*Leopardus pardalis*). O macaco-prego (*Cebus apella*) e o sagüi-de-tufo-preto (*Callithrix penicillata*) foram encontrados com muita freqüência, indicando altas densidades populacionais desses primatas no fragmento de estudo. Em relação à avifauna, foram registradas 49 espécies, a maioria das quais típicas de áreas abertas ou bordas de mata. Foram confirmadas, no entanto, algumas espécies que estão se tornando raras na região, como o pato-do-mato (*Cairina moschata*) e o tucanuçu (*Ramphastos toco*). Os resultados demonstram que fragmentos florestais deste porte representam refúgios de fauna nativa em uma região dominada quase que exclusivamente pela monocultura da cana-de-açúcar. Além dos aspectos faunísticos, a preservação desses fragmentos é de grande importância para a realização de estudos relacionados à preservação de espécies a médio e longo prazos, como projetos de reintrodução, translocação e saúde genética de populações isoladas.

Palavras-chave: avifauna, conservação, fragmentação, mamíferos, São Paulo.

INTRODUCTION

Forest fragmentation is one of the main problems affecting Tropical forests currently (Whitmore, 1997). Extensive forests are being destroyed at accelerating rates, leaving behind remnants that, in most cases, are immersed in a matrix of disturbed vegetation, pastures and crops. The effects of fragmentation are not only related to area reduction, but also to an increase in isolation among remaining fragments (Skole & Tucker, 1993). The joint action of these two factors cause severe alterations in the physical as well as in the biological environment of a previously intact forest (Lovejoy *et al.*, 1983; Bierregaard *et al.,* 1992).

A forest fragment can be, for example, too small to provide resources for wide-ranging species, or those with more specialised diets (Willis, 1979; Chiarello, 1999). The matrix of altered vegetation in which the fragments are immersed can reduce the movements of animals between fragments or the seasonal and altitudinal migrations that are characteristic of some forest species. Besides, forest fragments can only sustain small population sizes, which are more susceptible to local extinction due to several internal forces, including genetic, demographic, and environmental stocasticity, as well as profound alterations in competitive, predatory, and parasitic interactions (Soulé & Simberloff, 1986; Fonseca & Robinson, 1990; Chiarello, 1997). Additionally, populations reduced to small sizes are subjected to a range of problems related to the loss of genetic diversity (Franklin, 1980; Boecklen, 1986).

The impact of hunters and loggers is higher in forest fragments when compared to continuous forest as fragmentation increases the access of people to forest areas previously difficult to reach (Redford, 1992; Robinson, 1996). Finally, populations isolated in forest remnants are influenced by other "external" forces, as for example the invasion of exotic species, exposure to herbicides and pesticides from adjacent crop fields, and increased incidence of fires, to cite just a few (Janzen, 1983; Chiarello, 1997). Besides, since the perimeter/area ratio is greatly increased in forest fragments, the influence of edge effects are magnified (Murcia, 1995).

This paper presents data on mammals and birds recorded in a forest remnant located in a private property in Ribeirão Preto region, State of São Paulo, south-eastern Brazil. The aim of the study is to present a commented list of the species occurring in the fragment, stressing its biological value as well as its potential for future studies on conservation biology. The study area is isolated from other native forest fragments by extensive croplands, notably sugar-cane plantations and is subjected to the consequences of a centuries-old process of anthropogenic disturbance. Originally, native forests covered *ca*. 82% of São Paulo State but today they are restricted to only 8% of the state's area (Kronka *et al.*, 1993).

MATERIAL AND METHODS

Study area

The study area is located in two private properties, the Fazenda da Serra and Fazenda Ponta da Serra, located in the municipality of Jardinópolis, region of Ribeirão Preto, in northern São Paulo State (47°38'-47°41'W; 21°04'-21°06'S). The local topography is characterised by undulating hills with average altitude of 670 m a.s.l. The predominant soils are red latossols, structured "Terra Roxa", and quartzite sands (Borges, 1995). The climate is the *Cwa* of Köppen and the annual precipitation is *ca.* 1,802 mm, with a wet season from November to March and a dry season from April to October (Fiorio, 1995).

The vast majority of the area available to agriculture is occupied with sugar-cane plantations, followed by coffee, fruticulture and cereals (Borges, 1995). Regarding native vegetation, the study area is located in a transition zone between the domains of cerrado and the mesophitic, semi-deciduous forests (Atlantic forest *lato sensu*; Rizzini, 1963). As is typical in this region, the mesophitic forests occur in places of higher soil fertility, whilst cerrado (*lato sensu*) occur in sandy, acidic soils.

The observations were carried out in a forest fragment of *ca.* 150 ha formed by two main blocks linked to each other by a corridor of narrower width (Fig. 1). The northern part is located in the slope while the southern part stretches downwards and reaches the bank of Rio Pardo, forming an altitudinal gradient of *ca*. 200 m. The fragment is surrounded predominantly by Guinea grass pastures (*Panicum* spp.) and sugar-cane plantations.

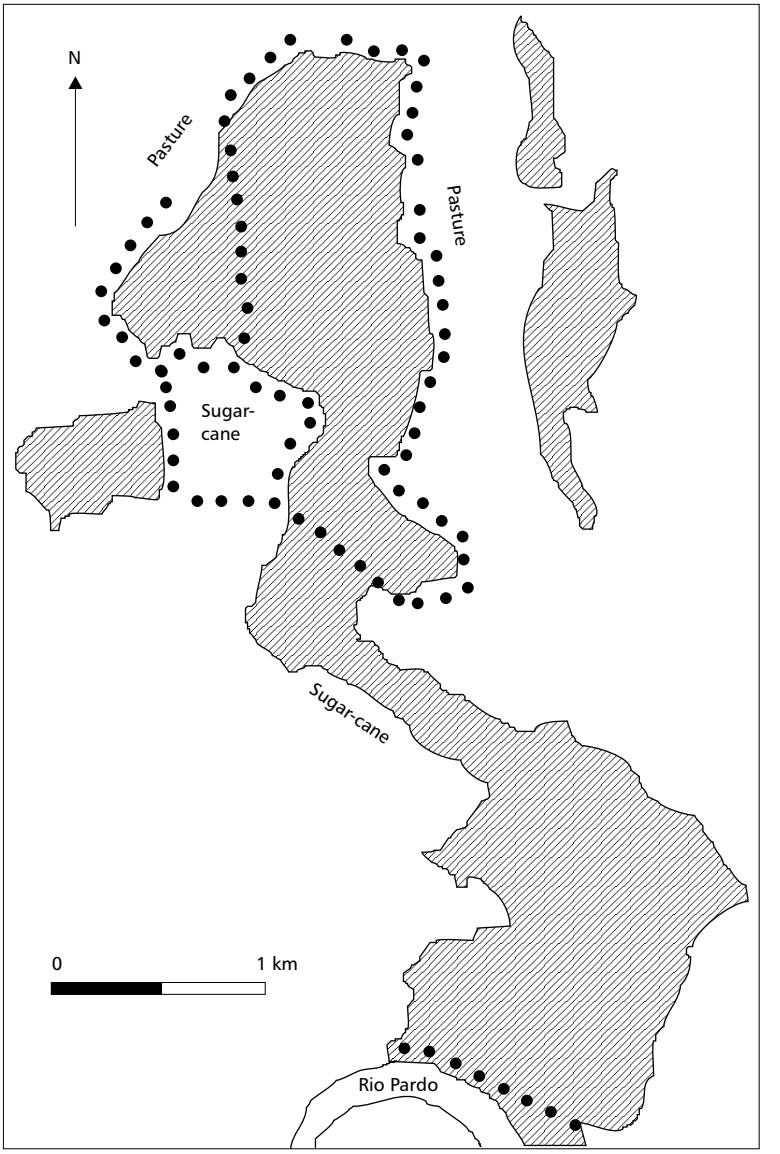

Fig. 1 — Map of the study area showing the main fragment with *ca.* 150 ha and three other adjacent smaller fragments. The southern part of the main fragment reaches the bank of Pardo River. The dotted line indicates places sampled during the study.

Three other smaller fragments are found nearby the main fragment, two to the east and one to the west of it.

Data collection

Data were collected mainly along a trail of 1 km in length located in the interior of the fragment but forest edges, the narrow "corridor", and the banks of Rio Pardo were also sampled (Fig. 1). After preliminary visits, data were collected in a total of six days, as follows: 11, 12, 13, 16, 17 an 18 of March, 1998, totalling 27,750 m of trails walked during 27.45 hours of observations. Trails and forest edges were walked at *ca*. 1 km/h with stops at every 20-30 m for listening and watching mammals and birds. A detailed description of the line-transect sampling, a technique that has been used successfully in a number of previous studies

(Chiarello, 1995, 1997, 1999), is provided by Buckland *et al*. (1993).

The sampling was restricted to the period of higher bird and mammal activity (05:30 h-10:00 h) and 8 x 32 binoculars were used during all observations. All mammal and bird species seen, heard, or whose footprints or faeces were observed, were recorded. Small mammals (rodents and marsupials) and bats were not sampled as time and logistical constraints prevented the use of additional sampling techniques. Reports of farm staff and local hunters were used to confirm the presence of species not recorded during this study.

Data analysis

Encounter rates were used as an index of relative abundance for mammal species seen during censuses, as used in previous studies (Chiarello, 1999), and by other authorities (Janson & Emmons, 1990; Malcolm, 1990). This index is species-specific and is calculated dividing the number of visual encounters by the total transect length, adjusted to 10 km. Wilson & Reeder (1993) was used as reference for mammal nomenclature and Sick (1997) for that of birds.

RESULTS

Mammals

A total of 20 mammal species were recorded in the study area (Table 1). This list is probably incomplete, however, due to the short period of observation which precluded the recording of some rare, shy, or elusive species. In general, the list presents species whose occurrence is expected in native forest fragments of this region, and includes one marsupial, three xenarthrans, two primates, eight carnivores, one artiodactyl, four rodents, and one lagomorph. Only two species were effectively seen during censuses, the black-tufted-ear marmoset (*Callithrix penicillata*), and the brown capuchin monkey (*Cebus apella*). The brown capuchin monkeys were the most abundant mammals in the area, with *ca*. 2.7 groups/10 km of census, followed by the black-tufted-ear marmoset, with 1.8 groups/10 km (Table 2).

Some rare species were recorded in the study area. The puma (*Puma concolor*), for example, was confirmed by scats and claw marks found in tree trunks within the forest. These evidences were not fresh, however, indicating that the puma has not frequented the fragment recently and probably is not resident there. Two other species that are becoming increasingly rare in the region were also confirmed: the maned wolf (*Chrysocyon brachyurus*) and the ocelot (*Leopardus pardalis*).

Birds

Forty nine bird species had their presence confirmed in the study fragment or in adjacent open areas (Table 3). As for mammals, this list in incomplete given the preliminary nature of the study. The majority of bird species recorded are typical of open areas or forest edges and some are found even in or nearby urban zones.

DISCUSSION

Mammals

The two primate species observed in the fragment are common in mesophitic forests of this region as well as in "cerradão" (savannah like vegetation with closed canopy). When compared to other studies, the encounter rates here calculated indicate high primate density for the study area. In mesophitic forest fragments of western São Paulo, for example, Cullen (1997) found brown capuchin monkeys at densities varying from 0.7 to 2.7 groups/10 km, and in forest fragments of Espírito Santo, densities varied from 0.6 to 2.5 groups/10 km for brown capuchins and from 0.2 to 2.2 groups/10 km for marmosets (Chiarello, 1997).

This high primate density is a likely consequence of two main factors. Firstly, although ocelots and pumas are present, other primate predators such as jaguars (*Panthera onca*) and raptors (*Harpia harpyja*; *Spizaetus* spp.), have long been extinct in the area. Sencondly, the forest destruction and consequent isolation between fragments prevent or greatly diminish dispersion of individuals to other areas, causing an increase in density in fragments. This phenomenon has also been observed in other isolated primate populations (Chiarello, 1993; Chiarello & Galetti, 1994).

Regarding the presence of pumas, it is necessary to mention that a 150 ha forest fragment is not large enough to sustain viable populations of this cat, which is probably using the fragment as a refuge. As found in other studies, this big cat needs areas many times larger, that may vary from 3,000 to more than 15,000 ha/individual (Oliveira, 1994).

TABLE 1

Mammal species recorded in the study fragment and adjacent areas of Fazenda da Serra, Jardinópolis, São Paulo State.

Common name/ORDER	Scientific name	Type of record*				Presence probable†
		Vi.	Fo.	Fa.	Re.	
DIDELPHIMORPHIA						
1 Common opossum	*Didelphis albiventris*					x
XENARTHRA						
2 Nine-banded armadillo	*Dasypus novemcinctus*		x			
3 Yellow armadillo	*Euphractus sexcinctus*					x
4 Southern tamandua	*Tamandua tetradactyla*					x
PRIMATES						
5 Black-tufted-ear marmoset	*Callithrix penicillata*	x				
6 Brown capuchin	*Cebus apella*	x				
CARNIVORA						
7 Crab-eating dog	*Cerdocyon thous*	x	x			
8 Maned wolf	*Chrysocyon brachyurus*		x		x	
9 Jaguarundi	*Herpailurus yaguarondi*					x
10 Ocelot	*Leopardus pardalis*				x	
11 Oncilla	*Leopardus tigrinus*					x
12 Puma	*Puma concolor*		x	x		
13 Coati	*Nasua nasua*				x	
14 Crab-eating raccoon	*Procyon cancrivorus*		x			
ARTIODACTYLA						
15 Brocket deer	*Mazama* sp.		x			
RODENTIA						
16 Porcupine	*Sphiggurus* sp.					x
17 Capybara	*Hydrochaeris hydrochaeris*				x	
18 Paca	*Agouti paca*		x		x	
19 Cavy	*Cavia aperea*					x
LAGOMORPHA						
20 Tapiti	*Sylvilagus brasiliensis*					x

* Type of record: Vi. visual encounter; Fo. footprints; Fa. faeces; Re. reported by locals.

† Species whose presence could not be confirmed during study but whose presence is likely there.

TABLE 2

Number of visual encounters and calls heard of two primate species recorded during census time in the study fragment.

Common name	Scientific name	Encounter		Encounter rate (Groups/10 km of census)
		Vocal	Visual	
Black-tufted-ear marmoset	*Callithrix penicillata*	4	4	1.79 groups
Brown capuchin monkey	*Cebus apella*	3	6	2.69 groups

TABLE 3

Bird species recorded in the study fragment and adjacent areas of Fazenda da Serra, Jardinópolis, São Paulo State.

Common name/ORDE	Scientific name	Tipe of record*		
		Vi.	Ca.	Re.
TINAMIFORMES				
1 Small-billed tinamou	*Crypturellus parvirostris*	x		
CICONIIFORMES				
2 Black vulture	*Coragyps atratus*	x		
ANSERIFORMES				
3 Brazilian duck	*Amazonetta brasiliensis*	x		
4 Muscovy duck	*Cairina moschata*	x		
5 White-faced whistling-duck	*Dendrocygna viduata*	x		
FALCONIFORMES				
6 Savanna hawk	*Buteogallus meridionalis*	x		
7 Laughing falcon	*Herpetotheres cachinnans*		x	
8 Roadside hawk	*Rupornis magnirostris*	x		
9 Yellow-headed caracara	*Polyborus plancus*	x		
GALLIFORMES				
10 Guan	*Penelope* sp.			x
GRUIFORMES				
11 Gra -necked wood rail	*Aramides cajanea*	x		
12 Red-legged seriema	*Cariama cristata*	x		
CHARADRIFORMES				
13 Southern lapwing	*Vanellus chilensis*	x		
COLUMBIFORMES				
14 Picazuro pigeon	*Columba picazuro*	x		
15 Ruddy ground-dove	*Columbina talpacoti*	x		
16 Scaled dove	*Scardafela squamata*	x		
17 White-tipped dove	*Leptotila verreauxi*	x		
PSITTACIFORMES				
18 Peach-fronted parakeet	*Aratinga aurea*	x		
19 Flaming parakeet	*Aratinga solstitialis*	x		
20 White-eyed parakeet	*Aratinga leucophthalmus*	x		
21 Plain parakeet	*Brotogeris chiriri*	x		
22 Blue-winged parrotlet	*Forpus xanthopterygius*	x		
CUCULIFORMES				
23 Striped cuckoo	*Tapera naevia*		x	
24 Pavonine cuckoo	*Dromococcyx pavoninus*		x	
25 Guirra cuckoo	*Guira guira*	x		
26 Smooth-billed ani	*Crotophaga ani*	x		
27 Squirrel cuckoo	*Piaya cayana*	x		

* Type of record: Vi. visual encounter; Ca. call heard; Re. reported by locals.

TABLE 3 (*Continued*)

Common name/ORDER	Scientific name	Tipe of record*		
		Vi.	Ca.	Re.
STRIGIFORMES				
28 Barn owl	*Tyto alba*		x	
29 Ferruginous pygm -owl	*Glaucidium brasilianu*		x	
30 Tropical screech-owl	*Otus choliba*		x	
31 Burrowing ow	*Speotyto cunicularia*	x		
CAPRIMULGIFORMES				
32 Pauraque	*Nyctidromus albicollis*	x		
PICIFORMES				
33 White-eared puffbir	*Nystalus chacuru*		x	
34 Toco toucan	*Ramphastos toco*	x		
35 Gree -barred woodpecker	*Colaptes melanochloros*	x		
36 Lineated woodpecker	*Dryocopus lineatus*	x		
PASSERIFORMES				
37 Barred antshrike	*Thamnophilus doliatus*	x		
38 Slaty antshrike	*Thamnophilus punctatus*	x		
39 Great antshrike	*Taraba major*	x		
40 Narrow-billed woodcreeper	*Lepidocolaptes angustirostris*	x		
41 Boat-billed flycatcher	*Megarynchus pitangua*	x		
42 Tropical kingbird	*Tyrannus melancholicus*	x		
43 Yellow-bellied elaeni	*Elaenia flavogaste*	x		
44 Brown-crested flycatcher	*Myiarchus tyrannulu*	x		
45 Pale-breasted thrush	*Turdus leucomela*	x		
46 Chalk-browed mockingbird	*Mimus saturninus*			
47 Flavescent warbler	*Basileuterus flaveolu*	x		
48 Sayaca tanager	*Thraupis sayaca*	x		
49 Saffron-billed sparrow	*Arremon flavirostri*	x		

* Type of record: Vi. visual encounter; Ca. call heard; Re. reported by locals.

In other localities of the Atlantic forest, the presence of pumas has been confirmed in fragments of *ca*. 1,500 ha, but, in these cases, the long-term survivorship is only possible because the cat uses also other forest fragments that occur nearby (Chiarello, 1997). It is noteworthy to mention that there is no recent record of puma attacks to domestic animals in Fazenda da Serra, indicating that this predator is getting its prey from the native fauna. A preliminary examination of two puma scats found in this farm has shown that capybaras (*Hydrochaeris hydrochaeris*), which are common in the marshlands of Rio Pardo, are being preyed upon.

Other species that deserves comment is the maned wolf (*Chrysocyon brachyurus*), which is included in the official Brazilian endangered species list (Bernardes *et al.*, 1990). As for pumas, it is rather surprising to find this species surviving in a zone of intensive agriculture in the neighborhoods of a large city like Ribeirão Preto. The maned wolf is not a forest dweller, rather, it inhabits open areas like cerrado (*lato sensu*), but is using the study fragment probably as a daytime refuge (Motta-Junior *et al.*, 1996). Although weighting up to 20-25 kg, the maned wolf feeds on a variety of food items, including fruits and small preys, like rats, lizards and birds. This diet flexibility is certainly con-

tributing for the survivorship of this predator in the region.

Birds

Some bird species were not expected to be found in the study fragment. Muscovy ducks (*Cairina moschata*), for example, were seen in flocks of up to eight individuals flying over the forest in the direction of Rio Pardo. This duck feeds during daytime in marshlands and ponds, but use forest trees as sleeping sites (pers. obs.). Although muscovy ducks have a wide geographic range, it is becoming increasingly rare in the study region due to the disapearing of marshlands as well as illegal hunting. Toco toucans (*Ramphastos toco*), the largest of the ramphastids, is another bird species that is disappearing from the region due to habitat loss. The presence of guans (*Penelope* spp.) was related by one of the owners of Fazenda da Serra (Rafael Borges, pers. comm.), but no individual of this species was seen or heard during census time, suggesting that few individuals are surviving there. Guans, however, have been recorded in a 250 ha forest fragment in the region of Campinas (Reserva de Santa Genebra), as well as other fragments of similar size (pers. obs.).

Faunal diagnosis

In general, the fauna recorded for the study area was composed by habitat-generalist species, with high capacity of adaptation to differing types of forest cover. This is not surprising because the farm is located in a region characterised originally by a mosaic of differing vegetation types, including both cerrado and mesophitic forests (IBGE, 1993). Therefore, the majority of its native birds and mammals are adapted, to a certain degree, to survive in small patches of forests isolated by more open vegetation. However, given the intensive agriculture that predominate in this region, very few forest patches still remain. The region of Ribeirão Preto is one of the most depleted of native forests in São Paulo State. Between 1962 and 1992, for example, this region lost *ca*. 410,000 ha of native vegetation, a reduction of 60% of its original cover (Kronka *et al.*, 1993). Only small and scattered fragments remain, and besides being isolated of each other, these fragments have been highly disturbed by selective logging, hunting, and intrusion of fires. In this sense, the study fragment is no exception, as its forest is secondary. The reduced area of this fragment, together with the effects of fragmentation, explain why some forest species no longer occur there. This is the case of large terrestrial predators such as jaguars (*Panthera onca*), or large terrestrial frugivores, like tapirs (*Tapirus terrestris*) and peccaries (*Tayassu pecari* and *Pecari tajacu*), and large mirmecophages, such as the giant anteater (*Myrmecophaga tridactyla*) and the giant armadillo (*Priodontes maximus*). As they have very large home ranges (large predators and terrestrial frugivores) or have specialised diets (large mirmecophages), these species are the most vulnerable to fragmentation and, generally, they can only survive in forest fragments larger than 20,000 ha (Chiarello, 1999).

This can also be observed in birds, because large raptors (*Harpya harpija* and *Spizaetus* spp.), large frugivores like curassows (*Crax fasciolata*), macaws (*Ara* spp.) and parrots (*Amazona* spp.), or large tinamids like solitary tinamous (*Tinamus solitarius*) and yellow-legged tinamous (*Crypturellus noctivagus*), have long disappeared in the area. This trend has already been noticed by Willis (1979), which observed that birds characteristic of forest edges (mostly small, insectivores birds) tend to increase in small fragments, while large frugivores and large insectivores tend to decrease in small patches of native forest. On the other hand, species that easily cross open areas or that use forest habitat occasionally (*Columbina talpacoti*, *Tyrannus melancholichus*, *Thraupis sayaca*, for example) are frequently seen even in very small fragments (Ribon, 1998).

Conservation potential

There are relatively few studies of tropical forest fragments that have been isolated for decades or more (Turner & Corlett, 1996). Small fragments are worth conserving, however, for a number of reasons. They can provide data, for example, on the proportion of the original number of species that can maintain viable populations in the long term. Also, to conserve small fragments can facilitate the recovery of primitive forests through the growth of secondary vegetation (Turner & Corlett, 1996).

Despite the absence of several species, the study fragment has an enormous biological

potential, notably due to the presence of endangered or rare species. Additionally, as remarked above, little remain of the mesophitic forests that once covered the largest part of São Paulo tablelands (Willis & Oniki, 1992), although the ecology and behavior of its native species are still poorly known. Most of what is known about the Atlantic forest fauna comes from studies carried out elsewhere, especially in the more humid forests of "Serra do Mar" and "Serra da Mantiqueira", where the majority of Atlantic forest remnants are concentrated.

As remarked by Willis & Oniki (1992) comparing the conservation status of birds in São Paulo, less bird species are disappearing from the coastal forests than from the interior and cerrado forests. Part of this results from the fact that less forest area of this region is protected in biological reserves. In São Paulo, for example, there are almost no reserves in the interior of the state. However, the conservation efforts in Brazil are mainly directed to humid forests, both Amazonian and Atlantic, while, by contrast, the cerrado, the interior forests, and the caatinga receive almost no attention" (Willis & Oniki, 1992).

The study area is potentially valuable for studies focusing on the conservation and management of fauna of isolated fragments. It is becoming increasingly necessary, for example, to understand how species surviving in small forest remnants are adapting to changes in the environment. Large predators like pumas and maned wolfs are good candidates for such studies as they present naturally low population densities, which make them very vulnerable to the effects of habitat reduction and isolation.

Another interesting alternative of research are reintroduction projects for those species that existed in the past but vanished due to anthropogenic disturbance. Among primates, for example, a 150 ha fragment could sustain some social groups of black howlers (*Alouatta caraya*) and masked titi monkeys (*Callicebus personatus*).

These two species occur in forest fragments of this region and have been recorded even in forest remnants of smaller size and more disturbed vegetation (pers. obs.). In this way, populations surviving in tiny fragments (*ca.* 10 ha or less), which have little chance of long-term survival, could be transferred to larger-sized fragments, such as the one studied here, where these species have been extinct.

Isolated populations present good opportunities for studies on their genetic "health". Due to isolation and consequent lack of dispersion of young individuals, the probability of inbreeding in such populations is greatly increased. It is known that inbreeding can cause, as generations succeed, increased homozigosity and loss of allelic viability (Soulé & Simberloff, 1986), causing, among other consequences, the appearance of infertile individuals or with reduced viability (Gilpin & Soulé, 1986).

Finally, these fragments can be used to study the penetration distance of edge effects, which include changes in the floristic composition and physiognomy due to increased exposure of edge vegetation to winds, hot air currents, solar radiation, etc. (Kapos *et al*., 1997). These studies would help to formulate future management actions to diminish the impact of edge effects, as for example, through the control of lianas and vines, which proliferate in fragments causing damage to trees, or through the growing of *Eucalyptus* or other fast-growing trees along forest edges, that could serve as effective wind-breaks.

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