PRIMATE POPULATIONS IN CONTINUOUS FOREST AND FOREST FRAGMENTS IN CENTRAL AMAZONIA. (*)

Anthony B. Rylands (**)
Alexine Keuroghlian (***)

SUMMARY

*Population densities of six primate species (**Saguinus midas**, **Pithecia pithecia**, **Cebus apella**, **Chiropotes satanas**, **Alouatta seniculus** and **Ateles paniscus**) were estimated in continuous forest and in isolated reserves (one of 100 ha and four of 10 ha). **Saguinus** densities in the continuous forest were found to be low, probably due to the lack of edge habitat and second growth favoured by them; **Pithecia**, **Cebus** and **Ateles** populations are also low, possibly because of more widely distributed and/or less abundant food sources than is true for other Amazonian regions, although hunting in the past, particularly of **Ateles** may also be a contributing factor; and **Chiropotes** and **Alouatta** densities were found to be similar to those observed in other areas of Amazonas forests. **Ateles** and **Chiropotes**, which occupy ranges on the order of three km² were excluded from the 100-ha reserve at the time of its isolation. Unfortunately populations were not known prior to isolation of this reserve but during isolation there remained four groups of **Saguinus**, two **Pithecia** groups, one **Cebus** groups and five **Alouatta** groups. One **Saguinus** group disappeared two months later, and one year post-isolation the **Cebus** group also left the reserve. Single **Alouatta** groups survive in the isolated 10-ha reserves. **Saguinus**, present in the four 10-ha reserves following isolation, have disappeared from two of them. One 10-ha reserve retains a group of **Pithecia**.*

INTRODUCTION

Agricultural activities in the terra firme tropical rain forest of Central Amazonia invariably result in isolated forest fragments. These fragments, isolated by cattle pasture and commercial crops, retain primate populations differing in size and composition on the areas of the forest and habitats and floristic communities they contain. In 1979, the World Wildlife Fund - U.S. and the National Institute for Amazon Research

---

(*) Paper presented at the Second Brazilian Primatology Congress, Campinas, São Paulo, 29th january to 2nd February, 1985.

(**) Instituto Nacional de Pesquisas da Amazônia, Manaus - AM.

(INPA) of Brazil initiated the Minimum Critical Size of Ecosystems Project (MCSE) involving the study of different sized forest fragments resulting from the forest clearence on three farms in the Agricultural District of Manaus, approximately 80 km north of the city (Fig. 1). The aim is to examine what size of isolated forest remmant is necessary to maintain the diversity and community structure characteristic of the forest before its isolation and what are the processes involved in the ecological changes which result when the remnant is too small (Lovejoy **et al.**, 1983). By agreement with farm owners, the areas of the forest left standing are standardized to 1-ha, 10-ha, 100-ha, 1000-ha, and 10,000-ha. These areas (hereafter called reserves) are marked out and studied before their isolation and left standing when clearance activities reach that part of the farm.

These are nine primate species which occur in this region, north of the Rio Amazonas and east of the Rio Negro in Brazil. Two of these have not been observed in the farms of the project area. One is the squirrel monkey, **Saimiri sciureus**, which is typical of flooded forest, and the weeper capuchin, **Cebus nigrivittatus**, of some unknown reason is also absent. Of the remaining seven, the night monkey, **Aotus trivirgatus**, although probably occurring in the area, has never been observed in the reserves. The remaining six species range in size from the midas (golden-handed) tamarim, **Saguinus midas**, of 450-550 gm to the black spider monkey, **Ateles paniscus**, of 7-9 kg (Table 1).

Studies of the primates in the reserve area started in July 1983, and here we report on our findings regarding their densities in the still-continuous forest and their survival in a reserve of 100 ha which was already in the process of isolation and four reserves of 10 ha, isolated during 1980-1984.

METHODS

The Study Area

The study was carried out on three farms approximately 80 km north of Manaus on the Manaus-Boa Bista highway (BR-174) ($2^{o}25'S$, $59^{o}W$) (Fig. 1). The terrain is undulating and bisected by numerous small streams. The predominant soils are nutrient-poor, yellow latosols. The vegetation is tall terra firme tropical rain forest with a closed canopy at 25-35 m and emergent trees reaching heights of 40-50 m. The understory in sparse with abundant stemless palms. The stream valleys are commonly abundant in patuá(**Jessenia batatua**) or (**Mauritia flexuosa**) palms. The annual precipitation in the Adolfo Ducke Forest Reserve nearby ($3^{o}00'S$, $59^{o}55'W$) during the years 1967-1979 was 2170-2900 mm with a dry season from June to October/November (monthly mean precipitation 83-166 mm) and a wet season from December to May (monthly mean precipitation 226-330 mm) (Marques-Filho **et al.** 1981).

The Reserves

Primate surveying was carried out in four 100-ha reserves, each of which contain four parallel trails, separated by 200 m and a fifth trail which bisects the other four down the middle of the reserve. Each trail is marked every 50 m. One of the reserves

(Porto Alegre, 3304) has an additional two lateral trails which were also surveyed. The total trail lengths are shown in Tables 2 and 3. The Dimona (2303), Florestal (1301) and km 34 (1302) reserves are not yet isolated and surveys within them are combined for estimating densities in continuous forest. The Porto Alegre (3304) reserve was largely isolated during the period June-August 1983, although a small isthmus of forest along a stream connected it with continuous forest until September 1984 when a swathe was cut across it, isolating the reserve completely. The cleared area around the reserve was not burned. The four 10-ha reserves were isolated from June to August 1980 (Colosso, 1202) April to August 1983 (Cidade Powell, 1207 & Porto Alegre, 3209) and from June to July 1984 (Dimona, 2206). The felled forest was burned around two of the reserves in the months following their isolation (1202 & 2206) but not around 1207 and 3209.

Survey Techniques

Primate population densities were estimated using the method of repeat transect censuring (NRC, 1981). The perpendicular distance from the path (DFP) of the first monkey seen at each sighting was used to examine the frequency of sightings at different distances from the path, and, from this, infer the maximum reliable sighting distance and hence the transect width (Kelker's method, see NRC, 1981). The density estimates for individuals are made on the actual numbers seen during surveying rather than average group size (Freese **et al.**, 1982). This results in a slight understimation because it is rare that all individuals in the group are counted. Results of transect surveying in the 100-ha isolate are compared with the numbers of primates known to occur in the reserve in order to examine any bias in the method for the different primate species.

RESULTS

Primate Densities in Continuous Forest

The surveys of the three 100 ha reserves which have not been isolated (1301, 1302 & 2303) are combined to provide estimates of the primate densities in continuous forest. The most abundant species in terms of groups/km^2 were **Alouatta**, followed by **Saguinus** (Table 2). **Alouatta** was also the most abundant in terms of individuals/km^2 but **Chiropotes**, which live in large groups, were the second most abundant, with **Saguinus** taking third place. The density estimates by surveying agree quite well with the picture obtained by examining the number of different groups with home ranges partly or entirely within the reserves (Table 4), except in the case of **Alouatta** and **Pithecia**. The survey method is evidently underestimating **Alouatta** numbers by one-half to two-thirds. This is confirmed in the Porto Alegre data where, due to isolation, it is known that the entire home ranges of 4-5 groups were contained within 100-ha and yet density estimates ranged from 0.8 to 1.6 groups km^2 during the three survey periods (Table 3). **Alouatta** spend long periods resting during the day in the upper canopy and are easily missed at these times. **Pithecia** are very quiet, retiring and fast-moving monkeys and their densities are

probably underestimated by one-quarter to one-half. There were some anomalies, however, in that, in three cases, species which have been seen in the reserves were not recorded during surveys. All three reserves have the full complement of species but **Saguinus** were not recorded during 83.6 km of surveying in the km 34 reserve. Two groups have been observed with their ranges just overlapping the edge of the reserve (Fig. 2). Neither **Pithecia** nor **Cebus** were recorded during 77.8 km of surveying in the Florestal reserve, although both species have been observed there: **Pithecia** on two occasions and **Cebus** on only one occasion.

Comparing the numbers of groups of each species in the three reserves, the results are quite uniform with two **Saguinus** group in each, one to two, or possible three, family groups of **Pithecia**, one to two **Cebus**, one to two **Chiropotes** groups and three to five groups of **Alouatta** (Table 4). A minimum of 6-9 **Ateles** were seen in each of the reserves, but because small subgroups are ephemeral and individuals were not differentiated except by size and sex, the actual numbers of individuals was probably higher. This sub-grouping behaviour makes it impossible to say how many groups were using the reserves and therefore groups/km^2 were not calculated.

Primate Densities in an Isolated Reserve of 100 ha

Observations of primates in the Porto Alegre reserve of 100 ha were started during the last stages of its isolation in June 1983. The isolation of the reserve resulted in the immediate loss of **Ateles** and **Chiropotes**.

Populations of the remaining primates are shown in Tables 3 and 4. Population estimates by surveying agree quite well in the observed situation in the reserve for **Saguinus** and **Cebus**, although, as explained previously, the numbers of **Pithecia** and **Alouatta** are underestimated. The rather high estimate for **Saguinus** in 1983 (Table 3) resulted from frequent, noisy group encounters over one of the trails (see below) during this time. The first half of 1984 underestimated and the second half overestimated the density of **Saguinus**. This is believed to have resulted from an imbalance in the total numbers of surveys of each of the trails during the respective time periods. For **Cebus**, the slight overestimation during 1983 occurred because, during one period of surveying, the group was feeding, sometimes twice daily, on two fruiting trees which were right by the survey trails. The lower estimate for the second half of 1984 occurred because the group were leaving and re-entering the reserve (see below). **Alouatta** numbers were one to three times higher than those estimated by surveying and **Pithecia** numbers were approximately double those estimated by surveying. **Pithecia** were only seen on two occasions during the first half of 1984.

Saguinus midas

From June till August 1983 there were four groups in the reserve. However, inter group disputes were frequently observed for two of these, approximately 100 m from the eastern boundary of the reserve. After August 1983, one group, which occupied a small home range of approximately 3-5 ha was not seen again. A field hand observed a group of

Saguinus leaving the reserve from its eastern edge in late August. Three groups have remained since then. Their ranges cover almost the entire reserve and are estimated to be approximately 30 ha. Two of the groups contain seven individuals and the third is composed of 9-10 individuals, although in December 1984 one of the smaller groups and the large group were observed with newborn twin infants.

Pithecia pithecia

During 1983 a minimum of five individuals were living in the reserve: two adult pairs and a juvenile, estimated to have been at least a year old. In the first half of 1984 they were seen on only two occasions; and not at all during surveying. In August 1984, however, a group of one adult pair, a juvenile female (about six months old), and a fourth unidentified saki, was seen on several occasions. The situation is not clear but it is possible the one adult pair has disappeared and the female of the remaining group of three gave birth during the wet season of 1983-1984.

Cebus apella

One group of 11-12 **Cebus** was isolated with the reserve. They were regularly seen during 1983 until the beginning of the dry season (June 1984) when they disappeared. In the first half of 1984 they were observed leaving and re-entering the reserve on its north and west boundaries to enter neighbouring forest approximately 100-250 m away. The last sighting of this group was on the 27 June 1984.

Alouatta seniculus

Five groups and a single male were observed in the reserve during 1983. The single male was observed in the south east corner of the reserve but in August 1984 a group of five individuals (one adult male, two adult females, one subadult male and one juvenile) had established themselves there. At least four other groups, ranging in size from 5-9 individuals, have remained in the reserve during 1984. However, changes in home ranges, extensive range overlap and the establishment of new groups make the situation as yet difficult to assess and more detailed studies, planned for 1985, are necessary.

Primate Densities in the Isolated Reserves of 10 ha

The four isolated 10-ha reserves retain populations of **Alouatta**. The Colosso reserve (1202), isolated in 1980, retained a group of 10 howlers immediately following its isolation (MCSE 1980). This group numbered eight individuals (one adult male, three adult females, two subadult males, a juvenile and an infant of approximately five months) in December 1984. A single male established himself in one part of the reserve in early 1984 and by December 1984 had achieved a mate and and offspring of approximately six months. The Porto Alegre 10-ha reserve (3209) contained a group of 6 individuals and the Cidade Powell reserve (1207) contained a group of 4-5 individuals in December 1984. A group of five howlers (one adult male, three females and a juvenile) was isolated in the Dimona reserve (2206) in June-July 1984. A female gave birth in October 1984 and the group numbered six in December 1984.

A group of 5-6 **Saguinus** were isolated in the Colosso reserve in 1984 but disappeared within a year. No **Saguinus** groups were isolated in the Dimona reserve, but groups do survive in the Porto Alegre reserve (six individuals) and the Cidade Powel reserve (4-5 individuals). The felled forest around these latter two reserves was not burned, resulting in a rapid upsurge of secondary forest around it. This may be the secret to the permanence of the group in the Porto Alegre reserve but the **Saguinus** in the Cidade Powell reserve also benefit from the fact that it was isolated by only 100 m. With the growth of sufficient vegetations to provide cover, the **Saguinus** group is able to leave and enter the reserve.

Pithecia are absent from all of the 10-ha reserves except that of Dimona, which maintains two adult males, two adult females and a juvenile.

DISCUSSION

PRIMATE DENSITIES IN CONTINUOUS FOREST

Saguinus midas

Saguinus midas densities are as low as the lowest estimates obtained by Muckenhirn **et al.** (1976) in Guyana, and considerably lower than those estimated by Thorington (1968) and Mittermeier (1977) in Surinam (Table 5). Both Thorington (1968) and Mittermeier (1977) report that **Saguinus midas** is more common in edge habitats, dense understories and second growth and this is confirmed in our observations of this species in continuous forest in the reserve areas. This habitat preference has also been observed for other tamarin and marmoset, **Callithrix**, species (Dawson, 1979; Bernstein **et al.**, 1976; Rylands, 1981; Branch, 1983; Terborgh, 1983). For this reason the tamarins do not occupy the forest uniformly and groups can be separated by as much as 1 km. A lack of suitable habitat in the continuous forest probably explains the low densities.

Pithecia pithecia

Pithecia are always rare (Buchanan **et al.**, 1981) but densities in the reserve areas are lower than in other regions, even when the underestimation is taken into account. They are believed to occupy small home ranges of less than 10-ha, in which case their rarity would indicate that they may be habitat specialists or at least dependent on certain floristic communities, but too little is known of their behaviour and habitat preferences in the wild to support this. **Pithecia** are hunted for food (their bushy tails are used as dusters) and this may be a contributing factor.

Cebus apella

Cebus densities are as low as any estimated for other regions in the Amazon. At Cosha Cashu, three to four groups can be found in 100-ha of forest, each occupying ranges of 50-70 ha (Terborgh & Janson, 1983). Low densities of **Cebus** in a number of localities in Peru (Table 5) are attributed to hunting pressure by Freese **et al.** (1982) and this may

be partly true for the **Cebus** in the reserves. This is not be whole story, however, because groups are no smaller than those at Cocha Cashu (not hunted) (8-14 individuals) but they are evidently using larger home ranges (more than 600 ha) (Spironelo, 1985). The distribution and abundance of food resources in the reserves probably account for the difference.

Chiropotes satanas

Bearded saki densities are rather lower than those estimated by Muckenhirn **et al.** (1976) and van Roosmalen **et al.** (1981) in Guyana and Surinam but slightly higher than the density estimated by Ayres (1981) in the reserve areas in 1980-1981 (Table 5). The large **Chiropotes** groups occupy home ranges of 200-250 ha (van Roosmalen **et al.**, 1981). Surveys of the congeneric white-nosed saki, **C. albinasus**, at Aripuanã indicate densities of 0.29, 0.39 and 0.52 groups/km² along three different trails (Rylands, 1982). Density estimates for a fourth trail of 0.94 groups/km² were inflated because abundant fruiting trees near by during the survey period. **C. albinasus** groups at Aripuanã have home ranges of 250-350 ha (Ayres, 1981) and occupied all parts of the survey area. Assuming that this is also true for the **Chiropotes** in the reserves, a home range estimate for 0.4 groups/km² would be 250 ha. It can be concluded, therefore, that the bearded saki populations are similar to those recorded elsewhere in its range.

Alouatta seniculus

Red howler populations are believed to have been underestimated by two to three times. This being so, densities are similar to those estimated for the Samiria basin and Cocha Cashu in Peru (Freese **et al.**, 1982; Terborgh & Janson, 1983) and La Macarena and patches of forest in the llanos in Colombia (Klein and Klein, 1976; Defler, 1981) (Table 5). Thorington **et al.** (1979) believed that the Hato Masaguaral populations are so high because **Alouatta seniculus** is best adapted to the seasonal, dry forest patches of the Venezuelan llanos and Defler (1981) suggests that the fact that they share the forests with only one other primate species may be a contributing factor. Home ranges recorded for **Alouatta** groups in Cocha Cashu (Terborgh and Janson, 1983) and El Tuparro (Defler, 1981) are between 10 to 20 ha and this was observed to be the case in the reserve areas. At Hato Masaguaral the home ranges are 3.21 to 7.44 ha (Neville 1972, 1976; Sekulic, 1982).

Ateles paniscus

Comparing density estimates of **Ateles** with those from other parts of its range indicate that they are very low (Table 5). **Ateles** populations have a considerably lower intrinsic rate of increase compared to **Alouatta**, despite their similar sizes. The gestation period is longer 226-232 days (Eisenberg, 1978) compared to 186-194 days for **Alouatta seniculus** (Crockett & Sekulic, 1982), the period of infant dependence is longer (18-28 months (Milton, 1981) compared to less than a year for **Alouatta** (Mack, 1979), the interbirth interval is longer (22-36 months (Milton, 1981) but less than a year for **Alouatta** (Mack, 1979) and females reach reproductive age at approximately six to seven years (Milton, 1981) compared to four to five years for **Alouatta** (Froehlich **et al.**, 1981). For this

reason **Ateles** are more vulnerable to hunting pressure than **Alouatta**, even though both are equally favoured by hunters. Hunting in the past undoubtedly, at least in part, for the low **Ateles** densities, although the possibility remains that a wider dispersion and lower abundance of the fruits preferred by **Ateles** in the reserve areas compared to other regions cited in Table 5 may also be a contributing factor.

To summarize, **Saguinus** densities in the continuous forest are rather low, probably due to a lack of edge habitat and the second growth patches favoured by them. **Pithecia**, **Cebus** and **Ateles** populations are low, possibly because of more widely distributed and/or less abundant food sources than is true for other Amazonian regions although hunting, particularly in the case of **Ateles**, may also be the reason. **Chiropotes** and **Alouatta** densities are similar to those observed in other areas of Amazonian forest where they have been studied.

Primates in the isolated Forest Fragments

Ateles and **Chiropotes** were excluded from the 100-ha reserve when it was isolated and it is unlikely that they will recolonize it because they are dependent on widely scattered, large crops of fruits, and both occupy home ranges of more than 200 ha (van Roosmalen, 1981; van Roosmalen **et al.**, 1981). On the basis of information regarding **Cebus apella** home range sizes at Cocha Cashu (Terborgh, 1983) and at Aripuanã (Rylands, 1982), it was expected that the **Cebus** group would survive in the reserve, but they disappeared approximately one year after its isolation. Since then it has been found that **Cebus** groups in the reserve areas are occupying home ranges exceeding 600 ha (Spironelo, 1985) and it is probable that they were facing a food shortage.

The loss of **Ateles** and **Chiropotes** in the isolated 100-ha reserve is unsurprising, although Bernstein **et al.** (1976) found **Ateles**, as well as **Cebus**, in an isolated second growth forest (2-20 years old) in northern Colombia. However, whereas continuous forest is still predominant in the areas we are studying, this was undoubtedly not so for the study area of Bernstein **et al.** (1976). Their forest patches were those left from a relatively long term diminution of once large tracts whereas the isolated reserves in our study are patches left standing in clearings in, as yet, predominantly continuous forest. The **Ateles** and **Cebus** groups observed by Bernstein **et al.** (1976) are, therefore, probably relict populations with nowhere else to go.

Saguinus, **Pithecia** and **Alouatta** remain in the reserve and all three species have bred since its isolation. **Alouatta** and **Pithecia** densities are similar to those estimated for continuous forest, but **Saguinus** densities are rather higher.

The exclusion of one of the four **Saguinus** groups isolated in the reserve is of interest when one notes that two **Saguinus** groups are surviving in the 10-ha reserves. If, as is believed, optimal habitats include secondary forest and forest edge mixed with tall primary forest (Thorington, 1968; Mittermeier & van Roosmalen, 1981; Terborgh, 1983), the minimum home range size as well as population sizes are governed by the amount of forest edge. The discrepancy between the situations in the 100-ha and 10-ha reserves may then be explained by the greater relative area of edge habitat and second growth surrounding

the latter. This may also explain why three groups survive in the isolated 100-ha reserve whereas the ranges of only two groups overlap the edges of any one of the 100-ha reserves in continuous forest (Fig. 2). The range of one **Saguinus** group overlapping the northwest corner of the Dimona reserve (2303) contains a large area of secondary growth and edge because the forest has been cut along the north edge and the home range of the group is approximately 15 ha, probably because of this.

Unfortunately the populations in the Porto Alegre 100-ha reserve were not known prior to its isolation. It may be that the floristic communities within the reserve are more favourable to **Saguinus**, irrespective of edge habitats created by its isolation, or that the isolation has compressed three groups into the reserve which will not survive in the long term. Time and further studies will tell, but the indications are that the increase in forest edge, the inevitable secondary growth along the margins and the increase in tree falls in the 10-ha reserves (Lovejoy **et al.**, 1983) resulting from the fragmentation of the forest will favor an increase in the **Saguinus** populations which remain. A similar conclusion was reached by Bernstein et al., (1976) for **S. leucopus**.

Alouatta populations in the isolated reserves approximate to those which would be expected from their densities in continuous forest. **Alouatta seniculus** has a very wide distribution which extends into the semi-deciduous dry forest of the llanos of Venezuela and Colombia. Defler (1981) found four groups in a 100-ha forest patch in the Colombian llanos each with home ranges of 10 to 20 ha, and six groups in a 150-ha patch, each with home ranges of 21-26 ha. This very similar to the situation we have observed. The groups in the 100-ha reserves are using larger home ranges than those restricted to the 10-ha fragments. The two groups in the Colosso 10-ha reserve (1202) indicate that they can restrict their ranges even further. The smallest home ranges have been recorded for the populations in forest patches at Hato Masaguaral in the Venezuelan llanos (3-7 ha. Neville, 1972; Sekulic, 1982). Preferred food sources are very abundant in these forest patches. Sekulic (1982) estimates that of the three key foods, **Ficus** occur in densities of 18 trees/ha, **Albizia** correspondingly 12 trees/ha and **Copernicia** palms 89 trees/ha. The abundance and concentration of **Alouatta** food resources is undoubtedly very different in the more diverse Amazonian forests of the reserve areas, but under any circumstances, howlers are evidently very flexible regarding their home range sizes and this probably reflects a considerable flexibility in their diet. One would expect that the howlers in the 10-ha reserves are including more leaves and possibly more mature leaves in their diet than those in the isolated 100-ha reserve or continuous forest. It is possible that the creation of secondary growth forest along the margins and the increase in secondary growth resulting from the increase in rate of tree falls may favour the survival of **Alouatta** in the small forest patches because of the abundance of young leaves resulting from the higher net productivity and rapid growth of pionner trees and vines (Opler, 1978). In addition, howlers may benefit from the loss of other large primates from the 10 and 100ha reserves through reduced competition for large fruit crops.

Pithecia groups have survived in the 100-ha isolated reserve and the 10-ha reserve isolated during June-July of 1984. As mentioned previously, their home ranges are approximately

10 ha or less (Buchanan **et al.** 1981) and it is possible that the latter group may survive. Their absence from the other 10-ha reserves may simply be because none were present at the time of isolation. They are vertical clingers and leapers (Fleagle & Mittermeier, 1980) and rarely if ever go to the ground (Buchanan **et al.**, 1981). They are therefore unlikely to recolonize a forest patch once they have become extinct there. They have no distinct habitat preferences, although Buchanan **et al.** (1981) record that they are most commonly observed in the middle canopy to understorey of high forest in Surinam. Their rarity, however, does indicate that they are habitat specialists within the forest they occupy and their survival in the 10-ha and 100-ha reserves possibly depends on the presence of certain, as yet undefined, floristic communities. They can thrive in a mixture of mature forest and second growth (Oliveira & Lima, 1981) and it possible that the increase in secondary growth along the margins and in tree fall areas in the isolated reserves might be favourable for their survival in them.

ACKNOWLEDGMENTS

This paper is contribution nº 27 in the Minimum Critical Size of Ecosystems Project of the World Wildlife Fund - U.S. and the Conselho Nacional de Desenvolvimento Científico e Tecnilógico (CNPq) through the Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus. The authors are most grateful to Dr. R. O. Bierregaard (Field Director of the Project) for his help and support and to Julie Evans (Cambridge University), Ana Margarida Serra Neves (Universidade de São Paulo, Ribeirão Preto), Jonathan Saxton (University of Cambridge) and Wilson Spironelo (Universidade Estadual Paulista Júlio Mesquita Filho, Rio Claro) for their help in collecting survey data during 1984. Our thanks also to two anonymous reviewers for their helpful criticisms of an earlier draft.

RESUMO

Atividades agropecuárias na floresta de terra firme na Amazônia Central resultam invariavelmente em fragmentos de florestas isoladas. Em 1979, o Fundo de Vida Selvagem (WWF-US) em convênio com o Instituto Nacional de Pesquisas da Amazônia (INPA - CNPq) deu início ao Projeto "Dinâmica Biológica de Fragmentos Florestais", envolvendo estudos dos efeitos dessa fragmentação em áreas (reservas) de tamanhos diferentes no Distrito Agropecuário da SUFRAMA, Manaus. Seis espécies de primatas ocorrem na área: ***Saguinus midas***, ***Pithecia pithecia***, ***Cebus apella***, ***Chiropotes satanas***, ***Alouatta seniculus*** *e* ***Ateles paniscus***. *Este estudo descreve densidades populacionais dessas espécies na floresta contínua (três reservas de 100 ha não isoladas), numa reserva isolada de 100 ha e em quatro reservas isoladas de 10 ha. A densidade de* ***Saguinus*** *é baixa, provavelmente por causa da falta de mata de borda e de mata secundária preferidas pelo gênero; populações de* ***Cebus*** *e* ***Ateles*** *também são baixas, talvez pela distribuição escassa e/ou baixa abundância de*

alimento em comparação com outras regiões amazônicas, embora a caça no passado, especialmente de **Ateles**, talvez seja um fator contribuinte; e **Chiropotes** e **Alouatta** ocorrem em densidades semelhantes às outras regiões de floresta amazônica. Grupos de **Ateles** e **Chiropotes**, que ocupam áreas de aproximadamente 3 km², foram excluídos da reserva de 100 ha no momento de seu isolamento. Infelizmente, populações nessa reserva, antes de seu isolamento, não foram investigadas, mas durante a isolação permaneceram quatro grupos de **Saguinus**, dois grupos de **Pithecia**, um grupo de **Cebus** e cinco grupos de **Alouatta**. Um grupo de **Saguinus** desapareceu depois de um mês e o grupo de **Cebus** abandonou a reserva após um ano. Grupos únicos de **Alouatta** sobrevivem nas reservas isoladas de 10 ha. Indivíduos de **Saguinus**, embora presentes nessas reservas logo após isolação, desapareceram de duas delas. Uma reserva de 10 ha mantém ainda um grupo de **Pithecia**.

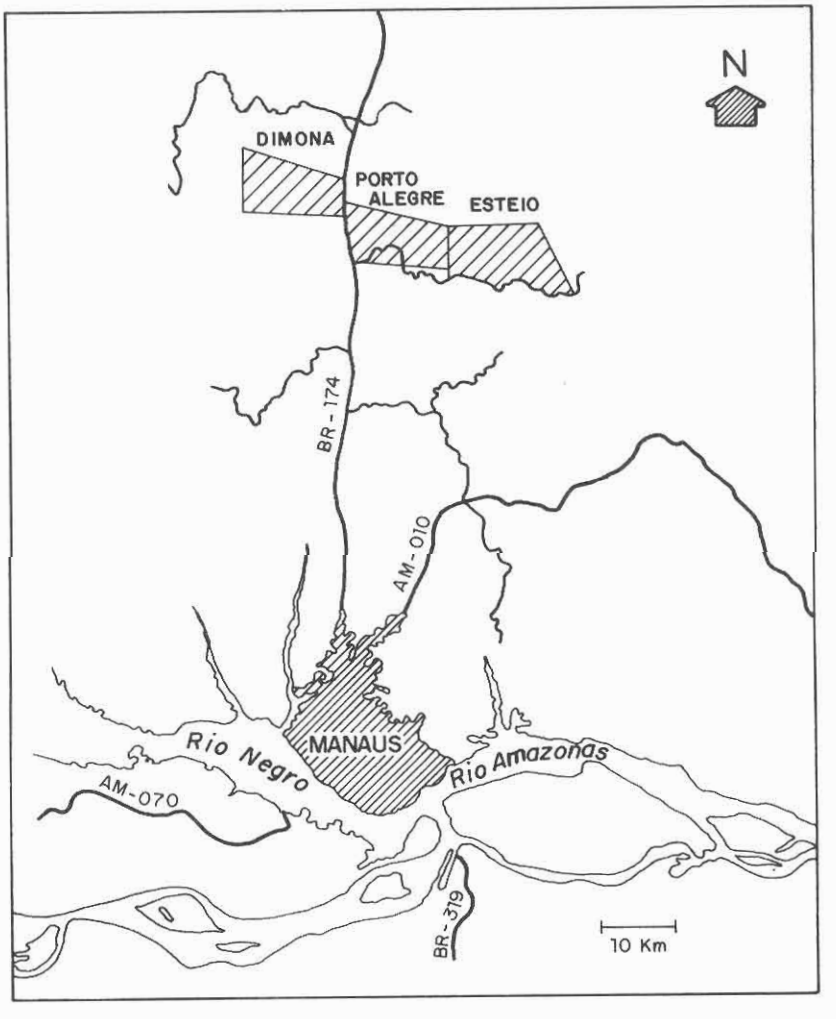

Fig. 1. The location of the three farms, Dimona, Porto Alegre and Esteio, of the Minimum Critical Size of Ecosystems Project (WWF-US/INPA).

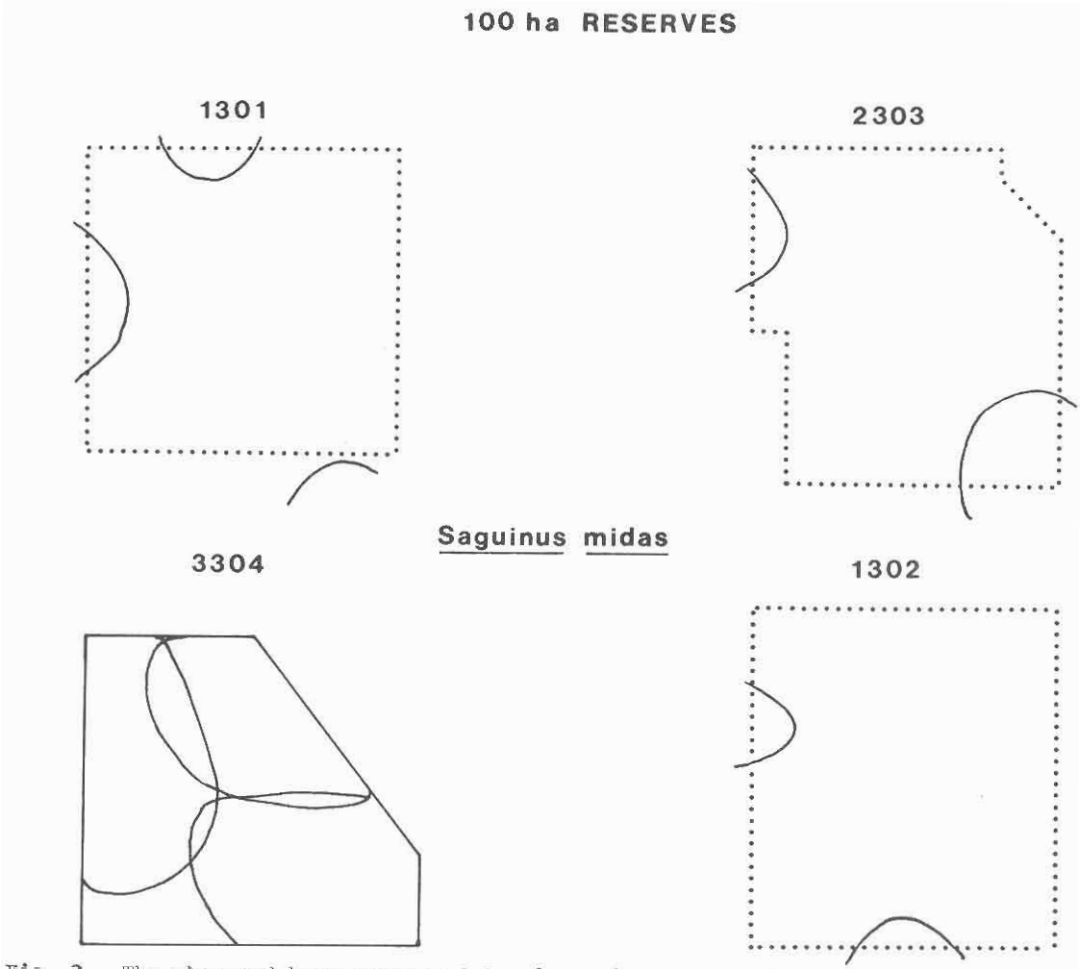

Fig. 2. The observed home ranges of **Saguinus midas** groups in the four 100-ha reserves. Reserve nº 3304 is isolated. Reserves 1301, 1302 and 2303 are only marked out in continuous forest.

Table 1. The primate species occurring in the Minimum Critical Size of Ecosystems Project (WWF-US/INPA) reserve areas.

Species		Average adult mass (g) *	Diet
CALLITRICHIDAE			
Saguinus midas midas	Golden-handed tamarin	492	Frugivore-insectivore
CEBIDAE			
Pithecia pithecia	Black-and-white saki	1871	Frugivore-seed predator
Cebus apella apella	Tufted capuchin	3450	Omnivore
Chiropotes satanas chiropotes	Bearded saki	2990	Frugivore-seed predator
Alouatta seniculus	Red howler monkey	7275	Frugivore-folivore
Ateles paniscus paniscus	Black spider monkey	7775	Frugivore

(*) From Fleagle & Mittermeier (1980).

Table 2. The population density estimates for primates in continuous forest. Surveys in the Dimona (2303), Florestal (1301) and km 34 (1302) 100-ha reserves combined.

Distance surveyed (km)	316.8
nº of trails	15
Total length of trails (m)	15,689
nº of surveys	333

	Transect width	Gr/km²	Ind/km²
Saguinus	0.04 km	0.6	3.9
Pithecia	0.05 km	0.2	0.7
Cebus	0.08 km	0.4	2.2
Chiropotes	0.08 km	0.4	5.5
Alouatta	0.04 km	2.0	10.5
Ateles	0.08 km	nc	1.0

(nc) Not calculated.

Table 3. Population density estimates for primates in the 100-ha reserve isolated in June 1983.

		Porto Alegre 06-12/1983 (3304)		**Porto Alegre** 01-06/1984 (3304)		**Porto Alegre** 07-12/1984 (3304)	
Distance surveyed		45.33		58.96		129.99	
nº of trails		06		06		06	
Total length of trails		5876		5876		5876	
nº of surveys		52		70		154	
	Transect width	Gr/km²	Ind/km²	Gr/km²	Ind/km²	Gr/km²	Ind/km²
Saguinus	0.04 km	5.5	35.3	2.1	20.03	4.8	25.6
Pithecia	0.05 km	1.3	4.8	0.0	0.0	0.5	1.7
Cebus	0.08 km	1.6	17.1	0.4	0.4	0.0	0.0
Chiropotes	0.08 km	0.0	0.0	0.0	0.0	0.0	0.0
Alouatta	0.04 km	1.6	6.1	0.8	3.8	1.5	5.8
Ateles	0.08 km	nc	0.0	nc	0.0	nc	0.0

(nc) Not calculated.

Table 4. The numbers of different primate groups identified with home ranges partly or entirely within the four 100-ha reserves.

	ISOLATED FOREST			CONTINUOUS FOREST		
	Porto Alegre (3304) 06-12/1983	**Porto Alegre** (3304) 01-06/1984	**Porto Alegre** (3304) 07-12/1984	**Dimona** (2303) 06/83-12/84	**Florestal** (1301) 06/83-12/84	**Km 34** (1302) 06/83-12/84
Saguinus	4	3	3	2	2	2
Pithecia[1]	2	1	1	1-2	2-3	1
Cebus	1	1	0	1-2	1	2
Chiropotes	0	0	0	1	1	2
Alouatta	5	5	5	4-5	4-5	3-4
Ateles[2]	0	0	0	9 ind.	6 ind.	7 ind.

(1) nº of family groups.
(2) Minimum number of different individuals.

Table 5. Population density estimates by other authors.

Species	Gr/km²	Ind/km²	Reference
Saguinus midas			
Raleighvallen-Voltzberb, Surinam	4	23.5	Mittermeier, 1977
Four localities in Guyana	0.4-2.7	2.3-13.9	Muckenhirn **et al.**, 1976
Porto Platon, Brazil		16.4-33.5	Thorington, 1968
Pithecia pithecia			
Surinam		0.8-7.0	Buchanan **et al.**, 1981
Four localities in Guyana	0.8-3.6	2.6-12.0	Muckenhirn **et al.**, 1976
Cebus apella			
Cosha Cashu, Peru	3.6	36.0	Freese **et al.**, 1982
Four localities in Peru	0.5-2.5	3.0-25.0	Freese **et al.**, 1982
Cobija, Bolívia	0.7	7.0	Freese **et al.**, 1982
Three localities in Guyana	0.9-1.5	10.6-17.1	Muckenhirn **et al.**, 1976
La Macarena, Colombia	1.5-2.3	5.8-9.6	Klein & Klein, 1976
Aripuanã, Brazil		9.4-40.0	Rylands, 1982
Chiropotes satanas			
Raleighvallen-Voltzberg Surinam		7.8	van Roosmalen **et al.**, 1981
Berbice River, Guyana	0.58	7.6	Muckenhirn **et al.**, 1976
Pakani, Guyana	0.97	12.7	Muckenhirn **et al.**, 1976
Agricultural District Manaus, Brazil	0.25		Ayres, 1981
Alouatta seniculus			
Samiria basin, Peru	6.1	30.5	Freese **et al.**, 1982
Cosha Cashu, Peru	4.8	24.0	Freese **et al.**, 1982
Six localities in Guyana	0.3-3.6	1.6-19.5	Muckenhirn **et al.**, 1976
Hato Masaguaral, Venezuela (Llanos)	13.3	118	Rudran, 1979
La Macarena, Colombia	2.3-5.8	11.6-29.0	Klein & Klein, 1976
El Tuparro, Colombia			
Llanos Area 1 (100 ha)	5.65	23.0	Defler, 1981
Area 2 (150 ha)	6.8	27.0	
Ateles paniscus			
Cocha Cashu, Peru	3.2	22.4	Freese **et al.**, 1982
Pakani, Guyana	3.4	8.1	Muckenhirn **et al.**, 1976
Aripuanã, Brazil		0.6-5.6	Rylands, 1982

Reference

Ayres, J. M. - 1981. Observações sobre a ecologia e o comportamento dos cuxiús (**Chiropotes albinasus** e **Chiropotes satanas**, Cebidae, Primates). Unpublished master's thesis. University of Amazonas and the National Institute for Amazon Research (INPA) Manaus.

Bernstein, I. S.; Balcaen, P.; Dresdale, L.; Gouzoules, H.; Kavanagh, M.; Patterson, Y. & Neyman-Warner, P. - 1976. Differential effects of forest degradation on primate populations. **Primates**, 17: 401 - 411.

Branch, L. C. - 1983. Seasonal and habitat differences in the abundance of primates in the Amazon (Tapajós) National Park, Brazil. **Primates**, 24: 424 - 431.

Buchanan, D. B.; Mittermeier, R. A.; van Roosmalen, M. G. M. - 1981. The saki monkeys, genus **Pithecia**. **In**: Coimbra-Filho, A. F. & Mittermeier, R. A. (eds.). **Ecology and Behavior of Neotropical Primates**, 1. Academia Brasileira de Ciências, Rio de Janeiro. p. 391 - 417.

Crockett, C. M. & Sekulic, R. - 1982. Gestation length in red howler monkeys. **Amer. J. Primatol.**, 3: 291 - 294.

Dawson, G. - 1979. The use of time and space by the Panamanian tamarin, **Saguinus oedipus**. **Folia Primatol.**, 31: 253 - 284.

Defler, T. R. - 1981. The density of **Alouatta seniculus** in the eastern llanos of Colombia. **Primates**, 22: 564 - 569.

Eisenberg, J. F. - 1978. Comparative ecology and reproduction of New World Monkeys. **In**: Kleiman, D. G. (ed.). **The Biology and Conservation of the Callitrichidae**. Smithsonian Institution Press, Washington, DC. p. 13 - 22.

Fleagle, J. G. & Mittermeier, R. A. - 1980. Locomotor behaviour, body size and comparative ecology of seven Surinam monkeys. **Amer. J. Phys. Anthrop.**, 52: 301 - 314.

Freese, C. H.; Heltne, P. G.; Castro, R. N.; Whitesides, G. - 1982. Patterns and determinants of monkey densities in Peru and Bolivia, with notes on distributions. **Int. J. Primatol.**, 3: 53 - 90.

Froehlich, J. W.; Thorington, R. W. Jr.; Otis, J. S. - 1981. The demography of howler monkeys (**Alouatta palliatta**) on Barro Colorado Island, Panama. **Int. J. Primatol.**, 2: 207 - 236.

Klein, L. L. & Klein, D. J. - 1976. Neotropical primates; aspects of habitat usage, population density and regional distribution in La Macarena, Colombia. In: Thorington, R. W. Jr. & Heltne, P. G. (eds.). **Neotropical Primates: Field Studies and Conservation**. National Academy of Sciences, Washington, DC. p. 70 - 78.

Lovejoy, T. E.; Bierregaard, R. O. Jr.; Rankin, J. M.; Schubart, H. O. R. - 1983. Ecological dynamics of tropical forest fragments. **In**: Sutton, S. L.; Whitmore, C. A. & Chadwick, A. C. (eds.). **Tropical Rain Forest Ecology and Resource Management**. Blackwell Scientific Publications, Oxford. p. 377 - 384.

Mack, D. - 1979. Growth and development of infant red howling monkeys (**Alouatta seniculus**) in a free ranging population. **In**: Eisenberg, J. F. (ed.). **Vertebrate Ecology in the Northern Neotropics**. Smithsonian Institution Press, Washington, DC. p.127-136.

Marques-Filho, A. de O.; Ribeiro, M. de N. G.; Santos, H. M. dos; Santos, J.M. dos - 1981. Estudos climatológicos da Reserva Florestal Ducke, Manaus-AM. IV. Precipitação. **Acta Amazonica**, 11: 759 - 768.

MCSE - 1980. Minimum Critical Size of Ecosystems, First Annual Report (1 October 1979-30 September 1980). World Wildlife Fund - U.S. and Instituto Nacional de Pesquisas

da Amazônia (INPA), Manaus. 12 p.

Milton, K. - 1981. Estimate of reproductive parameters for free-ranging **Ateles goeffroyi**. **Primates**, 22: 574 - 579.

Mittermeier, R. A. - 1977. **Distribution, synecology and conservation of Surinam monkeys.** Unpublished doctoral dissertation. Harvard University Cambridge.

Mittermeier, R. A. & Roosmalen, M. G. M. - 1981. Preliminary observations on habitat utilization and diet in eight Surinam monkeys. **Folia Primatol.**, 36: 1 - 39.

Muckenhirm, N. A.; Mortensen, B. K.; Vessey, S.; Fraser, C. E. O.; Sing, B. - 1976. **Report on a primate survey in Guyana**. Pan American Health Organization. Washington, DC. 49 p.

Neville, M. K. - 1972. The population structure of red howler monkeys (**Alouatta seniculus**) in Trinidad and Venezuela. **Folia Primatol.**, 17: 56 - 86.

---- - 1976. The population and conservation of howler monkeys in Venezuela and Trinidad. **In**: Thorington, R. W., Jr. & Heltne, P. G. (eds.). **Neotropical Primates: Field Studies and Conservation**. National Academy of Sciences. Washington, D.C. p. 101 - 109.

NRC - 1981. **Techniques for the Study of Primate Population Ecology**. National Research Council, National Academy Press, Washington, D.C.

Oliveira, J. M. & Lima, M. G. - 1981. Observações preliminares sobre o parauacú: Cebidae, Primata. (**Pithecia pithecia**, Desmarest, 1804). **Ciência e Cultura** (Suppl.), 33: 499 - 500. (Abstract).

Opler, P. A. - 1978. Interaction of plant life history components as related to arboreal folivory. **In**: Montgomery, G. G. (ed.). **The Ecology of Arboreal Folivores**. Smithsonian Institution Press, Washington, DC. p. 23 - 31.

Rudran, R - 1979. The demography and social mobility of a red howler (**Alouatta seniculus**) population in Venezuela. **In**: Eisenberg, J. F. (ed.). **Vertebrate Ecology in the Northern Neotropics**. Smithsonian Institution Press, Washington, DC. p. 107 - 126.

Rylands, A. B. - 1981. Preliminary field observations on the marmoset, **Callithrix humeralifer intermedius** (Hershkovitz, 1977) at Dardanelos, Rio Aripuanã. **Primates**, 22: 46-59.

---- - 1982. **The behaviour and ecology of three species of marmosets and tamarins (Callitrichidae, Primates) in Brazil**. Unpublished doctoral dissertation. University of Cambridge, Cambridge.

Sekulic, R. - 1982. Daily and seasonal patterns of roaring and spacing in forur red howler, **Alouatta seniculus**, troops. **Folia Primatol.**, 39: 22 - 48.

Spironelo, W. R. - 1986. Area de vida de um grupo de macaco prego, **Cebus apella apella** (Cebidae, Primatas), na Amazônia Central. **Resumos do XIII Congresso Brasileiro de Zoologia**, 2 - 7 February, 1986. p. 20. (Abstract).

Terborgh,J. - 1983. **Five New World Primates. A Study in Comparative Ecology.** Princeton University Press, Princeton.

Terborgh, J. & Janson, C. H. - 1983. Ecology of primates in southeastern Peru. **National Geographic Society Research Reports**, 15: 655 - 662.

Thorington, R. W. Jr. - 1968. Observations of the tamarin, **Saguinus midas**. **Folia Primatol.**, 9: 95 - 98.

Thorington, R. W., Jr.; Rudran, R.; Mack, D. - 1979. Sexual dimorphism of **Alouatta seni**

culus and observations on capture techniques. **In**: Eisenber, J. F. (ed.), **Vertebrate Ecology in the Northern Neotropics**. Smithsonian Institution Press, Washington, D.C. p. 97 - 106.

van Roosmalen, M. G. M. - 1981. **Habitat preference, diet, feeding strategy and social organization of the black spider monkey (Ateles paniscus paniscus, Linnaeus 1758) in Surinam**. Unpublished doctoral dissertation, University of Wageningen, Wageningen.

van Roosmalen, M. G. M.; Mittermeier, R. A.; Milton, K. - 1981. The bearded sakis, genus **Chiropotes**. **In**: Coimbra-Filho, A. F. & Mittermeier, R. A. (eds.). **Ecology and Behavior of Neotropical Primates**, I. Academia Brasileira de Ciências, Rio de Janeiro. p. 419 - 441.

(Aceito para publicação em 15.02.1989)