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Ecology and conservation of the Red-tailed Amazon *Amazona brasiliensis* in south-eastern Brazil

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Summary

The Red-tailed Amazon *Amazona brasiliensis* was found to be restricted to a complex mosaic of forests growing on the narrow coastal plain of eastern Brazil. The species depends on habitat heterogeneity for both food and breeding. In São Paulo state the 1,550 individuals are divided into 16 populations. The global total of the species may be around 3,600 birds. They feed mainly on fruits, flowers and nectar, also occasionally insects. Most nests are found in permanently flooded forest, apparently because of greater cavity availability. Poaching has had a great impact and is the most immediate threat to the species.

O Papagaio de Cara-Roxa *Amazona brasiliensis* é restrito a um complexo mosaico de florestas na estreita planicie costeira no leste do Brasil. Os papagaios dependem da heterogeneidade do ambiente tanto para sua alimentação como reprodução. No estado de São Paulo existem 1,550 papagaios, divididos em 16 grupos. A população total da espécie pode ser de 3,600 individuos. Os papagaios se alimentam principalmente de frutos, flores e néctar, com alguns casos de insetivoria. A maioria dos ninhos foi encontrada em florestas permanentemente inundadas (caxetais), aparentemente devido à maior disponibilidade de cavidades. A captura para o comércio ilegal tem tido um grande impacto sobre a espécie e é a maior ameaça à sua sobrevivência.

Introduction

The Red-tailed Amazon *Amazona brasiliensis* is a threatened species of parrot endemic to a narrow stretch of forest along the coasts of São Paulo, Paraná and Santa Catarina states, eastern Brazil (Collar *et al.* 1992). The first time it was recorded by scientists was in 1821, when J. Natterer collected one individual at Mel island, Paraná, with later records from southern São Paulo (Collar *et al.* 1992), but long before this, in 1501, A. Vieira dos Santos described "huge whirlwinds made of flying amazons, toucans and parakeets, and armies of beautiful ibises dressed in scarlet" over Paranaguá bay (freely translated from Paulino de Almeida 1966).

The species is known from lowland forests up to 700 m elevation, also using adjacent habitats like mangroves and sand-plain forest for both feeding and breeding (Scherer-Neto 1989). Red-tailed Amazons have been found to feed on over 42 species of fruits, leaves and flowers, *Calophyllum brasiliense* (Gutiferae) fruits being considered a particularly important resource (Scherer-Neto 1989,

Collar *et al.* 1992). Six of 18 recorded nests were found in the same species of tree, five others being recorded in dead palms (Scherer-Neto 1989).

The known population of the species is estimated to lie between 2,000 and 4,000 individuals, restricted to a 6,000 km^2 area (Diefenbach and Goldhammer 1986, Scherer-Neto 1988, 1989, Collar *et al.* 1992). The main factors affecting its survival have been habitat destruction (most intense in São Paulo), the felling of trees for the building of canoes, and illegal trade, which has increased since the 1980s; also, killing for food and target practice by local people ("caiçaras") has been a serious problem (Collar *et al.* 1992).

In this paper I present the results of a five-year study of the ecology, distribution and conservation of the Red-tailed Amazon in São Paulo state.

Study area and methods

Over the period 1991–1994, the distribution and population size of the Red-tailed Amazon was assessed through exhaustive searches of virtually all the remaining areas of Atlantic forest left in the region, spanning the entire length (over 550 km) of the São Paulo state coastal belt (Figure 1). In areas where the parrot was located, local populations were censused in the night roosts from April to September 1993.

Censuses were carried out after the night roosts used by each parrot population were located, a minimum of two counts (one in late afternoon and one in the early morning) being made at each roost. Since each population has several different roosts and moves between them, the figure used for population size was the maximum number of parrots counted at any of a given population's roosts.

During the censuses the direction of flight of birds arriving at and departing from a given roost was the same for all birds, even though they did not all arrive and depart at the same time. This direction was recorded and assumed to indicate the general foraging areas of each flock of parrots that made up the population, and I used this information to establish the ranges and identity of the different populations. I assumed that flocks which belonged to the same populations used the same roosts and foraging areas. During censuses I also counted family groups (adults and juveniles) in order to estimate recruitment.

More intensive studies of the food and breeding ecology of the Red-tailed Amazon were conducted from 1989 to 1994 on the southern coast of São Paulo in the region of Ilhas Comprida (c.24°30'S 47°45'W), Cananéia (c.24°52'S 47°50'W) and Cardoso (c.25°03'S 47°53'W) (Figure 1). General descriptions of the area are in Barros *et al.* (1991), de Grande and Lopes (1981) and Kirizawa *et al.* (1992).

For assessing food habits I recorded the identity and part of the plant eaten each time I found one or more amazons eating. I considered only the instances where amazons were definitely seen feeding, and discounted indirect evidence and second-hand reports.

Breeding biology was studied through the intensive monitoring of nine nests. Another 40 nests were discovered at different stages of the breeding cycle, and for these the characteristics of habitat, nest tree, height, number of eggs or nestlings and breeding success were recorded.

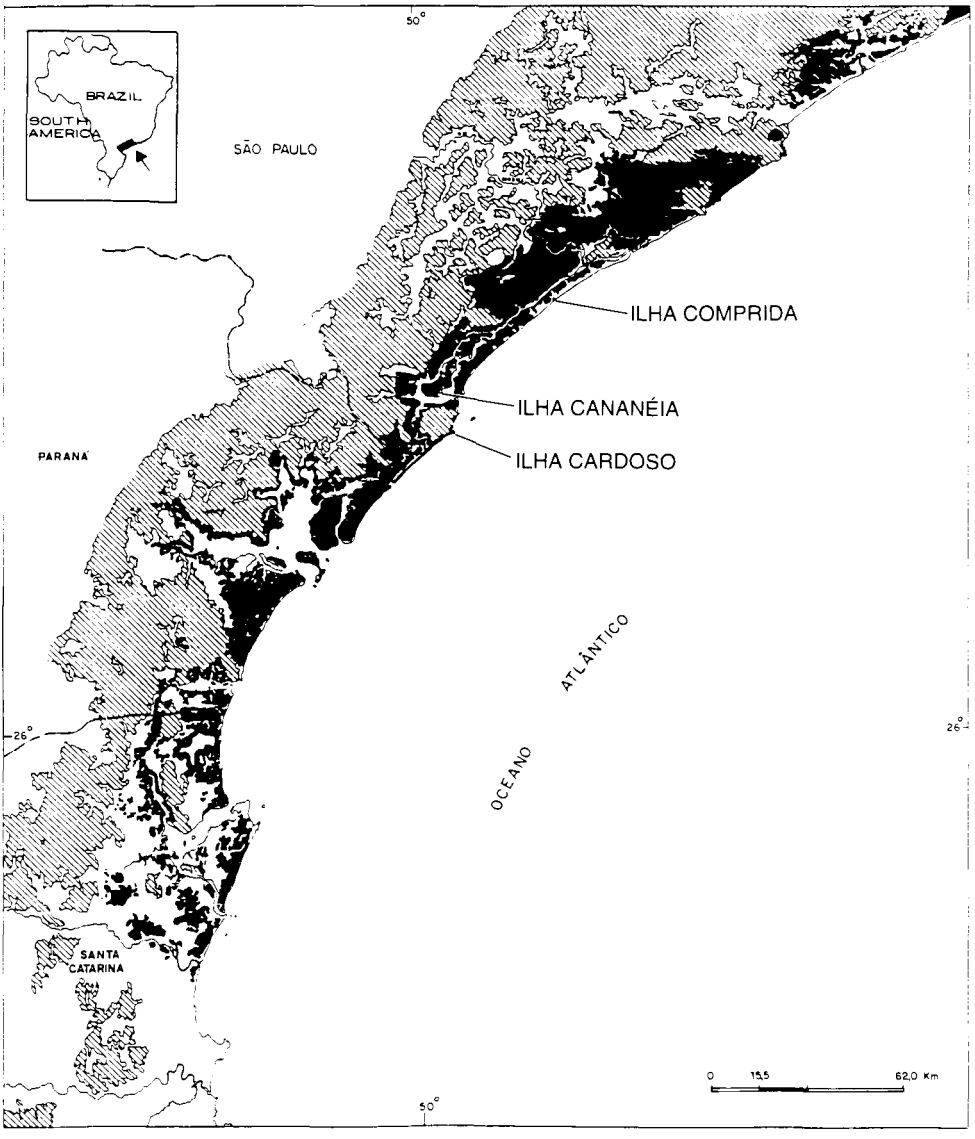

Figure 1. Habitat distribution of the Red-tailed Amazon *Amazona brasiliensis*. Lowland (coastal plain) forests are shown in black. Hatched areas show montane forest. Deforested areas are in white.

Available nest cavities were counted in 1 ha plots marked in each of the seven forest types in the region (see below). Each of the seven plots was exhaustively searched for cavities that a parrot could use for nesting. This was done only to obtain a general impression of the distribution of cavities in the forest mosaic.

Numbers of poached nestlings were assessed by interviews with trappers, middlemen and aviculturists throughout the state of São Paulo. In most cases the actual number of captured birds could be determined directly, as most trappers would show me their catch.

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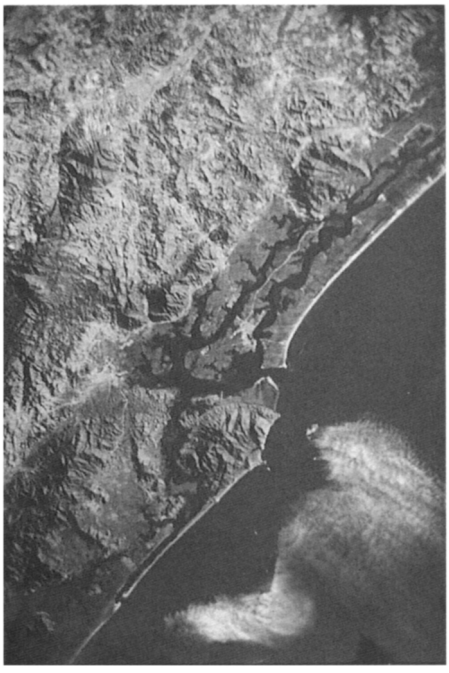

Figure 2. LANDSAT 1991 satellite imagery of the southern coast of São Paulo state, Brazil, showing the extent of the Red-tailed Amazon habitat. Note that the species s range is restricted to the plain between the sea and the Serra do Mar massif.

Habitat and distribution

Red-tailed Amazons in São Paulo were found to be restricted to lowland forest communities growing on Pleistocene-Holocene sandy soils of marine origin, which make up the narrow coastal plain between the sea and the Pre-Cambrian mountain massifs further inland (Figure 2).

The plain harbours a complex mosaic of different vegetation types unmatched elsewhere. In a 10–30 km stretch between the sea and the coastal mountains, the following five vegetation types (Figure 3) may be distinguished, although ecotones between them add further to the heterogeneity of the habitat.

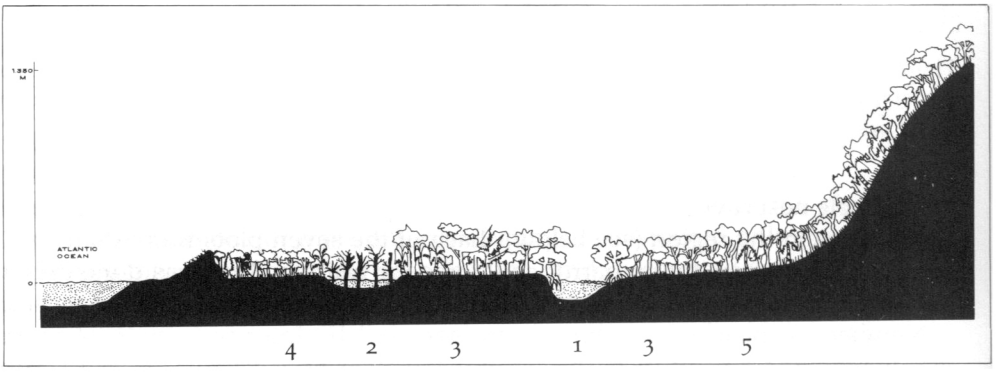

Figure 3. A cross-sectional diagram of Red-tailed Amazon habitat, showing the complex mosaic of different vegetation types.

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(1) Mangrove forest occurs along sea channels and the fringes of lagoons. It is dominated by *Rhizophora mangle*, *Avicenna schaueriana* and *Laguncularia racemosa*. Upstream of the estuaries, where the salinity is nil but the tidal influence is still felt, the vegetation is composed of *Erythrina speciosa*, *Gomidesia spectabilis* and *Hibiscus pernambucensis*.

(2) Flooded forest or "caxetal" grows in permanently inundated areas along rivers, at the interface between Holocene and Pleistocene beach ridges, and on paleomangrove deposits. It is dominated by *Tabebuia cassinoides* trees growing in monospecific stands, with stands of the palm *Arecastrum romanzoffianum* in patches of raised ground.

(3) Seasonally flooded forest or "guanandizal" is restricted to Pleistocene deposits where the water table rises to the surface during the rainy season (October to March). The dominant tree species is "guanandi" *Calophyllum brasiliense* and *Euterpe edulis* palms, with canopy height at around 15–20 m. The understorey is dominated by ground bromeliads and the trees *Didymopanax navaroi* and *Matayba elaeagnoides*.

(4) Sand-plain forest or "restinga" is in fact a mosaic of three different plant communities that grade into each other following the Holocene-Pleistocene gradient. Closer to the sea there is a shrubby vegetation 1.5–2 m high, dominated by the legume *Dalbergia ecastophyllum* and the shrub *Gaylussacia brasiliense*. Following this shrubby stretch is an arboreal vegetation 3–5 m tall dominated by myrtaceous and *Clusia* trees. On Pleistocene soils the forest gets taller (up to 15 m) and has a greater species diversity, with many *Arecastrum* and *Euterpe* palms. While ground bromeliads are ubiquitous in restinga, epiphytes are much commoner in the tallest forest.

(5) Transitional forest, growing where the plain meets the hills, is a tall forest 20–25 m high with a strong montane influence. Plant diversity is high, with many lauraceous trees *Cryptocarya aschersoniana*, figs, *Podocarpus*, *Cabralea*, *Geonoma* palms, and leguminaceous trees.

The amazons also wander into forests located on the lower slopes of the hills during the winter (May–August), apparently in search of food. The highest point an amazon was seen feeding was 200 m above sea level. At higher altitudes only flying amazons have been recorded, suggesting that such observations refer to passing birds only.

In the state of São Paulo amazons have been found from Mongaguá (24°05'S 46°30'W) south to the border with Paraná, in a stretch 190 km long and 20 km wide (Figure 1). The use of satellite imagery data (SOS Mata Atlântica 1993) showed that the amount of habitat available for the amazons in this area is very limited, with only 1,300 km^2 of lowland forest and just 90 km^2 of mangrove. When images of the situation in Paraná and Santa Catarina are also evaluated, the total available habitat covers only 3,057 km^2.

Amazon populations are not uniformly distributed. Between Mongaguá and the mouth of the Ribeira de Iguape river only 210 birds could be found, whereas 1,340 were censused from there to the Paraná border. This means that 85% of the state population is concentrated within an area of 5,000 km^2.

The Red-tailed Amazon is sympatric with only one other congener, the Orange-winged Amazon *Amazona amazonica*. A tiny population of this species exists at Peruibe (24°20'S 46°50'W), roosting together with the Red-tailed

Amazons. Nowhere was the latter species encountered at the same time and season as the Vinaceous Amazon *A. vinacea* (another threatened bird: see Collar *et al.* 1992). Although both occur in the south-eastern limits of Jacupiranga State Park (c.25°10'S 48°15'W) they do so in different seasons, Vinaceous in the summer and Red-tails in the winter.

Population

In 1993 the amazon population along the São Paulo coast was 1,550 individuals, mostly concentrated in the south (Figure 1). The amazons were divided into 16 distinct populations which numbered from 20 to 115 birds (for security reasons, no further details are given here). A certain degree of intermingling occurs between neighbouring populations, as noted at Ilha Cananéia, where the resident birds were once joined by individuals from Ilha Comprida, making a total of 157 birds.

The amazons are faithful to traditional roosts, using them as long as the trees are standing. Some roosts are located in isolated groups of trees, left standing when the surrounding areas were cleared, often quite close to towns. This behaviour makes censusing easier.

Food habits

I observed Red-tailed Amazons feeding on 68 different plant species in 143 feeding bouts (Table 1). Main food plants were *Arecastrum romanzoffianum*, *Psidium cattleianum* and *Calophyllum brasiliense*, all of which are found in different forest types.

Most records were of fruits (88.7%), both pulp and seed being eaten in most instances. Flowers and nectar accounted for 9.8% of the records, the amazons selecting species with abundant nectar that also attracted other birds like hummingbirds, Bananaquits *Coereba flaveola* and tanagers. When feeding on *Noranthea* flowers only the large nectaries were eaten. *Pseudobombax* flowers had their nectaries and ovary eaten without being plucked from the tree, whereas *Erythrina* flowers were plucked and completely destroyed, their cups being ingested.

Twice amazons were observed feeding on the exudates dropping from the fruits of the palm *Attalea* infested with beetle larvae. The exudate had a gelatinous consistency and a milky colour. After feeding on the exposed drops of exudate, the birds proceeded to break the fruit, licking its contents. Examination of the broken fruit showed that they had eaten the exudate and larvae but had discarded the fruit itself.

On five occasions amazons were also observed feeding on the old seed capsules of *Tibouchina holosericea* and *T. mutabilis*, which were used by arthropods. The birds chose old capsules still attached to the tree, opening them with the bill and ingesting the contents. Examination of the capsules showed them to be occupied by small spiders and insect pupae. Similar behaviour was observed while feeding on the seed pods of *Jacaranda puberula*. On one occasion three amazons were seen feeding on young leaves of the bromeliad *Aechmea nudicaulis*.

Table 1. Plants eaten by Red-tailed Amazons

	Feeding bouts	Part eaten	Month
Anacardiaceae			
Schinus terebinthifolius	3	Seed	May–June
Annonaceae			
Guatteria australis	1	Seed	
Aquifoliaceae			
Ilex theezans	2	Seed	October
Apocinaceae			
Aspidosperma olivaceum	1	Seed	
Bignoniaceae			
Tabebuia cassinoides	2	Fruits	January–February
Jacaranda puberula	1	Fruit	
Bombacaeae			
Pseudobombax grandiflorum	3	Fruit, flowers	May
Spirotheca passifloroides	2	flowers	
Bromeliaceae			
Vriesea betuminosa	2	Flowers, fruits	
Aechmea nudicaulis	1	leaves	
Celastraceae			
Maytenus obtusifolia	4	Fruits	October
Combretaceae			
Laguncularia racemosa	2	Fruits	March
Eleocarpacea			
Sloanea lasiocoma	1	Seeds	
Euphorbiaceae			
Alchornea triplinevia	2	Fruits	
Pera obovata	1	Seeds	
Guttiferae			
Clusia criuva	1	Fruits	December
Calophyllum brasiliense	6	Fruits	November–December
Lauraceae			
Cryptocarya aschesoniana	2	Seeds	
Ocotea aciphylla	1	Seeds	
Ocotea pulchella	2	Seeds	
Nectandra grandiflora	1	Seeds	October
Nectandra rigida	1	Seed	
Leguminosae			
Erythrina speciosa	5	Flowers, seeds	August–October
Inga edulis	3	Fruits	December
Schizolobium parahyba	2	Seeds	May
Copaifera trapezifolia	1	Seed	
Loranthaceae			
Struthanthus vulgaris	1	Seed	May
Magnoliaceae			
Talauma ovata	1	Seed	September
Malvaceae			
Hibiscus pernambucensis	2	Flowers	January–February
Marcgraviaceae			
Noranthea brasiliensis	3	Flowers, nectar	March
Melastomataceae			
Tibouchina mutabilis	1	Insects	March
Tibouchina holosericea	2	Insects	November–December

Table 1 (*cont.*)

	Feeding bouts	Part eaten	Month
Miconia dodecandra	2	Fruits	
Miconia cabuçu	3	Fruits	
Meliaceae			
Guarea macrophylla	2	Fruits	
Cabralea canjerana	1	Fruit	March
Moraceae			
Brosimum glaziovi	1	Fruit	
Ficus enormis	1	Fruit	
Ficus insipida	1	Fruit	
Cecropia cinerea	3	Fruit	November–January
Cecropia pachystachya	4	Fruit	December–January
Myrsinaceae			
Rapanea ferruginea	2	Seeds	October
Rapanea guianensis	3	Seeds	November
Myrtaceae			
Eugenia bimarginata	2	Fruit	
Eugenia sulcata	1	Fruit	
Eugenia oblongata	3	Fruit	
Campomanesia guaviroba	2	Fruit	
Myrcia rostrata	1	Fruit	
Myrcia grandiflora	1	Fruit	
Gomidesia spectabilis	2	Fruits	April
Marlierea tomentosa	2	Fruits	
Psidium cattleianum	6	Fruits	October–December
Calyptranthes polyantha	3	Fruits	November
Nyctaginaceae			
Guapira opposita	1	Seeds	
Palmae			
Arecastrum romanzoffianum	8	Fruits	February–April
Euterpe edulis	2	Fruits	July–August
Geonoma elegans	2	Fruits	August
Attalea dubia	2	Insects	August–September
Podocarpaceae			
Podocarpus sellowii	3	Fruits	
Rutaceae			
Esenbeckia grandiflora	3	Seeds	August
Rhizophoraceae			
Rhizophora mangle	1	Seeds	January
Sapindaceae			
Allophylus petidulatus	1	Seeds	April
Matayba elaeagnoides	1	Seeds	October
Sapotaceae			
Manilkara subsericea	1	Seeds	October
Theaceae			
Ternstroemia brasiliensis	2	Seeds	April–October
Ulmaceae			
Trema micrantha	4	Seeds	October–December
Verbenaceae			
Avicenna schaueriana	2	Fruits	
Vochysiaceae			
Vochysia bifalcata	1	Fruits	

Breeding biology

Data on 49 nest cavities are in Table 2. There was a great deal of variability in nest height and size. For example, nest cavities ranged from 4.2 m to 0.2 m deep, the highest nest being 15 m up in a tree, while the lowest was only 1.0 m above the water in a swamp. One nest was located in an arboreal termitarium 3 m above the ground. Another was in a 20 cm deep cavity amid the petioles in the crown of a live *Attalea* palm. (Both nests successfully raised two nestlings to pre-fledging stage, when the chicks were poached.) The general impression was that the amazons are not strongly stereotyped in nest-site selection.

Of 49 nests, 67% were in dead trees. The great majority of the nests (79.5%) were found in flooded forest and at the interface between flooded forest and other forest types. Dead trees occur throughout these habitats, owing to the variations in water level, which occasionally cause flooding forest patches on adjacent higher ground, killing the trees, mostly *Arecastrum* and *Calophyllum*.

Searches for cavities in the different forest types showed zero cavities per hectare in mangrove forest, 7/ha in sandplain forest (only in the tallest type growing on Pleistocene soils), 18/ha in seasonally flooded forest, and 39/ha in flooded forest. It was not possible to make a thorough search for cavities in transitional forest because of the heavy bromeliad populations of this forest type and because of the tallness of the trees; data from such areas were thus bound to be underestimates and were not used.

The minimum distance between nests simultaneously used by different pairs was 8 m. Territorial behaviour was restricted to the immediate vicinity of the nest.

Observations on the behaviour of birds at roosts revealed that pairs kept together within flocks, both when flying and feeding. This strongly suggests that amazon pairs remain together throughout the year.

From August to early September pairs leave the collective roost, keeping separate from other amazons during the day. The pairs start prospecting for potential nest cavities, one of them being more active in the search (observations of copulating birds suggest that the active bird seems more likely to be the male). After finding a cavity, one of the birds calls to the other and both examine it. The investigation of cavities is, however, a behaviour that occurs throughout the year.

After a cavity is selected, by the middle of September, courtship begins at the collective roost and around the nest. The male walks along the branches around the perched female, with head and facial feathers raised, giving him a fluffy appearance, and he opens his tail displaying its red patch. During this period one bird actively attempts to keep by the side of the other. Allopreening and regurgitating food into the partner's bill are common. Copulation has been observed from early October, coinciding with the discovery of the first active nests.

The number of amazons using the collective nocturnal roosts diminishes as females begin to spend the night at their nests a few days before laying, although some of the males continue to sleep at the roosts. Of nine nests, four males stayed in the collective roosts at the beginning of incubation, the other five roosting with the females in the nests. Only after the first week of

Table 2. Data on nests of Red-tailed Amazons

Nest tree	Tree height (m)	Nest height (m)	Live/ dead	Nest depth (m)	Nest diameter (m)
Arecastrum romanzoffianum	4.3	4.3	D	2.0	0.25
Arecastrum romanzoffianum	3.8	3.0	D	1.82	0.23
Arecastrum romanzoffianum	7.1	7.1	D	1.52	0.23
Arecastrum romanzoffianum	6.5	6.0	D	1.4	0.28
Arecastrum romanzoffianum	2.0	2.0	D	0.2	0.24
Arecastrum romanzoffianum	2.5	2.1	D	0.45	0.23
Arecastrum romanzoffianum	2.3	2.3	D	0.36	0.21
Arecastrum romanzoffianum	1.8	1.8	D	0.5	0.2
Arecastrum romanzoffianum	1.0	1.0	D	1.0	0.2
Arecastrum romanzoffianum	4.5	4.2	D	4.2	0.22
Arecastrum romanzoffianum	7.5	4.17	D	1.23	0.27
Arecastrum romanzoffianum	5.0	4.3	L	0.8	0.25
Arecastrum romanzoffianum	5.0	4.0	L	0.2	0.25
Arecastrum romanzoffianum	4.3	3.0	D	0.3	0.18
Arecastrym romanzoffianum	2.0	2.0	D	0.43	0.18
Arecastrum romanzoffianum	2.5	2.5	D	0.4	0.2
Arecastrum romanzoffianum	3.8	3.5	D	0.6	0.2
Arecastrum romanzoffianum	4.0	4.0	D	1.2	0.2
Calophyllum brasiliense	11.0	7.3	L	0.2	0.19
Calophyllum brasiliense	13.0	9.7	L	1.7	0.3
Calophyllum brasiliense	7.0	7.0	L	0.33	0.21
Calophyllum brasiliense	8.5	6.5	L	0.6	0.2
Calophyllum brasiliense	7.0	3.5	L	1.0	0.27
Calophyllum brasiliense	15.0	11.2	L	0.3	0.33
Calophyllum brasiliense	8.5	8.5	D	0.65	0.3
Calophyllum brasiliense	2.5	2.5	D	0.27	0.23
Calophyllum brasiliense	3.0	1.5	D	0.8	0.25
Calophyllum brasiliense	3.5	3.5	D	0.2	0.25
Calophyllum brasiliense	12.0	7.0	L	1.05	0.28
Calophyllum brasiliense	14.0	12.0	L	0.6	0.35
Calophyllum brasiliense	13.0	11.0	D	0.4	0.30
Attalea dubia	8.5	7.0	L	0.5	0.19
Attalea dubia	5.0	5.0	D	0.3	0.18
Ficus enormis	9.0	7.0	D	0.6	0.40
Ficus enormis	15.0	11.0	L	1.15	0.37
Cedrela fissilis	10.0	7.5	D	0.6	0.32
Manilkara subsericea	16.0	9.5	L	0.45	0.21
Copaifera trapezifolia	12.5	8.5	L	0.5	0.29
Copaifera trapezifolia	15.0	10.2	L	0.6	0.35
Vochysia bifalcata	8.5	8.5	D	0.83	0.28
Vochysia bifalcata	7.3	5.4	D	0.27	0.18
Schizolobium parahybum	13.2	7.5	L	0.47	0.22
n.id.	13.0	10.4	D	0.7	0.25
n.id.	6.0	5.5	D	0.4	0.23
n.id.	10.0	7.0	D	0.5	0.4
n.id.	7.0	5.5	D	0.3	0.2
n.id.	8.5	8.0	D	1.0	0.3
n.id.	2.5	2.5	D	0.8	0.19
n.id.	4.5	4.5	D	0.6	0.21

n.id, not identified.

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incubation did all the males take to roosting in the nests. The collective roosts are not used subsequently during the breeding season, and roosting habits of the non-breeding birds at this time are not known.

Of the nine nests closely monitored, five had four eggs and four had three eggs, laid at two-day intervals. Incubation lasted 27–28 days, and began with the first egg, so that hatching was asynchronous. This took place in late October and early November. Not all eggs hatched. Three nests had three chicks, five had two, and one had one. The three nests with three chicks had contained four eggs each; of the five nests with two chicks, two had held four eggs and three had three; the nest with one chick had three eggs.

The young were covered by feathers at 38 days, and obtained their fully grown flight feathers at 53–55 days. All nests were poached, but observations on captive birds suggested that fledglings would begin to leave the nest by early December at an age of 50–55 days.

Some pairs have a delayed nesting cycle. I have found nestlings as late as early April. These may represent re-nesting of pairs which lost their first brood earlier in the season.

All 49 nests studied failed. Forty-one were poached by trappers taking nestlings for sale. The remaining eight failures were caused by natural predators such as snakes, opossums and owls (six instances) and by strong winds causing trees to fall (two instances) (Martuscelli in prep.). I did not witness interference or failure caused by African bees.

A crude measure of recruitment rates could be made by observations of family groups which clearly contained juvenile birds in and immediately following the main fledging period. The protected population of 11 pairs breeding in Ilha do Cardoso State Park fledged 26 chicks in 1991, while in 1992 15 pairs produced 31 offspring (although for reasons unknown the total population, as censused at nocturnal roosts, remained stable at 94–98 individuals throughout the study period). At Cananéia, where poaching occurs, 87 parrots produced two fledglings in 1990–1991 and four in 1991–1992.

Threats

During my study, only one instance of natural predation of adult Red-tailed Amazons was witnessed, when a Mantled Hawk *Leucopternis polionota* killed a flying parrot returning to the roost at Ilha do Cardoso. Natural predators and winds take their toll of nestlings (see above). Strong intermittent winds of 60–80 kph, caused by the approach of cold fronts, occur during the onset of the rainy season in September/October, felling dead and emergent trees. The shallow roots of most trees make lowland forests vulnerable to these winds. For example, of 39 potential nest cavities in one flooded forest plot, seven were destroyed by wind in September 1992.

Deforestation has been identified as a threat to the survival of the Red-tailed Amazon. From 1985 to 1990, 12.5 km^2 of lowland and mangrove forests were destroyed in São Paulo, a 1.27% decrease in available habitat. In all, 35.54 km^2 of Red-tailed Amazon habitat was destroyed in the entire species's range in that five-year period (SOS Mata Atlântica 1993).

The main cause of habitat destruction has been the building of holiday and second homes. Most of the remaining lowland forest all over São Paulo is already held by development enterprises which are ready to clear their areas of land as soon as political opportunity permits (Figure 2).

Another threat is the expansion of agriculture and water-buffalo ranching. The state of São Paulo has implemented an official policy of converting wetlands into rice and other grain plantations. Such a policy is a direct threat not only to the main breeding grounds but also the foraging areas of the species. Water-buffalo ranching, an increasingly popular option in the marshy lowlands where the amazon lives, causes direct competition for food resources such as *Erythrina* and *Gomidesia* (the buffalo browse these small trees) and *Arecastrum* and *Euterpe* (which buffalo will push over to obtain the leaves and fruit). Moreover, ranchers clear forest to increase the area available for pasture.

Local people traditionally use hardwoods for making canoes, paddles and homes. The favoured timbers are from *Calophyllum* and all large myrtaceous and lauraceous trees. Such species provide both nest cavities and food for the amazons. The increasingly commercial nature of what were once subsistence crafts is leading to the over-exploitation of the resource, and to the elimination of all large trees in the more accessible areas.

Commercial exploitation of *Tabebuia cassinoides* trees and *Euterpe edulis* palms, although mostly illegal, is now taking place on a large scale, destroying both habitat and food resources. Wood from *Tabebuia* is used for making pencils for export to European markets. The enterprises involved are based in the city of Iguape and are controlled by multinational companies. The intensive harvesting of *Euterpe* palm-hearts, which are mostly consumed in Brazil, now represents a serious conservation problem throughout the Atlantic forest, as these fruits are probably a keystone resource for the large frugivore community of the ecosystem (Galetti in prep.), including the threatened Black-fronted Piping-guan *Pipile jacutinga*, Blue-bellied Parrot *Triclaria malachitacea* and Cinnamon-vented Piha *Lipaugus lanioides* (Collar *et al.* 1992).

Poaching for the cage-bird market is, however, the most immediate threat to the species. This began in 1980, when traffickers first found the species's breeding area. Interest has been so great that trappers have now started capturing adults and taking eggs from the nests. All trappers are from traditional communities, both "caiçaras" (artisan fishermen) and Guarani Indians.

In the 1991–1992 breeding season, 356 nestlings were stolen from nests in the municipalities of Iguape, Cananéia and Ilha Comprida alone, which cover only 25% of the species's total range (Martuscelli 1994a). Poaching has been recorded at every single locality in which the species occurs, even the ones where the population is relictual. The result has been virtually zero recruitment of young birds into the population (see Breeding).

Trappers frequently fell the nest tree, which diminishes the overall availability of nest sites. The two nests found in a termitarium and amongst the petioles of a palm were in an area of high poaching levels and apparently no natural cavities.

Hunting amazons for food still takes place. In São Paulo I recorded two instances. One case involved children killing a bird with slingshots. The other

occurred at Cananéia in June 1990, when 40 birds from a roosting flock of 87 were shot by local caiçaras for target practice and food.

Captive breeding has never occurred in either Brazil or Europe (Low 1992). The so-called captive-bred birds offered for sale by prominent Brazilian aviculturists are in fact wild-caught. All the captive populations are composed of birds illegally trapped and smuggled out of Brazil (Martuscelli 1994a). Indeed, it is the interest of foreign bird-fanciers and zoos, mainly in Europe, that has fuelled the poaching, by creating a demand among Brazilian aviculturists acting as middlemen. All the people trafficking in the species in Brazil are well known, but the government agencies have been lax in intervening.

Discussion

The Red-tailed Amazon is restricted to the narrow forested stretch between the sea and the coastal massifs. This habitat was probably once much more extensive, perhaps double its historical area, during the last sea regression 15,000 BP (Suguio *et al.* 1978), when the continental shelf was exposed. It is to be noted that the broadest stretch of shelf is exactly adjacent to the area in which the amazon survives today.

The findings of this study strongly suggest that Red-tailed Amazon distribution is tied to the sympatric occurrence of mangroves and forests dominated by *Calophyllum brasiliense* and *Tabebuia cassinoides*, and higher amazon densities are attained only where there is a rich mosaic that includes both mangrove and all types of lowland forest. The southern limit for the sympatry of these assemblages is at 26°50'S (Reitz *et al.* 1978, Cintron-Molero and Schaefer-Novelli 1992), close to where the southernmost population of amazons is found. This also strengthens the case for regarding the old record of the species from Rio Grande do Sul (von Ihering 1899) as erroneous. Moreover it helps explain the apparent puzzle of the species's concentration south of the Ribeira de Iguape river, given that a fairly large (c.400 km^2) tract of lowland forest exists in the Juréia-Itatins Ecological Station (c.24°20'S 47°10'W). The area is protected from trappers, yet only 40 amazons live there. However, it is only south of the river that there are broad expanses of mangrove bordering lowland forest. At Juréia-Itatins, amazons are found in the places where mangrove is associated with lowland forest, while at Pariquera-Abaixo State Park (24°40'S 47°50'W), where all forest types are disjunct from mangrove, amazons are present only seasonally. The northern limit of the sympatry of mangrove and lowland forests is the point where the Serra do Mar massif approaches the sea and there is almost no plain, around the cities of Santos and Cubatão (c.24°00'S). From this point to the border with Rio de Janeiro (23°20'S) the only amazons found in the coastal plain are *Amazona farinosa* and *A. rhodocorytha* (P. Martuscelli and F. Olmos unpubl. data).

The population of the species is 1,550 birds in São Paulo, a far greater number than the 300 estimated by Scherer-Neto (1989). The earlier figure seems to be the product of limited survey time and the missing of several important areas located in less accessible forest and swampy areas. In Paraná Scherer-Neto (1989) found 2,101 birds during four years of fieldwork. This figure was arrived

at by pooling numbers found at collective nocturnal roosts and censuses while foraging and flying, and so may be an overestimate.

Red-tailed Amazons use a wide range of fruit resources, being mainly seed predators. Feeding on arthropods has rarely been recorded in Neotropical parrots, but it is possibly commoner than thought (Martuscelli 1994b). Food plants grow in all types of forest in the region, but plants found in swampy areas seem most important. Breeding is synchronized with the fruiting of trees with large crops (most Myrtaceae, *Calophyllum brasiliense*), especially those growing in restinga. These data agree with de Grande and Lopes (1981) and Kirizawa *et al.* (1992).

The amazons do not seem to be selective with regard to nest cavities, using what is available and showing a certain degree of adaptability.

Conservation

Trade is at present the most immediate threat to the Red-tailed Amazon, despite views to the contrary in Low (1984), Scherer-Neto (1988, 1989) and Silva (1991), who all consider habitat destruction to be a worse threat. The only places where nests can be expected to escape poaching are Ilha do Cardoso State Park and Juréia-Itatins Ecological Station, and even adult birds are now being captured. Poaching has been so intense that the market has been flooded by Red-tailed Amazons, causing the prices to fall. In the early 1990s Argentinian middlemen were selling the species for as little as US$90 (Bertonatti 1992).

It is clearly vital to stop this international trafficking. Despite being listed on CITES Appendix I and being fully protected under Brazilian law, the species is becoming increasingly common in collections in Europe and the U.S.A. As stated above, all birds in these collections have been smuggled from Brazil and their possession is the result of illegal acts. In other words bird-fanciers around the world are pushing the Red-tailed Amazon to the brink of extinction, as they have done with another Brazilian endemic psittacine, Spix's Macaw *Cyanopsitta spixii* (see Collar *et al.* 1992).

Of 16 populations in São Paulo state only two, totalling 138 birds, are in protected areas such as parks or ecological stations and are not being poached. Occurrence within a protected area is, however, no guarantee on this issue. Another three populations, involving 254 birds, are being poached despite their presence inside protected areas. The main problem is lack of effective protection for most areas, which are "paper parks". Of the remaining habitat in São Paulo, only around 470 km^2 are in protected areas, and this is probably too low a figure for the long-term security of the species.

Based on the surveys undertaken during this study, four new protected areas have been proposed: on Ilha Comprida, on the mainland facing Ilha do Cardoso, at Pariquera-açu and Mongaguá. These, together with existing protected areas, would encompass the bulk of the population and remaining habitat in São Paulo. Nevertheless, a stronger commitment by the government is necessary to implement the full establishment of the parks and to provide them with adequate financial support.

The proposed reserves would also protect populations of several other threatened species such as Black-fronted Piping-guan, Golden-tailed Parrotlet

Touit surda and Brown-backed Parrotlet *T. melanonota*, Blue-bellied Parrot, White-necked Hawk *Leucopternis lacernulata*, Black-headed Berryeater *Carpornis melanocephala* and Cinnamon-vented Piha, plus mammals such as the black-faced lion tamarin *Leontopithecus caissara* and giant otter *Pteronura brasiliensis*.

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References

Barros, F., Fiuza de Melo, M. M., Chiea, S., Kirizawa, M., Wanderley, M. G. and Jung-Mendaçolli, S. L. (1991) *Flora fanerogâmica da Ilha do Cardoso*, 1. São Paulo: Instituto de Botânica de São Paulo.

Bertonatti, C. (1992) Diagnostico actual sobre el comercio de fauna silvestre. *Fundación Vida Silvestre Argentina, Bol. Téc.* 3.

Cintron-Molero, G. and Schaeffer-Novelli, Y. (1992) Ecology and management of New World mangroves. In U. Selinger, ed. *Coastal plant communities of Latin America*. New York: Academic Press.

Collar, N. J., Gonzaga, L. P., Krabbe, N., Madroño Nieto, A., Naranjo, L. G., Parker, T. A. and Wege, D. C. (1992) *Threatened birds of the Americas: the ICBP/IUCN Red Data Book*. Cambridge, U.K.: International Council for Bird Preservation.

Diefenbach, K. H. and Goldhammer, S. P. (1986) Biologie und Ökologie der Rotschwanzamazone *Amazona brasiliensis*. *Trochilus* 7: 72–78.

de Grande, D. A. and Lopes, E. A. (1981) Plantas da restinga da Ilha do Cardoso, São Paulo, Brasil. *Hoehnea* 9: 1–22.

von Ihering, H. (1899) *As aves do estado do Rio Grande do Sul*. Porto Alegre: Gundlach and Krahe.

Kirizawa, M., Lopes, E. A., Pinto, M. M., Lam, M. and Lopes, M. I. M. S. (1992) Vegetação da Ilha Comprida: aspectos fisionômicos e florísticos. *Revta. Inst. Flor.* 4: 386–391.

Low, R. (1984) *Endangered parrots*. Poole, U.K.: Blandford.

Low, R. (1992) *Parrots in aviculture: a photo reference guide*. Poole, U.K.: Blandford.

Martuscelli, P. (1994a) A parrot with a tiny range and a big problem: will illegal trade wipe out the Red-tailed Amazon? *PsittaScene* 6(3): 3–4.

Martuscelli, P. (1994b) Maroon-bellied Conures feed on gall-forming homopteran larvae. *Wilson Bull.* 106: 769–770.

Reitz, R., Klein, R. M. and Reis, A. (1978) Projeto Madeira de Santa Catarina. *Sellowia* 28–30: 218–224.

Scherer-Neto, P. (1988) Die Rotschwanz-amazone *Amazona brasiliensis* hat eine ungewisse Zukunft. *Papageien* 1: 23–26.

Scherer-Neto, P. (1989) Contribuição à biologia do Papagaio-de-Cara-Roxa *Amazona brasiliensis* (Linnaeus, 1758) (Aves, Psittacidae). M.Sc. thesis, Curitiba, Paraná.

Silva, T. (1991) *Psittaculture: the breeding, rearing and management of parrots*. Ontario: Silvio Mattachione.

SOS Mata Atlântica (1993) *Evolução dos remanescentes florestais e ecossistemas associados do domínio Mata Atlântica no período 1985–1990*. São Paulo.

Suguio, K., Martim, L. and Fairchild, T. R. (1978) Quaternary marine formations of the states of São Paulo and southern Rio de Janeiro. *Proceedings of the International Symposium on Coastal Evolution in the Quaternary, São Paulo, Brasil*.

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