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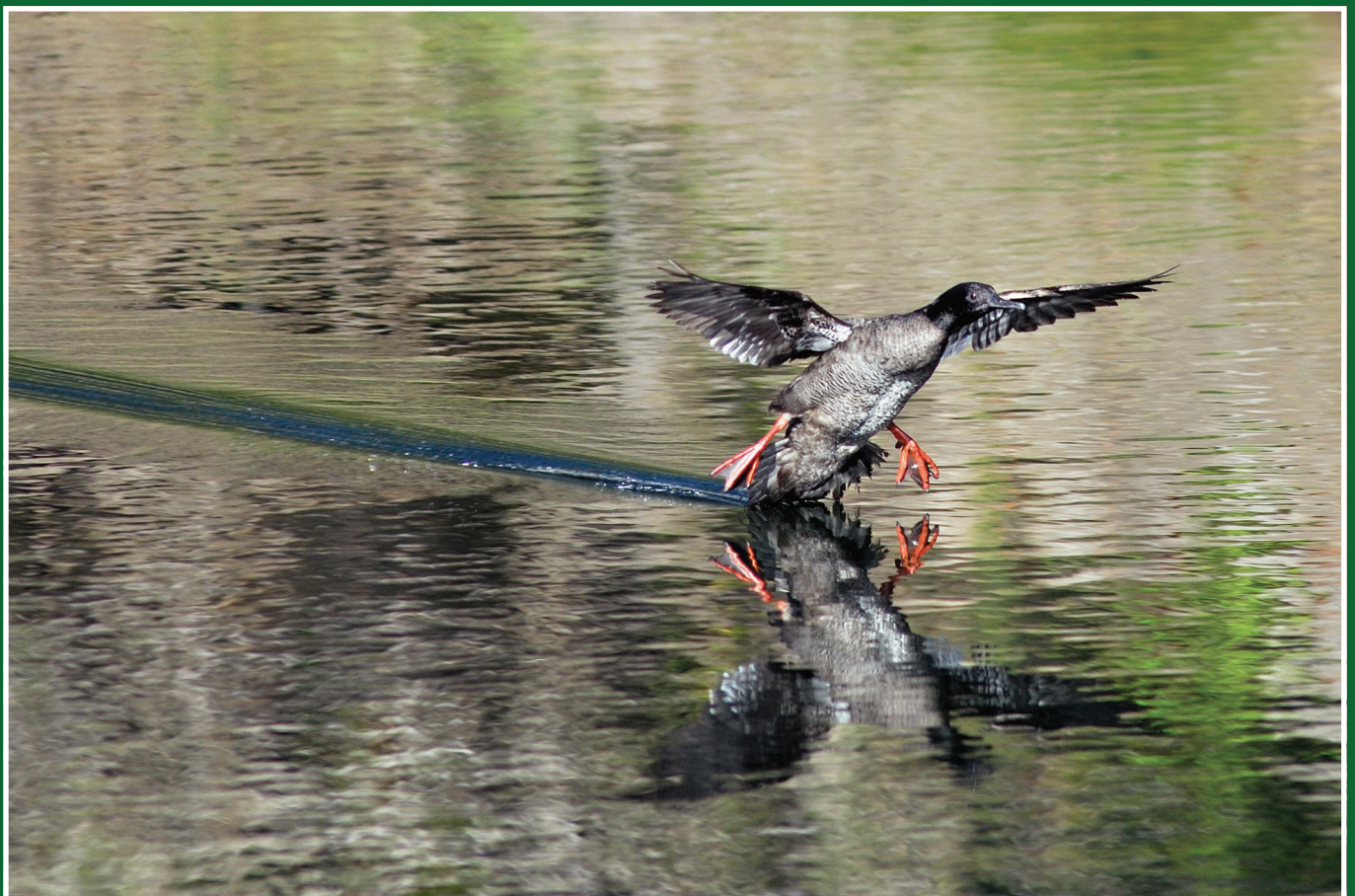
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Biology and population size of the Golden Parakeet (*Guaruba guarouba*) in western Pará, Brazil, with recommendations for conservation

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RESUMO: Biologia e tamanho da população da ararajuba (*Guaruba guarouba*) no oeste do Pará, Brasil, com recomendações para conservação. Neste trabalho, eu descrevo padrões de agrupamento, dieta, sítios reprodutivos da ararajuba – um psitacídeo ameaçado, pouco conhecido e endêmico da Amazônia brasileira – e analiso sua abundância e tamanho populacional no oeste do Pará. Em 2007, eu procurei por bandos e conduzi amostragens em transectos por quase 500 horas. Ao longo do ano, as ararajubas permaneceram em bandos (provavelmente familiares) de cerca de 10 indivíduos, confirmando informações prévias. A estimativa do resultado reprodutivo baseada na proporção de jovens com menos de 1 ano nos bandos (cerca de 13%) está dentro da variação que tem sido encontrada para outros psitacídeos, sugerindo um resultado reprodutivo aparentemente normal. Registros de alimentação (n = 82) confirmam uma dieta diversificada, que varia ao longo do ano, mas alguns itens (por exemplo, *Byrsonima* spp.; *Tapirira guianensis*) pareceram ser mais importantes. Todos as árvores com ninhos encontradas estavam em áreas abertas nas proximidades da mata contínua, e expostas a perturbação antrópica, indicando uma potencial vulnerabilidade. Ao contrário das expectativas, as amostragens indicaram que a ararajuba é tão comum quanto outros psitacídeos não ameaçados. A espécie provavelmente ocupa toda a região (uma linha de quase 340 km ao longo do rio Tapajós), com uma população de quase 500 indivíduos, a qual é a maior população conhecida. Baseado nesses dados e em registros recentes, o tamanho global da população da ararajuba é maior do que tem sido estimado previamente, de modo que seu *status* nas listas de espécies ameaçadas deve ser reavaliado.

PALAVRAS-CHAVE: Padrões de agrupamento; Dieta alimentar; Sítios reprodutivos; Abundância; Amazônia brasileira; Espécie ameaçada.

ABSTRACT: Biology and population size of the Golden Parakeet (*Guaruba guarouba*) in western Pará, Brazil, with recommendations for conservation. Golden Parakeets are a poorly known, endangered parrot endemic to the Brazilian Amazon. I describe the flocking patterns, the diet and nest sites of this species and estimate the abundance and size of its population in western Pará. During 2007, I spent about 500 hrs searching for flocks and making transect surveys. Golden Parakeets maintained family flocks of about 10 individuals throughout the year, confirming previous observations. My estimate of reproductive output from the proportion of first year juveniles in the flocks (around 13%) is within the range of estimates found for other parrots, suggesting a normal reproductive output. Feeding bouts (n = 82) confirmed a diversified diet that varies throughout the year, but some items (e.g., *Byrsonima* spp.; *Tapirira guianensis*) seem to be more important. All found nest trees were in open areas, adjacent to the continuous forest, exposed to the human disturbance, indicating a potential vulnerability. Surveys indicated that the Golden Parakeet is as common as other sympatric and non-threatened parrots, contrary to expectations. The species probably occupies the whole study region (a strip of about 340 km along the Tapajós river) with an estimated population size of about 500 individuals comprising the largest known population. My data and recent records of the species indicate that its global population size is larger than previously estimated and its official level of endangerment in the red lists should be re-examined.

KEY-WORDS: Flocking patterns; Feeding bouts; Nest sites; Abundance; Brazilian Amazon; Threatened species.

Golden Parakeets (*Guaruba guarouba*) are endemic to the Brazilian Amazon, occurring from western Maranhão to southeastern Amazonas, south of Amazon River (Laranjeiras and Cohn-Haft 2009). These parakeets have suffered dramatically from the illegal pet trade and have been listed as a threatened species (BirdLife International 2010). The global population is estimated at < 2500 individuals (BirdLife International 2010), and their geographic distribution has become more restricted in recent

years (Laranjeiras and Cohn-Haft 2009). Consequently, the long-term survival of Golden Parakeets is seriously jeopardized (Silveira and Belmonte 2005, Laranjeiras and Cohn-Haft 2009).

Despite its endangered status, Golden Parakeets remain poorly studied in the wild, with little known about their biology, including social organization, diet, nest sites, abundance and population size (Juniper and Parr 1998, BirdLife International 2010). Flock sizes range

from 3 to 30 individuals (Oren and Novaes 1986), but flock structure and composition are not well known. First published observations suggested the presence of multiple reproductive pairs, reproductive helpers (Oren and Novaes 1986) or related juveniles from different generations forming a big family group or clan (Reynolds 2003). These parakeets are known to eat fruits and seeds of different tree species, but the most are human-cultivated or from the secondary forest (Oren and Novaes 1986, Sick 1997, Juniper and Parr 1998). They are reported to nest in cavities of high and emergent trees of a few species in open and altered areas and no nest are known in the continuous forest (Oren and Novaes 1986, Silveira and Belmonte 2005). Regarding its abundance, previous studies suggest the species is rare and nomadic, with seasonal displacement along rivers, also associated with the fluctuation of food availability, but investigators may have been looking in suboptimal habitat (Collar *et al.* 1992). Current population estimates of Golden Parakeets are indirect and based on data of poor quality (BirdLife International 2010), and there are no accurate data concerning relative abundance throughout their range. The scarcity of these data limits conservation actions, such as protection of preferential areas, reintroduction programs and improvement of nest success.

I describe and analyze the flocking patterns, the diet and nest sites of Golden Parakeets and estimate the abundance and size of their population in western Pará (northern Brazil) – the most pristine area within its geographic distribution (Laranjeiras and Cohn-Haft 2009). Flock size data allowed insights into social organization, and the presence of first year juveniles in flocks indicated reproductive output in the region. Feeding bouts revealed important items for its diet, which may be managed in sites where Golden Parakeets occur. Similar aspects of found nest sites indicated areas that should be specifically safeguarded. Surveys and searches indicated where is the species and how many individuals are surviving in the whole study region, and how abundant is it compared to other parrots. All these data allowed to infer on the global status of the species and to recommend conservation efforts in the Amazon.

METHODS

Study area

My study was carried out in Amazônia National Park and adjacent areas in western Pará along the Tapajós River (04°33'S, 56°18'W) in northern Brazil (Figure 1). My observations were concentrated along the 'transamazônica' highway (BR 230) between the cities of Itaituba (km 0) and Jacareacanga (km 400). This highway is an unpaved track varying in width from 10 to 40 m. There are two

park's visitation and vigilance buildings: one at km 53 of the roadway beside the Tracoá River ('Tracoá' station), and one at km 65 at the border of Tapajós River ('Uruá' station). Near these buildings are trails and, south of the park, are a village (km 180) and a few farms, ranches and campsites.

The study area is within the Tropical Moist Forest Zone of the Holdridge Life Zone classification (Holdridge 1967), and hilly and lowland rain forests predominate (RADAM-Brasil 1975). Vegetation in the park is continuous primary forest, interrupted only by the highway and the strip of just a few meters of second growth that flanks it. Outside the park, much of the land along the road is deforested, covered by active or abandoned pastures and second growth extending as much as several kilometers from the road in places. Most of the entire study region is on unflooded uplands (*terra firme*), but there is seasonal flooding along some of the forested streams, creating limited areas of *igapó* forest.

The climate is hot and humid, with five dry months and mean annual precipitation ranging from 1800 to 2300 mm (Moraes *et al.* 2005). It is possible to recognize four seasons, including a "rainy season" from January to March (600-1000 mm precipitation), "end of rainy season" from April to June (400-700 mm), "dry season" from July to September (150-350 mm), and the "beginning of the rainy season" from October to December (400-600 mm).

Flock searches and flocking patterns

I spent about 400 hrs searching for Golden Parakeet flocks over eight months (January, March, May-August, October-December) in 2007. I traveled on foot and by bicycle or motorcycle along transamazônica highway stretches of variable length (from 2 km to 40 km), mainly in mornings (06:00-10:00) and afternoons (15:00-18:00), but also occasionally at midday. For all sightings (records), I noted date, direction of flight, the location (using GPS), and the size of the flock. Different records do not necessarily refer to different parakeets.

When I recorded a flock near dusk (around 5% of all records), I tried to follow it (and also used information from local people) in order to locate roosting and breeding sites. The number of individuals at roost sites was counted at dusk and dawn, for one to several days, depending on the duration of my stay in that particular region. I also noted behavioral interactions among parakeets at roosting sites, considering their potential importance to flocking patterns.

During the post-reproductive period (from March/April to July, according to Oren and Novaes [1986] and Laranjeiras [2008a]), I also counted the number of first year juveniles in observations during which I could watch the flock long enough (generally within the first ten minutes)

to detect every individual (usually at nest and feeding sites). First year juveniles were recognized by their plumage (streaked with various patterns of green that remained until the first molt, within the first year [P. Machado *in litt.* 2011]), begging behavior and more strident voice (Reynolds 2003, Silveira and Belmonte 2005, Laranjeiras 2008a).

I compared flock sizes from all records throughout the day partitioned into four ~ 3 hr periods (05:15-08:59; 09:00-11:59; 12:00-14:59; 15:00-18:15) and among seasons (see above) using analysis of variance (ANOVA with Tukey's post-hoc test). All analyses were performed using Systat 10 (SPSS 2000)

Description of diet

The diet evaluation was conducted over direct observations. Each time I saw Golden Parakeets eating (a Feeding Bout) during the searches, I noted date, the location (using GPS), the plant species, the item consumed, the size of the flock and the time of permanence in the feeding tree. If the flock or part of the flock moved to another tree, I recorded a new Feeding Bout. When I could not identify the tree species during the observations, I collected fruit samples and took pictures for later identification. Also, I recorded

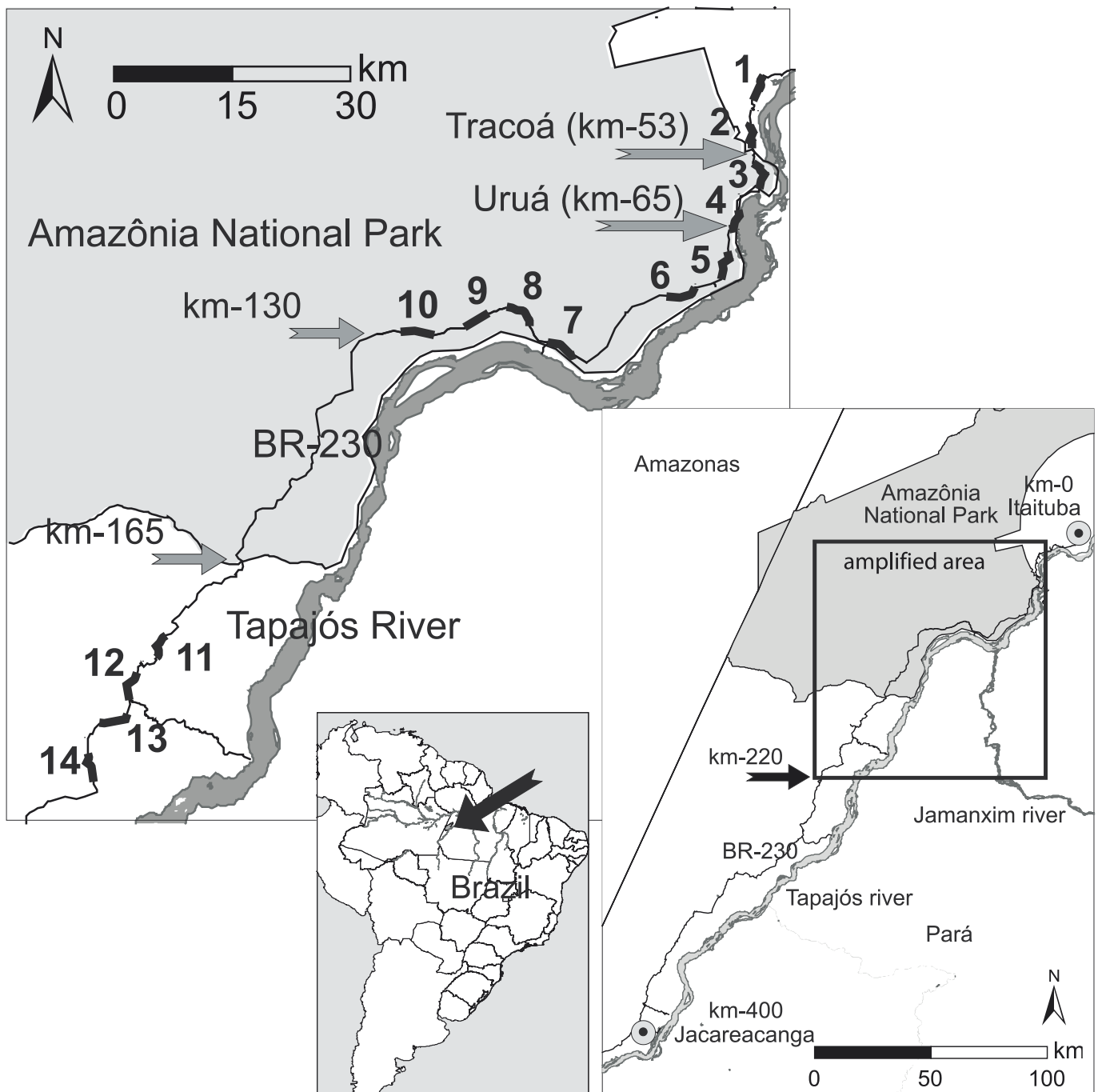


FIGURE 1: Location of Amazônia National Park (lower left) and the 'transamazônica' highway (BR 230), between Itaituba and Jacareacanga, at the left margin of Tapajós river (lower right). The black bulky stretches along the 'transamazônica' show the 4 km transects for population surveys. The arrows indicate the location of visitation and vigilance buildings of the park.

the presence of other parrots or frugivorous birds in the feeding sites.

Description of nest sites

I described nest (and roost) sites in accordance to the terminology of Guedes and Seixas (2002). A roost tree was confirmed as an active nest if one or more individuals remained in the tree while the other members of the flock left to forage. For each nest site found during the observations, I noted the location of the nest tree (using GPS), its condition (alive or dead), the presence of branches and its diameter at the breast height (DBH). I estimated the tree's height and the quantity and height of cavity entrance. I also noted the surrounding vegetation, the distance of the tree from the continuous forest and the subjection to the human disturbance (considering the proximity to the roadway or ranches). All these data were also noted for roost sites.

Population surveys

I conducted population surveys using the line transect method, finding parrots by their calls in the canopy or by seeing them fly across openings (Nunes and Betini 2002). I delineated 14 4 km transects on the 'transamazônica' highway (Figure 1) that allowed good visibility of parrot movements. Transects 1 and 2 crossed large (> 1 km²) altered areas north of the park, including a few disturbed or secondary forest paths. Transects 3 to 10 crossed primary and continuous forest inside the park, including few secondary and disturbed forest paths. Transects 11 to 14 were located in continuous forest and also crossed small (< 0.5 km²) disturbed areas south of the park.

I surveyed two adjacent transects per day between 06:00 and 09:00 by bicycle (which allowed long-distance movements in short periods) at 4 to 6 km/hr; this time interval is the main period of parrot activity (Roth 1984, Gilardi and Munn 1998, Pizo 2002). During these 1 hr surveys, I recorded all individuals seen or heard of any parrot species. To avoid double counting, I ignored birds flying in the same direction I was moving (Nunes and Betini 2002). I surveyed each transect from three to seven times during 2007 (see Results), conducting a total of 62 surveys.

Surveys resulted in an absolute and relative (per hour) number of records related to flocks and individuals for each species. These numbers reflect the conspicuousness of each parrot species (Nunes and Betini 2002), but also provide evidence concerning their relative abundance. Also, the surveys resulted in a presence-absence pattern.

Population estimates

In May 2007, I conducted a survey along a 340 km transect on the 'transamazônica' highway between Itaituba and Jacareacanga (starting at km 50 and ending at km 390 – Figure 1) to obtain information on a larger scale. This survey was conducted by motorcycle at an average speed of 30 km/hr during three days and always between 06:00 and 10:00 or 15:30 and 18:00. Every time a flock was spotted I stopped the motorcycle to annotate the same data as in the flock searches. This resulted in a minimum number of flocks and individuals along the road.

To estimate the size of the Golden Parakeet population in my study area, I summed the total number of individuals counted, either in flocks or alone, when I was confident that they referred to unique individuals or flocks, not counted previously. I mapped all records (from searching and surveys) and, following Tobias and Brightsmith (2007), I considered records more than 10 km apart to refer to different flocks (see Appendix). For records closer than this, when they were simultaneous, or when I found flock's roost or when the flocks' routes or sizes were different, I also counted them as different. This allowed estimates of minimum number of individuals. For example, if I recorded a flock of 12 individuals flying north and 5 min later another flock of eight individuals flying south, they likely represented different flocks for a total of 20 individuals. However, if these flocks were recorded on different days and some distance apart (e.g., 3 km between observations) it is more uncertain if these sightings represent different flocks, and they were counted as just 12 individuals.

RESULTS

Flocking patterns

I obtained 513 records of Golden Parakeets (Figure 2), including individual birds, pairs, and flocks ranging in size from 3 to 40 birds. Flocks averaged 10.2 ± 6.3 (SD) individuals, and flocks with 5, 6 and 7 individuals were the most recorded.

I found 11 roosts (eight of them as active nest, see below) that consisted of four to 20 individuals (average 11.5 ± 5.4 , for the first counting for each roost). In the four monitored roosts, the number of individuals did not vary over consecutive nights, but were reduced in three of them at later periods (see Figure 3). In all countings at dusk ($n = 19$), parakeets arrived in the roost site in a single flock. Before entering in the tree cavity, parakeets spent a variable time in non-social (resting, autopreening, locomotion or vigilance) and social interactions (allopreening, and playing and acrobatics involving usually

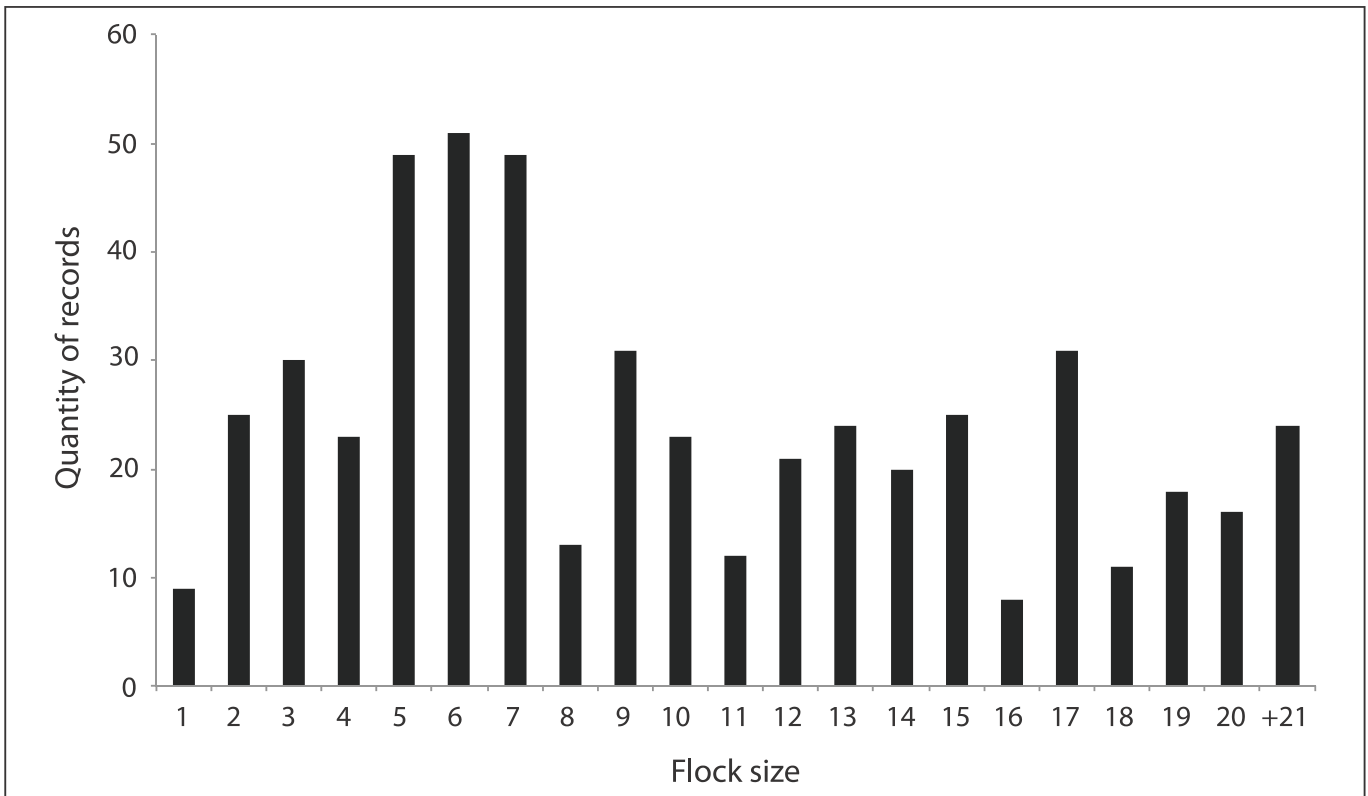


FIGURE 2: Quantity of records of individual birds, pairs and flocks of Golden Parakeet.

more than two individuals). On four occasions I recorded intense vocalization, followed by chasing and expulsion (no physical contacts) from birds sleeping in the roost tree to other Golden Parakeet's flocks that eventually appear in the roost site.

I found one to four first year juveniles (average 1.8 ± 0.9 SD) in flocks over 32 records (Figure 4). In three of these records, there were no first year juveniles in the flock. The first year juveniles represented in average 12.9% of individuals in the flocks.

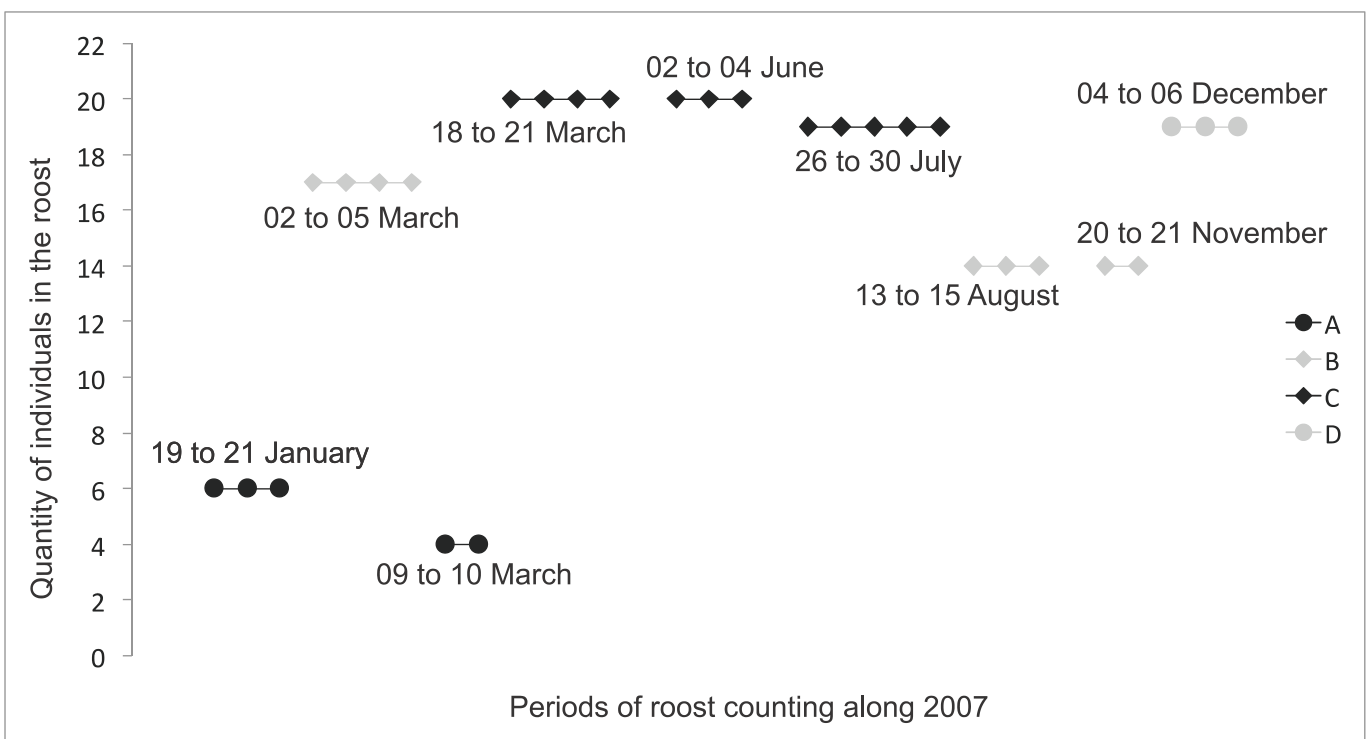


FIGURE 3: Number of individuals in four roosts at different periods. A = “Cocalino village” roost (north outside of the park); B = “km 112” roost (inside the park); C = “km 195” roost (south outside of the park); D = “km 205” roost (south outside of the park).

I found no significant difference in flock size throughout the day ($F = 1.6$, $P = 0.18$, $df = 3$, error $df = 509$ [Figure 5]). Flock size varied among seasons ($F = 6.1$, $P < 0.001$, $df = 3$, error $df = 509$). It was lower (8.9 ± 6 individuals) in the “rainy season” than in the “end of the rainy season” (11.8 ± 7 individuals, pairwise mean difference equal 2.8, $p \leq 0.001$). Other pairwise comparisons of flock size showed no differences.

Diet

I recorded the Golden Parakeet feeding in nine distinct tree species, at 82 events (Table 1). The most records ($n = 47$) were obtained on *Murici trees* (*Byrsonima* spp.) trees. The items consumed by the parakeets include the whole fruit, seeds, pulp, flowers, bud, nectar and the peel. At three feeding bouts, the Golden Parakeet shared the items with different parrots: Scarlet Macaw (*Ara macao*) and Blue-headed Parrot (*Pionus menstruus*). Golden Parakeets did not eat items from the *Morototó* (*Schefflera morototoni* – Araliaceae) and *Bacaba palms* (*Oneocarpus bacaba* – Arecaceae), abundant plants along the ‘transamazônica’ highway, which several other frugivorous birds (e.g., *Aburria jacutinga*, *Cotinga cayana*, *Ramphastos vitellinus* and parrots, including *A. macao*, *P. menstruus* and *Aratinga leucophthalmus*) feed on them.

Nest sites

I could confirm eight of 14 roost trees as active nests. All of them (roost and nest) were near to road or highway, inside open areas, adjacent (< 200 meters) to the continuous forest. In all cases, the trees were part of the remaining standing trees in the area. I identified seven of the trees: four as *Itauba* (*Mezilaurus itatuba* – Lauraceae); one as *Amarelão* (*Aspidosperma vargasii* – Apocynaceae);

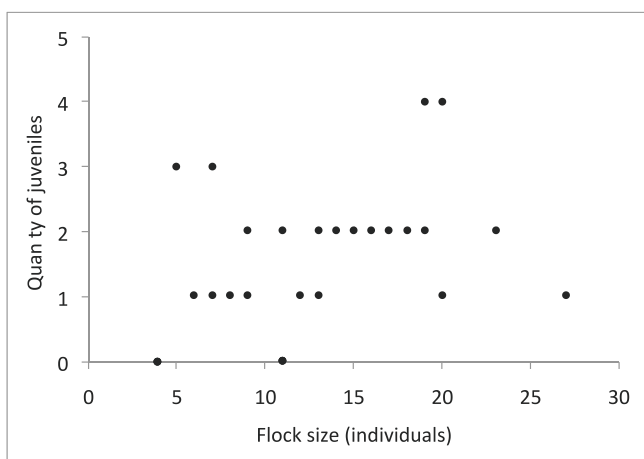


FIGURE 4: Quantity of first year juveniles by flock size of Golden Parakeet, considering 32 records.

other as *Ipê-Branco* (*Tabebuia roseoalba* – Bignoniaceae); and another as *Muiricatiara* (*Astronium lecointei* – Anacardiaceae). The most (seven) roost/nest tree were dead or leafless and their structural characteristics were very variable (Table 2).

Relative abundance

I identified 16 species of parrots during the transect surveys, totaling 650 records (Table 3). The Golden Parakeet was the 6th most common species recorded, with 0.65 flocks/h (40 records) or 5.1 individuals/hr (316 records) and was present along 11 of the 14 transects (Table 4).

Estimated population size

In the highway survey, I recorded eight flocks and 107 individuals. I located five flocks between km 190 and km 204, two flocks around km 240 and another at km 325. Summing to the other records, I counted a total of 46 independent flocks representing 484 individuals, along 20 stretches on the ‘transamazônica’ highway (see Appendix), including 138 individuals in 11 different roosts.

DISCUSSION

Flocking patterns

Flock size data and roost observations confirm that Golden Parakeets are one of the most gregarious neotropical parrots (see Oren and Novaes 1986, Sick 1997,

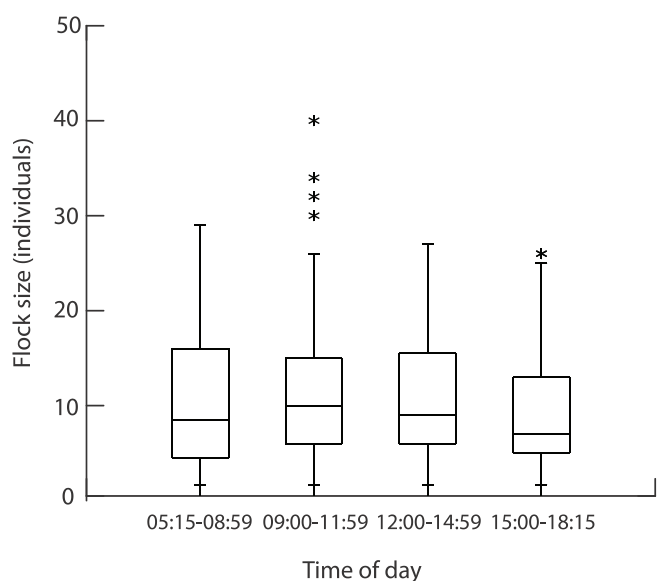


FIGURE 5: Variation on flock size of Golden Parakeet over time periods.

TABLE 1: Items of plant species consumed by Golden Parakeets in western Pará, along 2007.

Item	Species	Family	Months	Records	Flock size
Seed/pulp	<i>Byrsonima</i> sp. 1	Malpighiaceae	05-07	28	6-38
Seed	<i>Byrsonima</i> sp. 2	Malpighiaceae	02-06	19	5-19
Entire fruit	<i>Miconia</i> sp.	Melastomataceae	11	15	6-17
Fruit (peel?)	<i>Tapirira guianensis</i>	Anacardiaceae	11-02	15	4-17
Entire fruit	Undentified ssp. 1	Myrtaceae	07	1	15
Flower/nectar	Undentified ssp. 2	Fabaceae	08	1	9
Flower/bud	Undentified ssp. 3	Fabaceae	12	1	11
Flower/nectar	<i>Hymenaea</i> sp.	Leguminosae	11	1	11
Seed	<i>Pouteria</i> sp.	Sapotaceae	03	1	25
Total				82	4-38

TABLE 2: Average, standard deviation, maximum and minimum values for each characteristic of Golden Parakeet's nest tree in western Pará.

Parameter	Average	Standard deviation	Maximum	Minimum
Tree height	24	6	36	16
Diameter at breast height	1	0.3	1.5	0.5
Quantity of cavity entrances	2	1	6	1
Height of the 1 st cavity entrance	17	5	26	8
Distance to the forest	76	55	200	20

Gilardi and Munn 1998, Pizo 2002) and reinforce the idea flocks are family groups (Oren and Novaes 1986, Reynolds 2003), as do most parrot species (Gilardi and Munn 1998, Pizo 2002). I recorded more flocks with 5, 6 or 7 individuals, which may be explained by the formation of single family groups (with a pair and offspring [Pizo 2002]) provided by a high and variable clutch and brood size (from 2 to 9 [Oren and Novaes 1986]). The limited and invariable quantity of parakeets in a single roost/nest tree (< 20) and their behavior (getting in the roost in a single flock and aggressive reaction to the presence of a second Golden Parakeet flock) are not expected for parrots in roosting sites (see below), suggesting that even big flocks are formed by related individuals. Roosting sites of other parrot species congregate a variable number of different pairs or family groups (see Wermundsen 1999, Pizo 2002, Harms and Eberhard 2003, Cougill and Marsden 2004, Matuzak and Brightsmith 2007). Thus, once the quantity of first year juveniles in the flocks was never more than four, these big family flocks may be formed by multiple related pairs or non-reproductive juveniles from different generations, reinforcing the idea that Golden Parakeet flocks are clans (Reynolds 2003).

The estimate of reproductive output from the proportion of first year juveniles in the flocks during the post-reproductive period in 2007 (around 13%) is within the range of estimates found for other parrots, from 3% to 40% in different scenarios with human disturbance (Navarro *et al.* 1992, Martuscelli 1995, Vaughan *et al.* 2005, Matuzak and Brightsmith 2007, Renton and Brightsmith 2009). In eastern Pará, where trapping

for illegal pet trade occurs (Kyle 2005, Siveira and Belmonte 2005), recent observations found no first year juveniles in the Golden Parakeet flocks (Reynolds 2003), suggesting a limited reproductive output in that region. In my study area, the reproductive output seems to be normal.

There was no circadian pattern of flocking by Golden Parakeets. Flocks of almost all sizes were found throughout the day. Golden Parakeets do not sleep in large collective or multispecies roosts, which is one of the main reasons for flock variation among parrots (Chapman *et al.* 1989, Gilardi e Munn 1998, Rocha *et al.* 1998).

The magnitude of changes in flock size between seasons was minimal. This small difference (lower in the "rainy season" than in the "end of rainy season") can be explained by the recruitment of nestlings after the reproduction period (Pizo 2002, Matuzak and Brightsmith 2007) that is in the "end of rainy season" from April to July (Oren and Novaes 1986, Laranjeiras 2008a). The species remains in large flocks throughout the whole year – including the breeding season – confirming previous observations (Oren and Novaes 1986).

Diet

The diet of Golden Parakeets is varied, but some plant species seems to be more important and the parakeets do not eat any fruit. The most plant species recorded was not known previously (Sick 1997, Oren and Novaes 1986, Juniper and Parr 1998). My most feeding bouts were in the *Murici* (*Byrsonima* spp.) trees (from February to July, overlapping to reproductive and post-reproductive period), reinforcing that these plants, despite be abundant along the 'transamazônica' highway, are important in the Golden Parakeet's diet in the region (Kyle 2005). On the other hand, I did not record the Golden Parakeet feeding in other abundant plant species that were used by other parrots and frugivorous birds. For other localities, other plant species have been reported as important resources, such as *Croton matourensis* (Reynolds 2003) and *Euterpe* sp. (Sick 1997). The feeding diet

TABLE 3: Results of transect surveys of parrots in western Pará during 2007.

Species	Flocks/hour (total records)	Individuals/hour (total records)	Average size of flocks
Blue-headed Parrot (<i>Pionus menstruus</i>)	1.77 (110)	10.24 (635)	5.8
Orange-winged Parrot (<i>Amazona amazonica</i>)	1.52 (94)	6.00 (372)	3.9
Golden-winged Parakeet (<i>Brotogeris chrysoptera</i>)	1.44 (89)	5.45 (338)	3.8
White-eyed Parakeet (<i>Aratinga leucophthalma</i>)	1.26 (78)	11.31 (701)	8.9
Scarlet Macaw (<i>Ara macao</i>)	0.89 (55)	2.19 (136)	2.4
Golden Parakeet (<i>Guaruba guarouba</i>)	0.65 (40)	5.10 (316)	7.9*
Red-billed Macaw (<i>Orthopsittaca manilata</i>)	0.65 (40)	3.90 (242)	6.1
Mealy Parrot (<i>Amazona farinosa</i>)	0.52 (32)	1.55 (96)	3
Crimson-bellied Parakeet (<i>Pyrrhura perlata</i>)	0.48 (30)	2.06 (128)	4.3
Red-and-green Macaw (<i>Ara chloropterus</i>)	0.29 (18)	0.63 (39)	2.2
Red-fan Parrot (<i>Deroptryus accipitrinus</i>)	0.26 (16)	0.74 (46)	2.8
Yellow-crowned Parrot (<i>Amazona ochrocephala</i>)	0.26 (16)	0.68 (42)	2.6
Vulturine Parrot (<i>Pyrilia vulturina</i>)	0.23 (14)	0.42 (26)	1.8
Canary-winged Parrot (<i>Brotogeris versicolorus</i>)	0.10 (6)	0.94 (58)	9.6
Chestnut-fronted Macaw (<i>Ara severus</i>)	0.10 (6)	0.27 (17)	2.8
Blue-and-yellow Macaw (<i>Ara ararauna</i>)	0.10 (6)	0.23 (14)	2.3
Total	10.48 (650)	51.71 (3206)	

* Only for records during the transect surveys.

TABLE 4: Detection frequency of Golden Parakeet on all transects along 'transamazônica' highway (BR 230). 1 = present, 0 = absent

Transects	Surveys						
	Jan	Mar	May	Jun	Jul	Aug	Nov
1 (km 40-44)	—	—	0	—	0	—	0
2 (km 48-52)	0	0	0	—	0	—	1
3 (km 54-58)	1	—	0	0	0	0	0
4 (km 62-66)	—	0	0	1	0	0	0
5 (km 68-72)	0	0	0	0	1	0	0
6 (km 76-80)	—	—	1	1	0	1	1
7 (km 96-100)	—	—	0	—	0	—	0
8 (km 104-108)	—	—	0	—	1	—	0
9 (km 110-114)	—	—	0	—	1	—	1
10 (km 118-122)	—	—	0	—	0	—	0
11 (km 182-186)	—	—	0	—	0	—	1
12 (km 190-194)	—	1	0	—	0	—	1
13 (km 196-200)	—	1	1	1	1	1	1
14 (km 204-208)	—	—	0	1	0	0	0

of the species is not vulnerability, but these important plant species deserve attention in management of protected areas that shelter Golden Parakeets.

Nest sites and vulnerability

Despite the difficulty of finding nests inside the forest, my observations reinforce the idea that flocks seem to prefer isolated dead trees in open areas for nest, which has been linked to avoiding nest predation (Oren and Novaes 1986, Reynolds 2003, Silveira and Belmonte 2005). Parakeets may be attracted to these sites because the initial protection against forest predators, but nest trees in these sites are more exposed to natural (wind) and human

(burning, overthrowing or nest poaching) disturbance (see Silveira and Belmonte 2005, Laranjeiras 2008b). As the species is absent in advanced altered areas (such as pastures along transect 1 [see Table 4]), these nesting sites, instead of being a source for the population, are a sink. Nests in continuous forest remain to be discovered, but to investigate how long parakeets persist in these areas will be useful for understanding the vulnerability of the species; these sites, even human-made and with deteriorated biological importance, should be specifically managed and safeguarded in protected areas.

Contrary to expectations, the plant species and the structure of the nest tree were not restricted (see Table 2). The Angelim tree (*Dinizia excelsa* Leg. Mimosoideae) is reported as fundamental source for nest tree for Golden Parakeets and the cavity entrance are reported to be in elevated position (Oren and Novaes 1986, Silveira and Belmonte 2005). Although the most nest trees in my study were dead, the plant species and structure seem not be a vulnerability.

Relative abundance

In contrast to earlier reports (Collar 1997, Juniper and Parr 1998, BirdLife International 2010), my data suggests that Golden Parakeets do not seem to be rare, at least in western Pará. I recorded this species as much as I recorded other non-threatened parrots, suggesting similar abundances. Golden Parakeets may be more common than expected, even in other areas such as Tucuruí and Caxiuanã National Forest where the species has been found frequently (Cestari and Dantas 2008, R. M. Valente *in litt.* 2006).

Nomadism and seasonal displacement

The repeated presence of Golden Parakeet along some transects (see Table 4) and the feeding bouts (see Table 1) suggest that species keeps in the region along the year, contrary to expectations. In some stretches of the road, I found breeding and feeding sites, where in the flock searches I recorded the species during several periods of the day and in all seasons; I recorded the species feeding in almost all months and different items were consumed in different periods. The suspected nomadism and seasonal disappearing of flocks (BirdLife International 2010) may be factual for fragmented and intensely deforested landscapes of eastern Pará and Maranhão (Oren and Noaves 1986, Silveira and Belmonte 2005). At all, as the diet of Golden Parakeets seems to vary throughout the year, the continuous presence of flocks in the study region reinforces the importance of western Pará as a refuge for Golden Parakeets (Laranjeiras and Cohn-Haft 2009).

Estimated population size

The highway survey indicated that Golden Parakeets were present for the entire left margin of Tapajós River alongside the 'transamazônica' highway. I confirmed the species presence for several other stretches in addition to those from transects surveys. Also, some flocks (recorded in the transects surveys and flock searches) were not detected, which suggest the presence of other unrecorded flocks in the region.

My estimate of the size of the Golden Parakeet population in my study area (about 500 individuals) is conservative, representing the minimal number present in this pristine portion of its geographic range. This also represents the largest known population of Golden Parakeet. If the current global estimate (BirdLife International 2010) is correct, western Pará shelter 40-20% of it in just a strip of 340 km along 'transamazônica' highway.

Inferring global population size

The current estimate of global population size for Golden Parakeets (< 2500) is provided by an indirect and out-of-date data (see BirdLife International 2010) and seems to be underestimated. A new estimative is necessary considering: (i) the species has been recorded in several additional localities and the current distribution encompasses 340.000 km² (174.000 km² considering only the area that covers adequate habitat [see Laranjeiras and Cohn-Haft 2009]); (ii) the most part of the current area of occurrence is not so fragmented and is under protection, such as western and central Pará and southwestern Amazonas (see de Luca *et al.* 2009); (iii) the species seems not to be nomadic in preserved landscapes (see above);

and (iv) it is weakly probable that 40-20% of the global population would be in just a strip of 340 km along the 'transamazônica' highway, which crosses no more than 5% of the total area of occurrence (see below). Better data are available and a better estimative may be done.

A minimum population size of each current (post-1987) and known locality with Golden Parakeets results in a similar number to this previous estimative. There are 60 localities, with adequate and preserved habitat, where biologist (30 localities) or local people (also 30) have observed the species (see Laranjeiras and Cohn-Haft 2009). At least one flock must survive in each site and the flock size averages 10 individuals; usually each locality refer to more than one flock (up four, considering my data; see also Kyle 2005, Silveira and Belmonte 2005, Cestari and Dantas 2008), as it is for other threatened parrots (*e.g.*, Tobias and Brightsmith 2007). Thus, a minimum population size may be around 1080-2880 individuals (about 480 in my study area). This is a minimum population size and is consequently very conservative, because the most part of the area of occurrence and potential distribution of the species has not been inventoried satisfactorily, if inventoried (see Laranjeiras and Cohn-Haft 2009, Aleixo 2009, de Luca *et al.* 2009), suggesting unknown population. Also, surveys in adjacent areas of records of Golden Parakeet have revealed its continuous presence, diminishing lacunas. For example, just few groups of Golden Parakeets were known to inhabit the area of my study (see Oren and Parker III 1997), but with more surveys, more and more groups have been detected (see Kyle 2005, this study).

Although my study was not focused on generating density estimates, a conservative way to extract one is joining all localities of observations into a local area of occurrence. My observations were restricted to a strip of 340 km of the 'transamazônica' highway, where the most part of the forest around the road is continuous and functionally intact. Considering 10 km for each side of the road, there is an area of 6.800 km², with about 480 Golden Parakeets, generating a density estimate of one individual for each 14 km². Not considering first-year juveniles (13%), the estimate is 1 individual for each 16 km². This estimate is conservative (much lower than that used in the previous estimate of global population size of Golden Parakeets [0,9-2,5 ind/km², see BirdLife International 2010]) because it is not possible to know if all flocks in this area were recorded. Extrapolating this density estimate to the current area of occurrence that cover adequate habitat (174.000 km²), the population estimate ranges around 10.875 individuals.

Final recommendations for conservation

My study brings new information for conservation of Golden Parakeets. The region of the Tapajós River

not only represents the most pristine area within the geographic distribution of this species (Laranjeiras and Cohn-Haft 2009), but it also seems to currently shelter its largest known population, that keep in the region throughout the year. Based on my data and recent records of the species, its global population is larger than previously estimated and, as population size is one of the main criteria for conservation status evaluation (IUCN 2001), its level of endangerment in the red lists should be re-examined. The presence of the species in remnant-protected areas in eastern Pará and Maranhão may be used in their conservation strategies (Laranjeiras and Cohn-Haft 2009), but implementation of protection in the Tapajós River region (e.g., Amazônia and Jamanxim National Parks, Amaná, Tapajós and Itaituba National Forests) should help to insure the perpetuation of a healthy, wild population. The long-term survival of Golden Parakeets is jeopardized, but now there are more reliable data to be used for their protection and conservation, in a cost-effective sense.

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APPENDIX

Details of observations of Golden Parakeets on 20 stretches of the 'transamazônica' highway between Itaituba (km 0) and Jacareacanga (km 400).

1. Around **km 48**. (Cocalino Village). Simultaneous records of two flocks indicated at least 12 (4+8) individuals in this site (with one roost). Other 10 records may refer to the same birds.
2. Around **km 58**. Simultaneous records of two flocks indicated at least 24 (6+18) individuals in this section of the road. Other 14 records around this place may refer to the same parakeets.
3. Around **km 68**. Simultaneous observation of three flocks that grouped in the moment evidenced at least 41 (10+13+19) individuals in a feeding area. Other 176 records around this site may refer to the same parakeets.
4. Around **km 80**. Simultaneous observation of three flocks that grouped in the moment indicated 34 (7+11+16) individuals in this site. Other eight records may refer to the same parakeets.
5. Around **km 95**. Subsequent records of five flocks in a single day indicated 53 (3+9+11+15+15) individuals in around this section. Other four records may refer to the same parakeets.
6. Around **km 115**. A roost with 17 individuals and other potential roost with 6 individuals totalized 23 individuals in this section. Other 80 records during focal observations probably refer to the same birds.
7. Around **km 125**. Two subsequent records indicated 22 (12+10) individuals around this site of the road. Other two records may refer to the same parakeets.
8. Around **km 140**. Three subsequent records indicated 21 (7+14) around this site of the road. Other two records may refer to the same parakeets.
9. Around **km 150**. Subsequent observations of two flocks indicated 11 individuals (6+5) around this site. Another record may refer to the same birds.
10. Around **km 162**. Two records in different days indicated at least 12 individuals in this site.
11. Around **km 185**. Subsequent observations of three flocks indicated 19 (4+7+8) individuals around this site. Other three records may refer to the same birds.
12. Around **km 195**. Five roosts around this site totalized 64 (19+19+14+6+6) individuals. Other 142 records probably refer to the parakeets from these roosts.
13. Around **km 205**. Two roosts totalized 34 (19+15) individuals around this site. Other 43 records may refer to parakeets from these roosts.
14. Around **km 240**. Subsequent records of two flocks indicated 18 (14+4) individuals around this section of the road.
15. Around **km 260**. A single record of a flock with 15 individuals in this site.
16. Around **km 300**. A single record of a flock with 11 individuals in this site.
17. Around **km 312**. A single record of a flock with 8 individuals in this site.
18. Around **km 325**. Two subsequent records of different flocks with 18 and 15 individuals indicated at least 33 individuals around this site.
19. Around **km 345**. A single record of a flock with seven individuals.
20. Around **km 360**. Simultaneous records of two flocks with 11 individuals each one indicated 22 individuals around this site.