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TEMPORAL VARIATION IN ROOST USE BY THE ENDANGERED VINACEOUS-BREASTED PARROT (*AMAZONA VINACEA*) IN SOUTHERN BRAZIL

Viviane Zulian[1*] · Andressa S. Volinski[2*] · Maria Virginia Petry[3*] · Eliara Solange Müller[4]

[1] Programa de Pós-Graduação em Ecologia, Instituto de Biociências, Universidade Federal do Rio Grande do Sul, CP 15007, Porto Alegre RS 91501-970, Brazil.

[2] Universidade Regional Integrada do Alto Uruguai e das Missões, URI, Erechim - RS, 99709-910, Brazil.

[3] Universidade do Vale do Rio dos Sinos, São Leopoldo RS 93020-190, Brazil.

[4] Laboratório de Ecologia e Química, Área de Ciências Exatas e Ambientais, Universidade Comunitária da Região de Chapecó, Chapecó SC 33218-000, Brazil.

E-mail: Viviane Zulian · zulian.vi@gmail.com

Abstract ·The endangered Vinaceous-breasted Parrot (*Amazona vinacea*) is endemic to the Atlantic Forest, but only has a few known populations. Western Santa Catarina region, in Brazil, is within the IUCN "Possibly Extant" range for the species, but until 2011 it only had two documented records of the species. By 2017, increased search efforts have identified ten roost-sites of the species in this region. In this study, we aimed to evaluate temporal variation in the number of Vinaceous-breasted Parrots in one roost in western Santa Catarina over three years, and to describe the vegetation characteristics of different locations within the roost. Roost counts were performed at dawn or dusk, with two observers located at different points around the roost. Each observer recorded the number, time, and flight direction of parrots arriving or departing the roost. The highest number of individuals recorded in the roost was 184 parrots in January 2015, but we observed a cyclical variation in the number of parrots using the roost between the years. The highest mean number of parrots at the roost occurred during the non-breeding season —March, January, and May—, while the lowest number of parrots were recorded during the breeding season —September, October, and November. The number of parrots using the roost also varied among years, with greater number of parrots using the roost during the non-breeding seasons of 2014 and 2015. Sites used by parrots within the roost were characterized by tall and sparse trees, predominantly *Araucaria angustifolia*, absence of an understory, and anthropic use. Future surveys for population size and trends assessment should be done during the non-breeding season, when the individuals are aggregate in the collective roosts.

Resumo · Variação temporal no uso do dormitório pelo papagaio-de-peito-roxo (*Amazona vinacea*) no sul do Brasil
O papagaio-de-peito-roxo, *Amazona vinacea*, é uma espécie endêmica da Mata Atlântica, mas com poucas populações conhecidas. A região oeste de Santa Catarina, apesar de estar localizada entre duas grandes manchas de habitat para a espécie, até 2011 contava apenas com dois registros documentados de *A. vinacea*. Com o aumento do esforço de busca pela espécie, até o final de 2017, dez dormitórios foram mapeados. Neste estudo, objetivamos: avaliar a variação no número de indivíduos de papagaio-de-peito-roxo usando um dormitório coletivo no Oeste de Santa Catarina ao longo de três anos; e descrever a vegetação de diferentes locais no dormitório coletivo. Realizamos as contagens no entardecer e/ou amanhecer, com dois observadores localizados em dois pontos no entorno do dormitório. Cada observador registrava o número de indivíduos, a hora e a direção de voo dos papagaios quando chegavam ou saiam do dormitório. O maior número de papagaios registrados em uma contagem foi 184, em janeiro de 2015, mas observamos uma variação cíclica no número de papagaios utilizando o dormitório ao longo de cada ano. Os maiores números de papagaios no dormitório foram registrados durante o período não-reprodutivo, nos meses de janeiro, março e maio, enquanto os menores números de indivíduos foram registrados em setembro, outubro e novembro, durante o período reprodutivo. O número de papagaios utilizando o dormitório variou ente os anos, sendo maior durante o período não reprodutivo de 2014 e 2015. Os sítios utilizados como dormitório são caracterizados por árvores de grande porte e esparsas —especialmente *Araucaria angustifolia*— ausência de subosque e por uso antrópico. Contagens para estimar o tamanho populacional e tendências populacionais para a espécie devem ser realizadas durante o período não-reprodutivo, quando os indivíduos estão agregados no dormitório coletivo.

Key words: *Araucaria angustifolia* · Atlantic Forest · Non-breeding season · Psittacidae · Roost counts

INTRODUCTION

The Vinaceous-breasted Parrot (*Amazona vinacea*) is an endemic species of the Atlantic Forest, inhabiting around 430,000 km^2 in Brazil, Argentina, and Paraguay (Forshaw 2010, Zulian et al. 2021). This species is strongly affected by forest destruction and habitat fragmentation, as well as nest poaching (Collar & Juniper 1992, Wright et al. 2001, BirdLife International 2022), which has caused an apparent decline in its population size (BirdLife International 2022). The species is currently listed as "Endangered" by the International Union for Conservation of Nature (IUCN) (BirdLife International 2022) and is considered a

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high priority for research and conservation (Stotz et al. 1996).

The apparent decline in population size has caused a reduction in the geographic range of the species. The species recently disappeared from east-central Paraguay, southern Misiones, Argentina, and the vicinity of the Parana River (Cockle et al. 2007). Recent global abundance estimates, based on counts performed in 98 sites in Argentina, Brazil, and Paraguay during 2016 and 2017, indicate that the population size of the Vinaceous-breasted Parrot is around 8,000 individuals (Zulian et al. 2020). Brazil accounted for approximately 90% of the Vinaceous-breasted Parrot global population, with the largest parrot groups recorded in the southern states of Rio Grande do Sul, Santa Catarina, and Paraná (Zulian et al. 2020).

The Vinaceous-breasted Parrot has a gregarious behavior and uses communal night-time roosts (Sick 2001). This behavior facilitates counting of individuals in the evening as they arrive at the roost, or in the morning when they depart (Nunes & Betini 2002, Dénes et al. 2018). Thus, roost counts are an efficient and cost-effective method for assessing local population sizes of parrots. Anecdotal reports suggest that characteristics of roost-sites used by Vinaceous-breasted Parrots may vary among populations and regions. There are reports of the species roosting in areas with *Pinus* sp. (Abe 2004, Prestes et al. 2014), *Syagrus romanzoffiana,* and isolated *Araucaria angustifolia* in the middle of grasslands (Cockle et al. 2007), as well as *A. angustifolia* forests (Prestes et al. 2014). The species even uses sites near cities and agricultural areas to roost and forage (Abe 2004, Cockle et al. 2007), showing some plasticity in habitat use.

Western Santa Catarina region, southern Brazil, is within the IUCN "Possibly Extant" range for the Vinaceous-breasted Parrot (Birdlife International 2022). It is located between two large patches of Vinaceous-breasted Parrot habitat: the Atlantic Forest of Misiones, Argentina, to the west, and the *Araucaria* forest of the highlands of Santa Catarina to the east. However, until 2011 there had been only two documented records of the species in western Santa Catarina (Gandolfi & Müller 2006, Azevedo and Ghizoni-JR 2008). By the end of 2017, increased search effort had identified 10 different roost-sites in this region (Zulian et al. 2020). In this study, we focused our attention on one of the known roosts and aimed to: 1) evaluate variations in the number of Vinaceous-breasted Parrots over three years in the communal roost of western Santa Catarina, and 2) describe the vegetation of different sites within the communal roost. Mapping and monitoring this communal roost contributes to the knowledge of the current distribution of the species, as well as our understanding of local seasonal fluctuations in population size and roost use. Understanding this variation will help to determine the best period to conduct population surveys for assessment of population size, reducing the risk of under or overestimation of the population size in future research and monitoring. The description of the vegetation where the parrots roost improves our knowledge of the natural history of the species and contributes information supporting decision-making by environmental agencies regarding licensing for vegetation suppression.

METHODS

Study area. The study was conducted on private properties located around the Floresta Nacional de Chapecó (FLONA) in the municipality of Guatambú in western Santa Catarina state, southern Brazil (27°5'18.42"S, 52°46'50.33"W) (Figure 1). This region has a mesothermal super-humid temperate climate, with annual average temperatures between 10°C and 15°C, well distributed rainfall during the year, a summer season from December to March, and a winter season from June to September (IBGE 2002). The breeding season of the Vinaceous-breasted Parrot starts at the end of winter (August—September) and extends until the end of spring (December). The study area consists of a transition zone between *Araucaria* forest and seasonal deciduous forest (Klein 1978).

Parrot roost surveys. The number of parrots in the roost was monitored through counts from two observation points located near the roosting area (Figure 1). The two points were chosen because of their visibility considering the flight routes of the parrots. Two observers —one at each observation point— performed counts simultaneously. The time, number of individuals, and flight direction of arrival or departure from the roost were recorded for each parrot. We performed between 1 and 14 counts per month, completing 250 counts in total between November 2011 and March 2015, except for June 2014, when counts were not performed. Counts were performed at dawn, starting 30 minutes before sunrise, or at dusk, 90 minutes before sunset, and lasted until no activity was detected for 20 minutes. During the first six months of the study, we performed 13 paired counts in the afternoon and in the consecutive morning to evaluate if the two counts differed. After each counting session, the two observers compared their records to determine the minimum number of parrots counted in the session. The comparison between the counts was done to reduce the possibility of double counting, considering that sometimes both observers counted the same parrot flock. We determined the minimum number of parrots using the roost in each count session based on information on the time, flight direction, number of parrots in each flock recorded by each observer, and the difference between the number of parrots recorded arriving and leaving the roost (Zulian et al. 2020). Statistical analyses were conducted using the minimum number of parrots recorded in each count session performed either in the dusk and in the dawn.

Vegetation surveys. Five sites, less than 1,500 meters apart, were used by Vinaceous-breasted Parrots within the roost area (Figure 1). We described vegetation at each site by phytosociological surveys in a number of small plots (Durigan 2009) to provide an overview of species composition, tree height, and basal area at parrot roost-sites. We established 10 x 10 m survey plots, distributed around the center of each site, with a variable number of two to five plots depending on the heterogeneity of the site. For example, in site 1, which was composed by cropland and sparse *A. angustifolia* and had little variability in richness, we sampled only two plots. In total, we sampled 18 plots over the five sites used by parrots. We measured the circumference at the breast height (CBH) of all trees with CBH >12 cm. Using the CBH, we

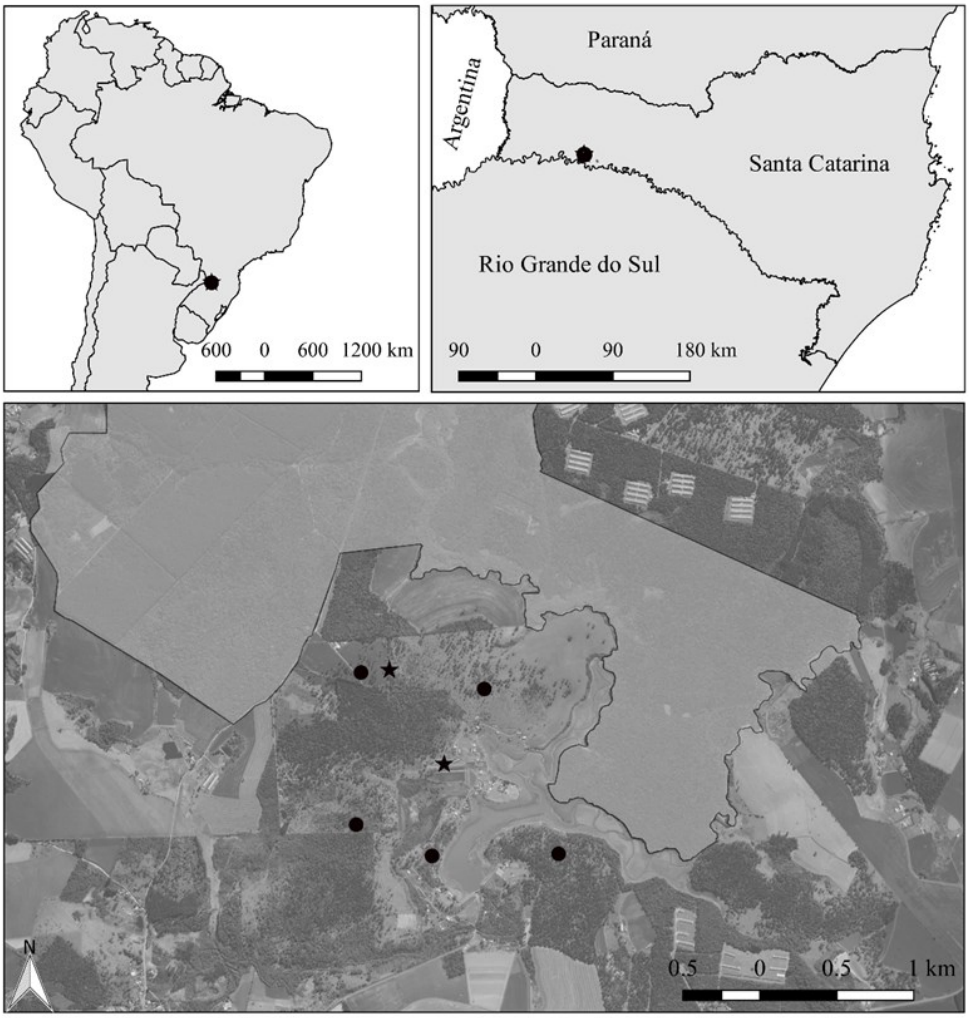

Figure 1. Roosting area of the Vinaceous-breasted Parrot (*Amazona vinacea*) in western Santa Catarina, Brazil. Stars denote counting points, dots indicate sites used by the the Vinaceous-breasted Parrot to roost. The area inside the gray polygon is the Floresta Nacional de Chapecó conservation area.

calculated the diameter at breast height (DBH) and the basal area (BA) of each tree as:

$$BA = \pi\left(\frac{DBH}{2}\right)^2$$

We addressed the total BA for each sampling plot and then calculated the mean BA among the sampling plots from each site. The height of each tree was estimated by comparison to a pole of known height. For trees with more than one trunk, DBH and BA were calculated for each trunk separately and summed (Durigan 2009). We described the roost sites based on the information about the species richness and abundance, as well as the mean BA and height of trees in each site. Nine of the 13 plant species encountered were identified to species. Dried specimens were kept in the herbarium of the Universidade Comunitária da Região de Chapecó (Unochapecó). To describe vertical vegetation structure and draw the vegetation profiles, we recorded all the vegetation present within a 10 x 30 m plot at each of the five roost-sites (Martinez et al. 2008, Durigan 2009).

Data analysis. A Shapiro-Wilk normality test confirmed that data on the minimum number of parrots recorded per count session did not conform to a normal distribution ($P < 0.0001$). To evaluate if the counts performed at dusk differed from the counts performed at dawn of the next day, we used a Wilcoxon paired test. To determine whether counts differed among survey months we performed a Kruskal-Wallis test using each month as a factor and counts in each month as sampling units. To evaluate seasonal variation in roost use between the breeding (August–December) and non-breeding (January–July) seasons, we applied a Wilcoxon test using each count session as a sampling unit. We also applied Kruskal-Wallis tests to compare the minimum number of parrots recorded in count sessions for different seasons and years. We assumed a $P < 0.05$ as statistically significant. Analyses were performed using the software RStudio 1.1.4 (RStudio Team 2016).

RESULTS

Temporal variation in roost use. We found a significant difference between months in the number of parrots using the roost (Kruskal-Wallis $\chi 2 = 170.86$, df = 39, $P < 0.0001$). Greater numbers of parrots were recorded in roost counts during the non-breeding season of 2014, particularly in the months of March (mean: 142 ± 12), April (mean: 133 ± 14), and May (mean: 140 ± 21) (Figures 2 and 3). The greatest minimum number of parrots counted in a single count session was 184 parrots in January 2015, followed by 161 parrots in March 2012, January 2014, and May 2014. Fewest parrots were recorded in the months of October 2014 (mean: 2 ± 2), followed by November 2011 (mean: 3 ± 2)

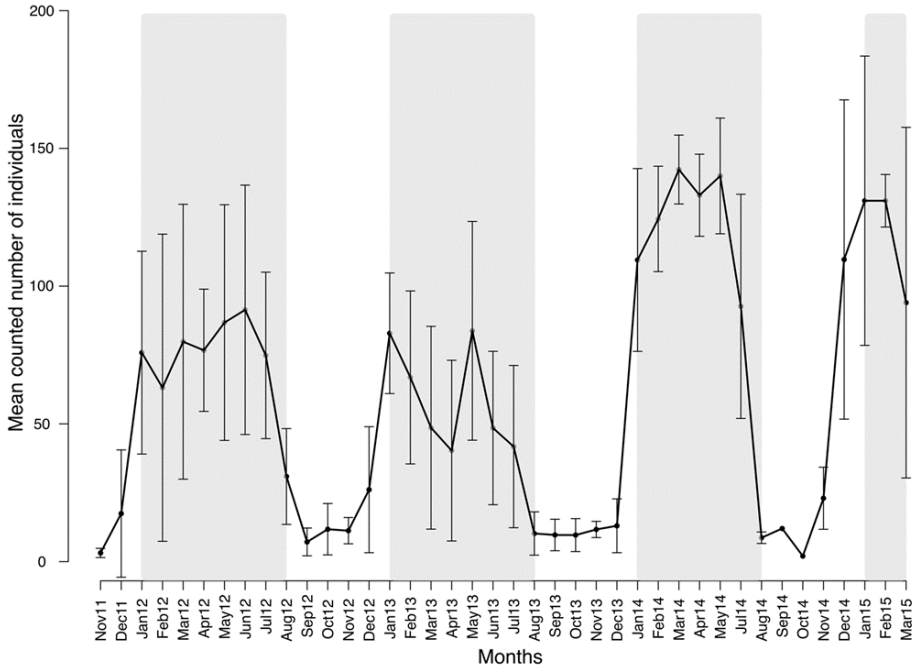

Figure 2. Mean monthly number of Vinaceous-breasted Parrots recorded during roost surveys from November 2011 to March 2015 in western Santa Catarina, Brazil. Vertical bars represent the standard deviation. See text for number of counts per month. Shaded rectangles indicate the non-breeding season months.

and September 2012 (mean: 7 ± 5), and on four occasions no parrots were recorded in the count sessions (November and December 2011, and two counts in April 2013).

This cyclical pattern of increase and decrease in numbers of parrots using the roost throughout the year reflected a significant seasonal variation in roost use by parrots (W = 1670, df = 1, $P < 0.0001$). More parrots were recorded in the non-breeding season months of January to July (Figure 2), with a mean of 80 ± 26 parrots per count session, compared to a mean of 12 ± 18 parrots per count session in the breeding season. Seasons also differed between years. The non-breeding seasons of 2014 and 2015 recorded significantly more parrots using the roost (Kruskal-Wallis $\chi 2 = 139.31$, df = 7, $P < 0.0001$, mean of 124 ± 27 parrots in 2014. and mean of 120 ± 44 parrots in 2015; Figure 3). On the other hand, the fewest parrots were recorded in the breeding seasons of 2011 (mean: 12 ± 13) and 2013 (mean: 12 ± 18; Figure 3). The mean number of parrots using the roost was lower during the non-breeding season of 2013 when compared with the same period in the other years (Figures 2 and 3). Finally, we found no significant difference between counts conducted at dusk and at next day's dawn (V = 37.5, P = 0.59).

Characterization of roost areas. The sites used by the Vinaceous-breasted Parrot to roost in western Santa Catarina were characterized by tall and sparse trees, with few plant species present (Table 1). Among tree species, parrots always used *A. angustifolia* trees for roosting. The number of plant species recorded in each site varied between three (in sites S1 and S3) and 10 (S5) (Table 1). Sites S1 and S2 have sparse *A. angustifolia* among grasslands and croplands, where corn (*Zea mays* L.), soybean (*Glycine max* L. Merrill), and beans (*Phaseolus vulgaris* L.) are cultivated. The understory is totally absent in these two sites (Supplementary Figures A and B). These sites also had the greatest average DBH (S1: 0.54 ± 0.12 m; S2: 0.32 ± 0.20 m; Table 1). Sites S3 and S4 were composed predominantly of grasses and shrubs, with the presence of livestock and understory regeneration (Supplementary Figures C and D). Site S5 was characterized by the sporadic presence of cattle and sheep, resulting in the removal of understory. In addition, areas nearby Site S5 that are associated with the Guatambú dam on the Tigre River are used for camping, with cabins and frequent movement of people and vehicles (Supplementary Figure E). The five areas used as roost by the parrots have been altered due to human activities.

DISCUSSION

The Vinaceous-breasted Parrot was faithful to the roost area over the years of the study, returning to roost-sites after the breeding season. The Vinaceous-breasted Parrot showed the same pattern of congregating in large flocks during the non-breeding season, and presenting small, dispersed family groups in the breeding season as has been observed for other *Amazona* parrots (Alonso 2001, Cougill & Marsden 2004, Berg & Angel 2006, Martinez & Prestes 2008, Moura et al. 2010). The months with the lowest averages (August–December) corresponded to the breeding season, when most of the population is dispersed for nesting. Season is one of the main factors influencing variation in the number of Vinaceous-breasted Parrot using the roost area. The behavior of leaving the roost area during reproduction has been described in other studies of Vinaceous-breasted Parrot (Abe 2004, Prestes et al. 2014), and in other *Amazona* parrot species (Alonso 2001, Sipinski 2003, Scherer-Neto & Toledo 2007, Martinez & Prestes 2008, Moura et al. 2010).

Given that fewer parrots congregate in the roost during the breeding season, it is possible that reproductive parrots remain close to their nesting sites throughout the breeding

Table 1. Mean ± standard deviation of vegetation characteristics of the five sites within the roosting area of Vinaceous-breasted Parrots (*Amazona vinacea*) in western Santa Catarina, Brazil. Total and mean number of species in the sampled sites. Means calculated from variable number of survey plots at each site (see text).

	Sites				
	S1	**S2**	**S3**	**S4**	**S5**
Total N species	3	4	3	5	10
Mean N species	2 ± 0	2.8 ± 0.8	2.6 ± 0.6	3.3 ± 1.15	3.8 ± 1.5
Total abundance	6	35	24	32	31
Mean abundance	3 ± 0	7 ±2.7	8 ± 1	10.7 ± 3.8	6.2 ± 3.7
Mean DBH (m)	0.54 ± 0.12	0.32 ± 0.20	0.24 ±0.19	0.25 ± 0.17	0.29 ± 0.20
Mean height (m)	12.8 ± 3.4	8.4 ± 5.4	6.3 ± 4.1	9 ± 6.9	10.4 ± 5
Mean basal area (m^2)	0.71 ± 0.1	0.74 ± 0.2	0.6 ± 0.08	0.7 ± 0.33	0.6 ± 0.25

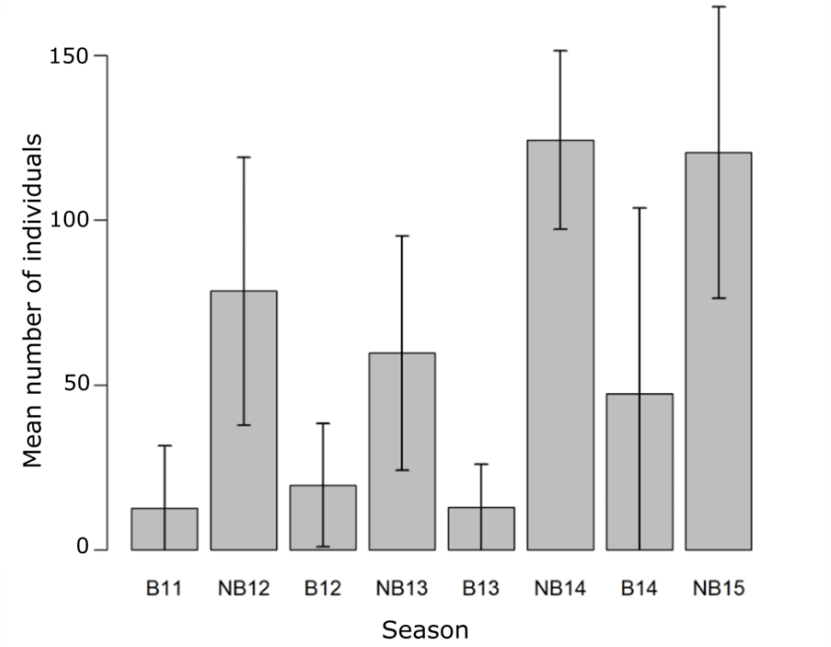

Figure 3. Mean number of Vinaceous-breasted Parrots recorded in roost surveys during the breeding (B) and non-breeding (NB) seasons from 2011 to 2015 in western Santa Catarina, Brazil.

season and only immature and unpaired individuals use the roost during this time. The behavior of remaining close to the nesting sites during reproduction has been observed in the Red-tailed Parrot (*A. brasiliensis*; Martuscelli 1995), the Orange-winged Parrot (*A. amazonica;* Moura et al. 2010), and the Tucuman Amazon (*A. tucumana*; Rivera et al. 2012), but not in the Red-spectacled Parrot (*A. pretrei*; Martinez & Prestes 2008), and in the Red-lored Amazon *A. autumnalis* (Berg & Angel 2006). For the latter two species, even though the number of individuals decreases in the roost during the breeding season, males continue to use the roost area, along with the non-breeding and young individuals (Martinez & Prestes 2008, Berg & Angel 2006).

The number of individuals using the roost between March and April in 2013 was low when compared to the same period in 2012, 2014, and 2015. Seeds of the *A. angustifolia* tree mature in March and are an important food resource for the Vinaceous-breasted Parrot (Prestes et al. 2014, Tella et al. 2016). The lower number of parrots counted during this period of 2013 may be related to a lower availability of *A. angustifolia* seeds, which was observed by the authors during the field work and was also reported by locals who collect the seeds for their own consumption. Seasonal variation in movements by the Vinaceous-breasted Parrot are not well known, but they are likely influenced by food availability (Straube et al. 2004, Forshaw 2010). Prestes et al. (2014) showed that a group of Vinaceous-breasted Parrots changed the roost site and had a daily movement of 17 km to feed on the abundant seeds of *Podocarpus lambertii* in eastern Santa Catarina, Brazil. This nomadic behavior of searching for food has been observed for the Red-spectacled Parrot, which migrates to the southeastern Santa Catarina during the seed maturation period of *A. angustifolia* (Martinez & Prestes 2008). Low food availability can also cause a central roost to break into several peripheral roosts (Carrara et al. 2007), decreasing the number of individuals in an area (Seixas 2009) and influencing the choice of roost-site (Martinez & Prestes 2008). Considering this nomadic behavior of the Vinaceous-breasted Parrot, one should not interpret the increase or decrease in the mean number of individ-

uals using this roost between years as a change in the population size of the species.

Although Abe (2004) reported the Vinaceous-breasted Parrot using a homogeneous *Pinus* sp. as roost site, we did not observe the species using *Pinus* sp. or *Eucalyptus* sp. plantations (exotic species) in the present study, even though they were present near the roost area. Prestes et al. (2014) found the species to use mainly forest environments with *A. angustifolia* as a roost site. We also observed that the Vinaceous-breasted Parrot used sparse *A. angustifolia* trees to roost. Similar roost sites were recorded by Cockle et al. (2007), who noted that *Syagrus romanzoffiana* in pastures and *A. angustifolia* among scattered crops could be used as roost by the Vinaceous-breasted Parrot. The use of homogeneous plantations, mainly of *Pinus* sp. and *Eucalyptus* sp., has been reported for some *Amazona* parrot species (Martinez & Prestes 2008, Carrara et al. 2010, Prestes et al. 2014). These environments may provide protection for parrots as camouflage (Carrara et al. 2007). The absence of an understory appears to be an additional condition in the choice of suitable roosting sites for *Amazona* species (Carrara et al. 2010).

The area chosen by the Vinaceous-breasted Parrot as a roost, due to the characterization performed in this study, needs to have tall trees (preferably *A. angustifolia*), sparse vegetation, and the absence of an understory. Despite the collective roost being in altered areas, it is located on the margins of the Floresta Nacional de Chapecó (FLONA Chapecó), a conservation area with 1,287 hectares. The parrot population was observed using this conservation area possibly only for food and reproduction, as reported by Marsden et al. (2000), who observed parrots (*Amazona* sp.) visiting a conservation area during the day in search of food while roosting in smaller fragments in surrounding areas. During our field observations, we noticed that the vegetation at the Floresta Nacional de Chapecó is substantially different from the vegetation at parrot roost sites —presenting developed understory and absence of emergent *Araucaria angustifolia* trees. We recorded the Vinaceous-breasted Parrot foraging in the *A. angustifolia* trees, but not using the FLONA to roost, which could be related to vegetation characteristics. This area is also important source of breeding sites for Vinaceous-breasted Parrot (ESM pers. observ.). The maintenance of this conservation area, along with the creation of other conservation areas where the species has been recorded, is important to sustain parrot populations (Collar & Juniper 1992).

This study represents a significant contribution to the knowledge of the natural history and ecology of the Vinaceous-breasted Parrot and should be of value to its management and conservation. The information on roost location and number of parrots using the roost has been already reported to the environmental agencies to guide future decision making. Since roosts probably concentrate the parrot population of an area, replicated roost counts represent a viable method for long-term population monitoring (Cougill & Marsden 2004, Berg & Angel 2006, Rivera et al. 2012). The highest number of individuals were reported between March and June, which must be the priority months to conduct surveys in this study area. A potential goal for future studies is to compare the number of the Vinaceous-breasted Parrot in roost areas with the seed yield of nearby *A. angustifolia*. Continued monitoring of the roost of the present study, searching for other roost areas in western Santa Catarina, and tracking individuals (using GPS or radio collars) are essential actions for better understanding the population dynamics and movements of the Vinaceous-breasted Parrot.

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REFERENCES

Abe, LM (2004) Caracterização do hábitat do papagaio-de-peito-roxo *Amazona vinacea* (Kuhl, 1820) no município de Tunas do Paraná, região metropolitana de Curitiba, Paraná. Dissertação de mestrado: Ciência do solo, Universidade Federal do Paraná Curitiba, Paraná, Brazil.

Alonso, HG (2001) Conductas de gregarismo y vocalización de la cotorra cubana (*Amazona leucocephala*). *Ornitologia Neotropical*: 141–152.

Azevedo, MAG & IR Ghizoni-JR (2008) Aves. Pp 131–145 *in* Cherem, JJ & M Kammers (eds). *A fauna das áreas de influência da Usina Hidrelétrica Quebra Queixo*. Erechim, Rio Grande do Sul, Brazil.

Berg, KS & RR Angel (2006) Seasonal roosts of Red-lored Amazons in Ecuador provide information about population size and structure. *Journal of Field Ornithology* 77: 95–103.

BirdLife International (2022) *Amazona vinacea*. The IUCN Red List of Threatened Species. Available at http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22686374A93109194.en [Accessed 17 January 2022].

Carrara, LA, LCP Faria, PTZ Antas, JR Matos, RC Sartório & ET Scopel (2010) Plantios comerciais de *Eucalyptus* como dormitórios comunais de papagaios *Amazona* spp.: convergência seletiva. *Revista Brasileira de Ornitologia* 18: 49–54.

Carrara, LA, LP Faria, FQ do Amaral & M Rodrigues (2007) Dormitórios do papagaio-verdadeiro *Amazona aestiva* e do papagaio-galego *Salvatoria xanthops* em plantio comercial de eucalipto. *Revista Brasileira de Ornitologia* 15: 135–138.

Cockle, K, G Capuzzi, A Bodrati, R Clay, H del Castillo, M Velázquez, JI Areta, N Fariña & R Fariña (2007) Distribution, abundance, and conservation of Vinaceous Amazons (*Amazona vinacea*) in Argentina and Paraguay. *Journal of Field Ornithology* 78: 21–39.

Collar, NJ & AT Juniper (1992) Dimensions and Causes of the Parrot Conservation Crisis. Pp 1–24 *in* Beissinger, SR & NFR Snyder (eds.). *New World parrots in crisis: solutions from conservation biology*. Smithsonian Institution Press, Washington, DC, USA.

Cougill, S & SJ Marsden (2004) Variability in roost size in an *Amazona* parrot: implications for roost monitoring. *Journal of Field Ornithology* 75: 67–73.

Dénes, FV, JL Tella & SR Beissinger (2018) Revisiting methods for estimating parrot abundance and population size. *Emu - Austral Ornithology* 118: 1–13.

Durigan, G (2009) Métodos para análise de vegetação arbórea. Pp. 652 *in* Cullen Jr L, R Rudran & C Valladares-Pádua (eds.). *Métodos de Estudos em Biologia da Conservação e Manejo da Vida Silvestre.* Universidade Federal do Paraná, Curitiba, Paraná,

Brazil.

Forshaw, JM (2010) *Parrots of the world*. Princeton University Press, Princeton, New Jersey, USA.

Gandolfi, DFB & Müller, ES (2006) O Efeito da Formação Vegetal sobre a Comunidade de aves na Floresta Nacional de Chapecó/SC (Gleba I), 34 f. Monografia (Pós-graduação Lato Sensu Diagnóstico Ambiental e recuperação de Áreas degradadas), Universidade Comunitária da Região de Chapecó, Chapecó, Brazil.

IBGE (2002) Mapa de Clima do Brasil. Available at ftp://geo ftp.ibge.gov.br/informacoes_ambientais/ climatologia/mapas/ brasil/Map_BR_clima_2002.pdf [Accessed 7 January 2019].

Klein, R (1978) *Mapa fitogeográfico do Estado de Santa Catarina.* Herbário Barbosa Rodrigues, Itajaí, Santa Catarina, Brazil.

Marsden, SJ, M Whiffin, L Sadgrove & P Guimarães (2000) Parrot populations and habitat use in and around two lowland Atlantic Forest reserves, Brazil. *Biological Conservation* 96: 209–217.

Martinez, J & NP Prestes (2008) Tamanho populacional, tamanho médio de bando e outros aspectos demográficos do papagaio-charão (*Amazona pretrei*). Pp 178–206 *in* Martinez J & NP Prestes (eds). *Biologia da conservação: estudo de caso com papagaio-charão e outros papagaios brasileiros.* UPF Editora, Passo Fundo, Rio Grande do Sul, Brazil.

Martinez, J, NP Prestes & R Noetzold (2008) Os ambientes do papagaio-charão (*Amazona pretrei*): fisionomia e estrutura da vegetação. Pp 105–138 *in* Martinez J & NP Prestes (eds). *Biologia da conservação*: *estudo de caso com papagaio-charão e outros papagaios brasileiros.* UPF Editora, Passo Fundo, Rio Grande do Sul, Brazil.

Martuscelli, P (1995) Ecology and conservation of the Red-tailed Amazon *Amazona brasiliensis* in south-eastern Brazil. *Bird Conservation International* 5: 405–420.

Moura, LN de, JME Vielliard & ML da Silva (2010) Seasonal Fluctuation of the Orange-Winged Amazon at a Roosting Site in Amazonia. *The Wilson Journal of Ornithology* 122: 88–94.

Nunes, MF & GS Betini (2002) Métodos de estimativa de abundância de psitacídeos. Pp. 99–112 *in* Galetti M & MA Pizo (eds.). *Ecologia e conservação de psitacídeos no Brasil.* Melopsittacus Publicações Científicas, Belo Horizonte, MG

Prestes, NP, J Martinez, JC Kilpp, T Batistela, A Turkievicz, É Rezende & VTR Gaboardi (2014) Ecologia e conservação de *Amazona vinacea* em áreas simpátricas com *Amazona pretrei*. *Ornithologia* 6: 109–120.

Rivera, L, N Politi & EH Bucher (2012) Ecología y conservación del Loro Alisero (*Amazona tucumana*). *El hornero* 27: 051–061.

RStudio Team (2016) *RStudio:* Integrated Development for R. RStudio, Inc., Boston, Massachusetts, United States. Available at http://www.rstudio.com/.

Scherer-Neto, P & MC Toledo (2007) Avaliação populacional do papagaio-de-cara-roxa (*Amazona brasiliensis*) (Psittacidae) no Estado do Paraná, Brasil. *Ornitologia Neotropical* 18: 379 –393.

Seixas, GHF (2009) Ecologia alimentar, abundância em dormitórios e sucesso reprodutivo do papagaio-verdadeiro (*Amazona aestiva*) (Linnaeus, 1758) (Aves: Psittacidae) em um mosaico de ambientes no Pantanal de Miranda, Mato Grosso do Sul, Brasil. Tese de Doutorado, Universidade Federal de Mato Grosso do Sul Campo Grande, Mato Grosso do Sul, Brazil.

Sick, H (2001) *Ornitologia brasileira.* Nova Fronteira, Rio de Janeiro, Rio de Janeiro, Brazil.

Sipinski, EAB (2003) O papagaio-de-cara-roxa (*Amazona brasiliensis*) na Ilha Rasa, PR – Aspectos ecológicos e reprodutivos e relação como ambiente. Dissertação de Mestrado, Universidade Federal do Paraná Curitiba, Paraná, Brazil.

Stotz, DF, JW Fitzpatrick, TA Parker III & DK Moskovits (1996) *Neotropical birds: ecology and conservation.* 1st ed. University of Chicago Press, Chicago, Illinois, USA.

Straube, FC, A Urben-Filho & D Kajuwara (2004) Aves. *in Livro vermelho da fauna ameaçada no estado do Paraná*. Instituto Ambiental do Paraná, Curitiba, Paraná, Brazil.

Tella, JL, FV Dénes, V Zulian, NP Prestes, J Martínez, G Blanco & F Hiraldo (2016) Endangered plant-parrot mutualisms: seed tolerance to predation makes parrots pervasive dispersers of the Parana pine. *Scientific Reports* 6: 31709.

Wright, TF, CA Toft, E Enkerlin-Hoeflich, J Gonzalez-Elizondo, F Rojas -Suárez, V Sanz, A Trujillo, et al., (2001) Nest poaching in Neotropical Parrots. *Conservation Biology* 15: 710–720.

Zulian, V, ES Müller, KL Cockle, A Lesterhuis, R Tomasi Júnior, NP Prestes, J Martinez, M Kéry & G Ferraz (2020) Addressing multiple sources of uncertainty in the estimation of global parrot abundance from roost counts: A case study with the Vinaceous-breasted Parrot (*Amazona vinacea*). *Biological Conservation* 248: 108672.

Zulian, V, DAW Miller, G Ferraz (2021) Integrating citizen-science and planned-survey data improves species distribution estimates. *Diversity and Distributions* 27: 2498–2509.