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Temperament of Psittaciformes and its implications in pre- and post-release stages of translocation projects

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Dissertação apresentada ao Programa de Pós-Graduação em Biodiversidade e Conservação da Natureza da Universidade Federal de Juiz de Fora como requisito parcial à obtenção do título de Mestre em Biodiversidade e Conservação da Natureza. Área de concentração: Comportamento, Ecologia e Sistemática.

Orientadora: Prof[a]. Dr[a]. Aline Cristina Sant'Anna

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Quando criança, eu tinha um sonho: cuidar dos animais. Mas como poderia imaginar que uma atitude que acreditava ser tão simples poderia ser tão difícil de ser concretizada? As oportunidades são poucas e a corrupção corrompe até mesmo quem se diz fazer o bem aos animais. Por isso, eu gostaria de agradecer primeiramente à Aline, minha orientadora, e ao Cristiano, meu coorientador, por terem me dado a oportunidade de colocar em prática aquilo que há muito vinha almejando, sem deixar a ética de lado.

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sonhados, pelas escolhas feitas apesar das incertezas, pelos esforços realizados e pelas conquistas que abriram caminho para que chegasse até aqui.

“Animals have personalities and minds and emotions” (Jane Goodall, 2016).

RESUMO

O temperamento pode influenciar as respostas comportamentais de animais em contextos pré- e pós-soltura. Estudos que avaliam essa relação com representantes da ordem Psittaciformes ainda são escassos, por isso buscamos entender as implicações do temperamento de psitacídeos em contextos inseridos no pré- e pós-soltura de projetos de translocação. Também objetivamos: a) conduzir uma revisão sistemática sobre temperamento em Psittaciformes, focando em aspectos metodológicos e revelando as principais dimensões identificadas para essa ordem; b) investigar os efeitos comportamentais de rádio-colares em duas espécies de psitacídeos neotropicais, *Pionus maximiliani* e *Primolius maracana*, e explorar a relação entre o temperamento e suas diferenças na adaptação aos colares; e c) investigar as associações entre temperamento e o comportamento dessas aves após a soltura. Apesar de encontrarmos 22 dimensões de temperamento para a ordem Psittaciformes, notamos uma falta de padronização nas terminologias utilizadas na literatura. Comportamento pré- e pós-soltura foi o tema mais investigado nos estudos que avaliaram o temperamento de Psittaciformes. O uso do colar afetou o orçamento comportamental das aves, que se habituaram somente parcialmente aos aparelhos. O temperamento não se mostrou relacionado com a adaptação aos colares, mas *Pionus maximiliani* interagiu mais com eles do que *Primolius maracana*. As aves mais tímidas demoraram mais a sair do viveiro e as mais ousadas tenderam a se aproximar mais de pessoas ao entrar em casas. Após a soltura, os animais passaram mais tempo se movimentando e interagindo entre si do que quando estavam em cativeiro. Os contextos pré- e pós-soltura de translocações são críticos para a adaptação dos animais na natureza, sendo aparente a relação do temperamento dessas aves com seus comportamentos expressos depois de serem soltos. Estudos como esse nos ajudam a predizer o tipo de comportamento que esses animais irão apresentar depois de soltos, dessa forma podemos aplicar estratégias pré- e pós-soltura mais eficazes como uma forma de ajudar na adaptação de animais translocados e evitar conflitos.

Palavras-chave: comportamento; papagaio, personalidade; rádio colar; soltura.

ABSTRACT

Temperament can influence behavioral responses in pre- and post-release contexts. Studies evaluating this relationship in representatives of the order Psittaciformes are still scarce. Thus, we aimed to understand the implications of psittacine temperament in pre- and post-release contexts within translocation projects. Our objectives included: a) conducting a systematic review on temperament in Psittaciformes, focusing on methodological aspects and identifying the main dimensions for this order; b) investigating the behavioral effects of neck collars on two Neotropical psittacine species, *Pionus maximiliani* and *Primolius maracana*, while exploring the relationship between temperament and differences in collar adaptation; and c) analyzing associations between temperament and the behavior of these birds after release. Although we identified 22 temperament dimensions for the Psittaciformes order, there is a noticeable lack of standardization in the terminology used in the literature. Pre- and post-release behavior was the most frequently studied topic in research on Psittaciformes temperament. The use of collars affected the behavioral budget of the birds, which only partially habituated to the devices. Temperament was unrelated to collar adaptation, but *Pionus maximiliani* interacted with the collars more than *Primolius maracana*. Shyer birds took longer to exit the aviary, whereas bolder individuals tended to approach humans more often. After release, the birds spent more time moving and interacting with each other compared to when they were in captivity. Pre- and post-release contexts of translocations are critical for the adaptation of animals to the wild, and there is a clear relationship between the temperament of these birds and their behaviors post-release. Such studies contribute to predicting the behavior of parrots after release, facilitating the development and application of more effective pre- and post-release measures to enhance their adaptation and to avoid human-wildlife conflicts.

Keywords: behavior; parrot, personality; radio collar; release.

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1 GENERAL INTRODUCTION

The study of stable interindividual differences in animal behavior, also known as temperament or personality (RÉALE et al., 2007) (hereafter referred to as temperament), may be valuable in several areas. For instance, it can contribute to improving the welfare of companion and livestock species (HEDLUND and LØVLIE, 2015; MARÇAL-PEDROZA et al., 2021, 2023; TRAVNIK et al., 2020), as well as aiding in the conservation efforts for threatened wild species (DE AZEVEDO and YOUNG, 2021). Thus, expanding the knowledge about interindividual differences in the behavior of a species would be relevant, so it can be used in several contexts in which they are involved. This is the case with birds of the order Psittaciformes (parrots, macaws, and alike), commonly found in captivity and with various conservation programs underway worldwide.

For example, the success of psittacine releases in conservation programs is dependent on several factors, like method of release, number of individuals released, presence of native parrots (WHITE et al. 2021), presence of predators, availability of supplementary feeding, habitat quality (WHITE et al., 2012), and origin of the animals (BRIGHTSMITH et al., 2005). Recently, other studies have also investigated the relationship between the behavior of parrots and the success of these releases (BUSSOLINI et al., 2024; SILVA et al., 2020; LOPES et al., 2018). Thus, we aimed to understand the implications of psittacine temperament in pre- and post-release contexts within translocation projects to identify more suitable animals for release.

Radiotelemetry is frequently used in translocation studies with parrots (VOLPE et al., 2022; VILARTA et al., 2024; PURCHASE et al., 2024). Even though, to our knowledge, there are no previous studies investigating the effects of radio collars or GPS collars on parrots' behaviors. These devices have been reported to cause behavioral, physical, and physiological adverse effects in other animals such as rats (BIBIANO et al., 2022), red pandas (VAN DE BUNTE et al., 2021), and the scimitar-horned oryx (STABACH et al., 2020). Even with acute responses to these collars, some studies have documented an adaptation to these devices, but the responses vary depending on the animal studied. For example, from four (WEBSTER & BROOKS, 1980) to 10 days for meadow voles (HAMLEY & FALLS, 1975); and from two to three years for greater snow geese (LEGAGNEUX et al., 2013). Therefore, another aim of the study was to investigate the behavioral effects of neck collars on two psittacine species while exploring the relationship between temperament and differences in collar adaptation.

Also, we can evaluate temperament in release studies to establish connections between animals' behavioral patterns and what happens to them after release. For instance, bolder swift-foxes (*Vulpes velox*) died faster than shyer ones after being released (BREMNER-HARRISON et al., 2004). Conversely, more exploratory turtles (*Emydoidea blandingii*) had higher survival rates than less exploratory ones (ALLARD et al., 2019). Therefore, our last aim was to analyze associations between temperament and the behavior of these birds after release.

The species used in this study belong to the family Psittacidae of the order Psittaciformes (Class: Aves). Both the Scaly-headed parrot (*Pionus maximiliani*) and the Blue-winged macaw (*Primolius maracana*) are widely distributed among South American countries, generally inhabiting tropical forests, transition areas, and anthropized environments, and have a frugivorous and granivorous diet (BIRDLIFE INTERNATIONAL, 2016, 2024; COLLAR et al., 2020a, 2020b). As to their conservation status, Scaly-headed parrots are of least concern, but Blue-winged macaws are nearly threatened according to the IUCN Red List of Threatened Species (BIRDLIFE INTERNATIONAL, 2016, 2024).

This master's thesis was divided into three chapters. In the first one, we conducted a systematic review on the temperament of Psittaciformes, focusing on methodological aspects (published in Applied Animal Behavior Science in July 2024, DOI: https://doi.org/10.1016/j.applanim.2024.106348). The second chapter addresses the behavioral effects of neck collars on these birds, and the third chapter focuses on their behavioral responses shown after release and how they may be related to temperament.

2 CHAPTER 1 – TEMPERAMENT OF PSITTACIFORMES: A SYSTEMATIC REVIEW[1]

1.1 INTRODUCTION

The order Psittaciformes (Class Aves) includes the families Strigopidae (four species of New Zealand Parrots), Cacatuidae (22 species of Cockatoos), Psittaculidae (202 species of Old-World Parrots), and Psittacidae (177 species of New World and African Parrots) (Birds of the World, 2022). It contains species widely present in the global pet market (MUNN, 2006), having close contact with humans in this context. Many Psittaciformes are involved in various conservation issues, with the species exposed to several threats in their natural distribution areas, putting certain populations at severe risk of extinction (BERKUNSKY et al., 2017; VERGARA-TABARES et al., 2020), while others are considered invasive species in different regions of the world (PRUETT-JONES, 2021).

The study of stable interindividual differences in animal behavior, also known as temperament or personality (RÉALE et al., 2007) (hereafter referred to as temperament), may be valuable in several areas. For instance, it can contribute to improving animal welfare of companion and livestock species (HEDLUND and LØVLIE, 2015; MARÇAL-PEDROZA et al., 2021, 2023; TRAVNIK et al., 2020), as well as aiding in the conservation efforts for threatened wild species (DE AZEVEDO and YOUNG, 2021). Thus, expanding the knowledge about interindividual differences in the behavior of Psittaciformes would be relevant, so it can be used in several contexts in which species of this order are involved.

Previous initiatives have been undertaken to characterize and understand the implications of Psittaciformes' temperament. These efforts aim to determine how knowledge about temperament can be applied to improve the management and conservation practices, including welfare, handling of captive individuals, release into the wild, environmental enrichment, and other aspects. This helps improving captive management conditions and supports conservation programs. In existing published papers, a number of different temperament dimensions have been described, including 'alertness', 'vigilance', 'neophobia / neophilia', and 'shyness / boldness', among others (COUTANT et al., 2018; FOX and MILLAM, 2004, 2010; RAMOS et al., 2020).

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[1] Article published in Applied Animal Behavior Science in July 2024 (https://doi.org/10.1016/j.applanim.2024.106348).

The methods of assessment also vary across studies, ranging from different behavioral tests and observations of routine behaviors (coding) to qualitative methods (observer ratings) (CUSSEN and MENCH, 2014; FOX and MILLAM, 2014). In this literature, it became evident that there is a lack of standardization in terminologies and methods applied. These inconsistencies make it challenging to compare results and does not allow valid cross-species comparisons of temperament differences within Psittaciformes order. A comprehensive summarization of the existing knowledge aiming to understand and organize the methodological diversity, identifying gaps and proposing new themes for future research would be useful. While reviews summarizing knowledge on temperament in Psittaciformes and the methodologies used in these studies are nonexistent, valuable contributions have been provided by review articles about temperament / personality for other taxonomic groups, like fishes (LUCHIARI and MAXIMINO, 2023), amphibians (KELLEHER et al., 2018), reptiles (WATERS et al., 2017), birds (VAN OERS and NAGUIB, 2013), domestic mammals (FINKEMEIER et al., 2018), such as domestic dogs (JONES and GOSLING, 2005), cats (TRAVNIK et al., 2020) and bovines (HASKELL et al., 2014). A similar approach would be useful for researchers dedicated to studying temperament in Psittaciformes.

Systematic reviews (SR) consist of the summarization of existing knowledge about a particular subject capable of showing the current state of the knowledge, and highlight research gaps, guiding future studies on the theme (MACKENXIE et al., 2012; OWENS, 2021; PULLIN and STEWART, 2006). Such reviews would be valuable for future researchers helping them to design and standardize methods (e.g. selecting the most appropriate behavioral tests, determining terminology for characterizing the main temperament dimensions, determining the viable number of tests repetitions with individual parrots, the best age and context to assess these individuals), what would contribute to consolidating this research field. This review aimed to systematically integrate studies on the temperament of Psittaciformes, focusing on methodological aspects. It also aimed to reveal the main temperament dimensions described for these species, identify research gaps, and suggest new research questions deserving the scientific community’s attention. This would be the first study of this kind about the temperament of Psittaciformes.

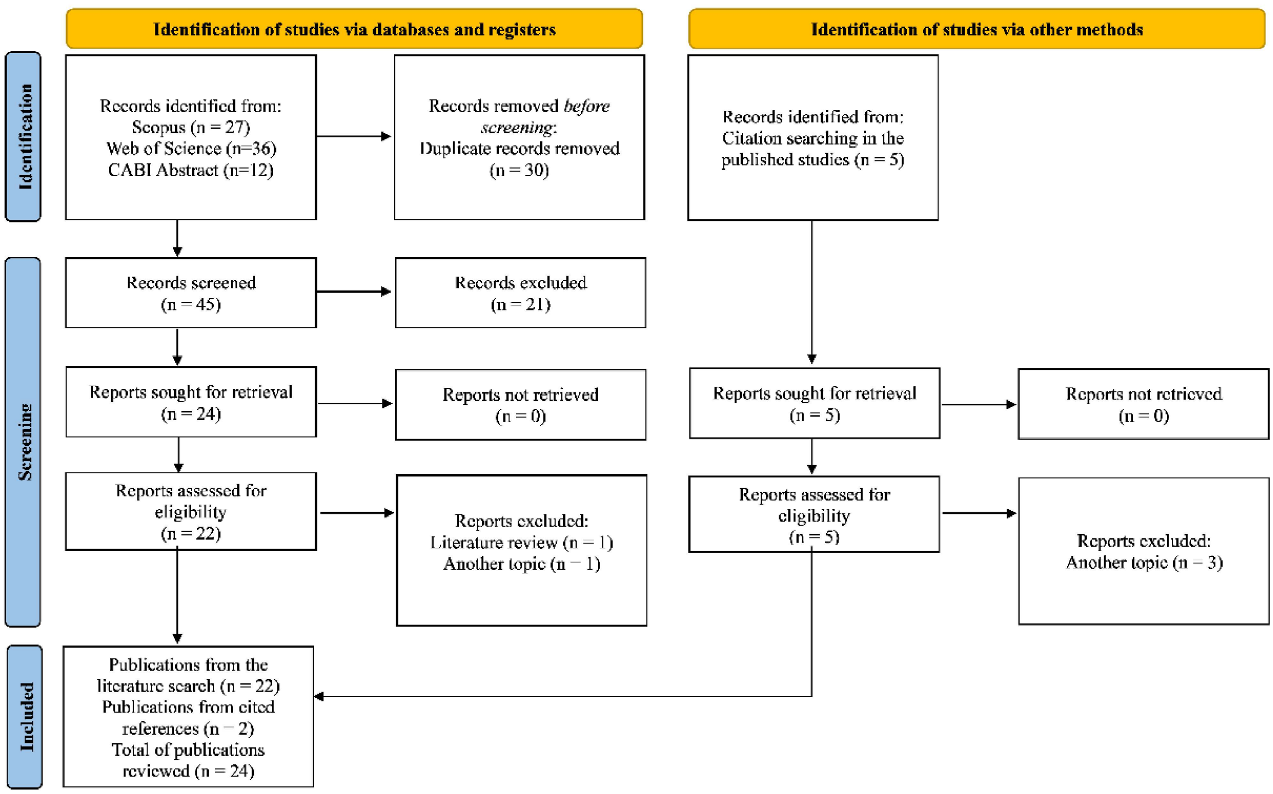
1.2 MATERIAL AND METHODS

1.2.1 Search strategy

This is a theoretical study and, therefore, does not need ethical approval. This SR followed the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA) methodology (PAGE et al., 2022) (Figure 1). The search strategy followed the 'Population, Intervention and Context' (PICo) terms for qualitative data: Population (parrot or parakeet or psittacine or Psittacidae or Psittaciformes), Intervention (personality or temperament or reactivity or "individual differences"), and Context (behavi* or neoph* or bold* or shy* or responsiveness or fearfulness) (MUNN et al., 2018). The papers included in this review evaluated individual differences in the behavior of any Psittaciformes species.

We considered papers that were peer-reviewed, written in English, Portuguese or Spanish and published in any year. The search for the publications was conducted from June 2023 until September 2023, using three databases (CABI, Scopus, and Web of Science).

Figure 1 - Flow chart PRISMA 2020 (PAGE et al., 2022) indicating the number of publications included and excluded in each stage of the systematic review about the temperament of Psittaciformes.



Source: Elaborated by the author (2024).

1.2.2 Publications selection criteria and screening

The papers went through a process of screening, that consisted of three stages. In the first stage, the selection of the papers was done based on the articles' titles (Figure 1). For that, three researchers selected, individually, the publications they judged most relevant. It was selected publications that evaluated individual differences in behavior, OR personality, OR temperament of species belonging to the order Psittaciformes. When discrepancies emerged, a fourth researcher made a final decision. The selected articles were retrieved and then went through the second stage, in which their abstracts were analyzed by one of the authors (Figure 1). Those that did not fit in the subject, were excluded from the review.

For the last stage, we searched for additional publications not identified in the search through the databases, by looking into the reference lists of the included publications (Figure 1). Citations that were judged relevant were retrieved, had their abstracts analyzed and, in case they passed the selection criteria, they were included in the review.

1.2.3 Data extraction

For data extraction, Microsoft Excel software was used. In this stage, the articles were completely read and, in case any of them was not relevant, they were excluded from the review. The first and last authors of the present study were responsible for data extraction, that were categorized in columns in MS-Excel. The following information was collected: author, year of publication, study design, country, terminology used, how temperament was defined, temperament measure type, behavioral test used, number of test repetitions, terms used to define temperament dimension, results, correlated traits, sample size, species used, and research context (if the subjects studied were wild animals or kept under human care, i.e. captive).

1.2.4 Word cloud

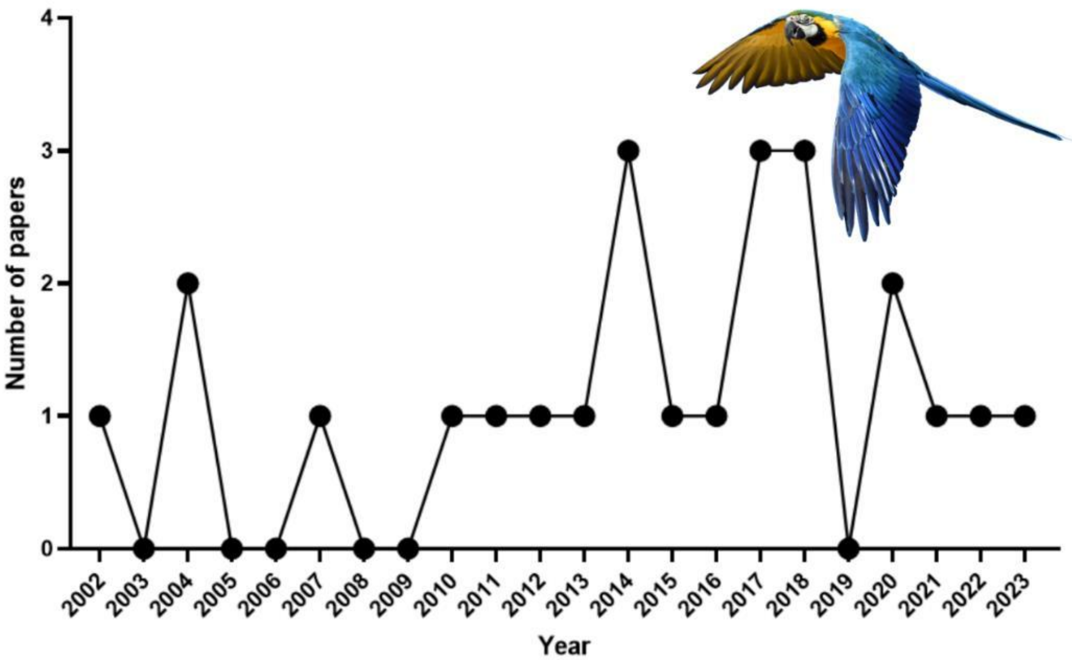
To determine whether the choice for the search terms was adequate, a word cloud was created using the wordcloud R package (FELLOWS, 2018). A word cloud displays the most used words in a text, providing a graphical and quantitative synthesis. For the construction of the cloud, we used the keywords and titles of the publications included in the SR.

1.3 RESULTS

1.3.1 Number of publications

The initial search resulted in 75 publications. After removing the duplicates and screening the papers for eligibility a total of 24 were retained for the SR (Figure 1). The first studies were published in 2002 (n = 1 study; 4.17 %), 2004 (2; 8.33 %), and 2007 (1; 4.17 %) and, from 2010 and forward, they began to be published more frequently (Figure 2). Between the years 2010 and 2023, the articles were published with an average of 1.43 articles per year (Table 1).

Figure 2 - Number of papers published per year from 2002 to 2023.



Source: Cristiano Schetini (2024).

1.3.2 Most commonly used terms

The most commonly used terminologies to refer to interindividual behavioral differences were personality (11; 45.83 %) and temperament (8; 33.33 %). Terms such as individual differences (2; 8.33 %) and coping styles (1; 4.17 %) were also used. Only two studies did not present any specific terminology (Table 1). The most frequently mentioned words from the key words and titles of the articles, according to the word cloud, were personality (16; 66.67 %), parrot (12; 50 %), parrots (12; 50 %), Amazon (11; 45.83 %), and *Amazona* (11; 45.83 %) (Figure 3).

Figure 3 - Word cloud with the most frequent terms used in the titles and keywords from the selected articles. The bigger the word, the more frequent it was.

Source: Larissa Gomes (2024).

1.3.3 Countries and researchers

Most of the studies were conducted in the United States, with 12 (50 %) publications and Brazil had the second highest number of publications, with eight studies (33.33 %), while four studies (16.67 %) were from the European continent.

Fox and Millam, together, published four articles about the temperament of Psittaciformes (2004, 2007, 2010, 2014). Ramos et al. published three (2020, 2021, 2023), and two articles were published by Cussen and Millam (2014, 2015) and Kerman et al. (2016, 2018). The remaining authors published only one article each (Table 1).

Table 1 - Summary of the information extracted from the 24 articles included in this review.

Reference	**Terminology**	**Method**	**Method description**	**Tests (repetitions)**	**Species (N)**	**Environment**	**Temperament dimensions**	**Subjects related**
MEEHAN and MENCH, 2002	Not described	Coding	Behavioral tests	Novel object (6), Handler response (12)	*Amazona amazonica* (16)	Research center	Fearfulness, Exploration	Environmental enrichment
FOX and MILLAM, 2004	Personality	Coding	Behavioral tests	Novel object (6)	*Amazona amazonica* (19)	Research center	Neophobia	Rearing method
FUNK and MATTESON, 2004	Individual differences	Coding	Cognitive scales	Object permanence (until 3), Means-end (-), Spatial relationships (-)	*Cyanoramphus auriceps* (11)	Laboratory	Activity, Exploration	Rearing method
FOX and MILLAM, 2007	Personality	Coding	Behavioral tests	Novel object (17)	*Amazona amazonica* (34)	Research center	Neophobia	Environmental enrichment
FOX and MILLAM, 2010	Temperament	Coding/Rating	Behavioral observation, behavioral tests, and Cockatiel Temperament Instrument	Novel object (2), Novel social situation (1)	*Nymphicus hollandicus* (68)	Research center	Aggression, Agreeableness/Affiliativeness, Sociability/Boldness, Sensibility, Playfulness	Methodology
CALLICRATE et al., 2011	Personality	Coding	Behavioral tests	Tonic immobility (3), Open field (1), Barrier threat (1), Tendency to flock (3), Novel object (3), Foraging and competition (1), Predator threat (1)	*Melopsittacus undulatus* (23)	Pet store	Shyness-Boldness	Comparing sex and/or species
METTKE-HOFMANN et al., 2012	Not described	Coding	Behavioral tests	Novel environment (1)	*Trichoglossus ornatos* (12), *Trichoglossus haematodus moluccanus* (14), *Neopsittacus pullicauda* (14), *Charmosyna josephinae* (14), *Charmosyna papou goliathina* (16), *Charmosyna pulchella* (12), *Psephotus chrysopterygius* (16), *Psephotus varius* (14), *Psephotus haematonotus* (22), *Northiella haematogaster* (14)	Commercial breeder	Exploration	Life history
VAN ZEELAND et al., 2013	Coping style	Coding	Behavioral tests	Manual restraint (1), Novel object (1), Open field (1)	*Psittacus erithacus* (22)	Parrot sanctuary	Proactivity-Reactivity	Abnormal behavior

CUSSEN and MENCH, 2014	Personality	Rating	Personality Instrument Assessment	NA	*Amazona amazonica* (20)	Research center	Neuroticism, Extraversion	Cognition
FOX and MILLAM, 2014	Personality	Rating	Cockatiel Personality Instrument	NA	*Nymphicus hollandicus* (20)	Research center	Agreeableness, Boldness, Affiliativeness	Social behavior
KRASHENINNIKIVA and SCHNEIDER, 2014	Individual differences	Coding	Behavioral and cognitive tests	String-pulling (10), String-pulling in a social condition (10), Novel feeder (5)	*Amazona amazonica* (58)	Parrot Zoo	Fearfulness	Social behavior
CUSSEN and MENCH, 2015	Personality	Rating	Personality Instrument Assessment	NA	*Amazona amazonica* (13)	Research center	Neuroticism, Extraversion	Abnormal behavior
KERMAN et al., 2016	Personality	Coding	Behavioral tests	Novel object (1), Emergence (1), Predation risk (1)	*Myiopsitta monachus* (33)	Research center	Boldness	Comparing sex and/or species
DE AZEVEDO et al., 2017	Personality	Coding	Behavioral tests	Novel object (2)	*Amazona aestiva* (30)	IBAMA	Shyness-Boldness	Pre- and post-release behavioral training
LOPES et al., 2017	Personality	Coding	Behavioral tests	Novel object (2)	*Amazona aestiva* (31)	CETAS	Shyness-Boldness	Pre- and post-release behavioral training
MEDINA-GARCIA et al., 2017	Personality	Coding	Behavioral tests	Novel environment (2), Novel object (3), Novel social condition (2), Novel food (1)	*Melopsittacus undulatus* (42)	Commercial breeder	Exploration, Neophobia, Sociability	Cognition
COUTANT et al., 2018	Temperament	Coding	Behavioral tests	Novel environment (3), Novel object (3), Reaction to unknown person (3), Play with the experimenter (3), Food reward (3)	*Psittacus erithacus* (15), *Amazona aestiva* (12), *Amazona automnalis* (4)	Parrot shelter	Anxiety/Vigilance, Curiosity/Neophilia	Comparing sex and/or species
KERMAN et al., 2018	Personality	Coding	Behavioral tests	Novel object (2), Emergence (2), Predation risk (2)	*Myiopsitta monachus* (41)	Research center	Boldness	Social behavior
PAULINO et al., 2018	Temperament	Coding/Rating	Behavioral tests and rating scale	Novel environment (1)	*Amazona rhodocorytha* (10)	CEREIAS	Anxious	Environmental enrichment

RAMOS et al., 2020	Temperament	Coding	Behavioral tests	Novel object (1), Reaction to unknown person (1), Reaction to potential predator (1)	*Amazona vinacea* (13)	CETAS	Vigilance, Risk-taking	Environmental enrichment
SILVA et al., 2020	Temperament	Coding	Behavioral tests	Open field (1)	*Amazona aestiva* (50)	CETAS	Boldness	Pre- and post-release behavioral training
RAMOS et al., 2021	Temperament	Coding	Behavioral tests	Novel object (1), Reaction to unknown person (1), Reaction to potential predator (1)	*Psittacara leucophtalmus* (12)	CETAS	Vigilance, Boldness, Responsiveness to humans	Social behavior
FRANZONE et al., 2022	Temperament	Coding	Behavioral tests	Novel object (3), Reaction to unknown person (3)	*Amazona aestiva* (23), *Amazona rhodocorytha* (5), *Amazona vinacea* (10)	CETAS	Activity, Neophilia, Alert, Risk-taking	Pre- and post-release behavioral training
RAMOS et al., 2023	Temperament	Coding	Behavioral tests	Novel object (3), Reaction to unknown person (3), Manual restraint (2)	*Amazona aestiva* (23), *Amazona rhodocorytha* (5), *Amazona vinacea* (10)	CETAS	Activity, Neophilia, Vigilance, Fearfulness	Pre- and post-release behavioral training

Source: Elaborated by the author (2023).
Note: (N) = sample size; (-) = information not provided; NA = not applicable; IBAMA = Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute of the Environment and Renewable Natural Resources); CETAS = Centro de Triagem de Animais Silvestres (Wild Animals Rehabilitation Center); CEREIAS = Centro de Reintrodução de Animais Selvagens (Wildlife Reintroduction Center). Source: Elaborated by the author (2024).

1.3.4 Origin of the animals

All the studies used animals under human care, with 10 (41.67 %) from laboratory colonies and research centers, eight (33.33 %) from wildlife rehabilitation centers, and six (25 %) from stores and commercial breeding colonies, zoos, shelters, or sanctuaries. From the articles included in this SR, only two (8.33 %) included animals captured in the wild, however, these same animals had been held captive for five and six years until the moment of the study (KERMAN et al., 2016, 2018).

1.3.5 Families, genera, and species

Of the four families from the order Psittaciformes (Psittacidae, Psittaculidae, Cacatuidae, and Strigopidae), Psittacidae (18; 75 %), Psittaculidae (4; 16.67 %), and Cacatuidae (2; 8.33 %) were studied. Twelve different genera were evaluated, and the genus *Amazona* was the most studied (14; 58.33 %). Only one species from the Cacatuidae family was evaluated, the cockatiel (*Nymphicus hollandicus*) (Table 1).

The average sample size from the published papers was 34.21 and ranged from 10 (PAULINO et al., 2018) to 148 animals (METTKE-HOFMANN et al., 2012) (Table 1). Regarding sample size per species, the numbers were quite diverse. Sample sizes per species varied from four and five red-fronted (*Amazona autumnalis* - COUTANT et al., 2018) and red-browed (*Amazona rhodocorytha* - FRANZONE et al., 2022; RAMOS et al., 2023) Amazon parrots up to 58 orange-winged Amazon parrots (*Amazona amazonica* - FOX and MILLAM, 2010) or 68 cockatiels (*Nymphicus hollandicus* - KRASHENINNIKOVA and SCHNEIDER, 2014) (Table 1). These low sample sizes per species might compromise cross-species comparisons. Indeed, in only three studies (12.5 %) cross-species differences in temperament have been investigated (COUTANT et al., 2018; METTKE-HOFMANN, 2012; RAMOS et al., 2023).

1.3.6 Temperament dimensions

A total of 22 different terminologies used to characterize temperament dimension were compiled in the publications reviewed, as follows: ‘fearfulness’, ‘exploration’ (MEEHAN and MENCH, 2002), ‘neophobia’ (FOX and MILLAM, 2004), ‘activity’ (FUNK and MATTESON, 2004), ‘aggression’, ‘agreeableness’, ‘affiliativeness’, ‘sociability’, ‘boldness’, ‘sensitivity’, ‘playfulness’ (FOX and MILLAM, 2010), ‘proactivity’ (VAN ZEELAND et al., 2013), ‘neuroticism’, ‘extraversion’ (CUSSEN and MENCH, 2014), ‘anxiety’, ‘vigilance’, ‘curiosity’, ‘neophilia’ (COUTANT et al., 2018), ‘anxious’ (PAULINO et al., 2018), ‘risk-taking’ (RAMOS et al., 2020), ‘responsiveness to humans’ (RAMOS et al., 2021), and ‘alert’ (FRANZONE et al., 2022) (Table 1). The term most used to characterize a temperament dimension in Psittaciformes was ‘boldness’, in nine (37.5 %) articles, but in three of these publications (12.5 %) the authors treated the dimension as ‘shy-bold’ axis or ‘shyness-boldness’. ‘Neophobia’ and / or ‘neophilia’, together, were included in six (25 %) publications. ‘Exploration’ and ‘vigilance’ came in third, with four articles (16.67 %) each. A brief description of each one of the most cited temperament dimensions follows below:

- ‘Boldness’, also found as ‘shy-bold’ or ‘shyness-boldness’ axis, reflects the behavioral responses presented by the animal in a challenging (but not new) situation (RÉALE et al., 2007). Depending on the animal profile, the animal can have a higher (‘bold’) or lower (‘shy’) propensity to take risks when searching for resources, foraging, or when it encounters a predator or human. Some authors refer to this dimension as ‘proactivity / reactivity’ axis (VAN ZEELAND et al., 2013) or ‘risk-taking’ (RAMOS et al., 2020) as synonyms of ‘boldness’.
- ‘Exploration’ reflects the behavioral responses presented by the animal in novel environments (RÉALE et al., 2007). Depending on the profile, the animal can show more (‘fast explorer’) or less (‘slow explorer’) exploratory behaviors. The assessment schemes focus on components of movement (locomotion) in the novel environment as a measure of exploration.
- ‘Neophobia / neophilia’ are two extremes of the same dimension (axis), but they can be found in the literature only as ‘neophobia’ or ‘neophilia’. This dimension reflects the behavioral responses presented by the animal towards a specific novel stimulus, such as novel food items or novel objects (RÉALE et al., 2007). The responses of latency to touch, distance kept from the stimuli, and the time spent interacting with it are usually considered to characterize this dimension. Depending on the profile, the animal can be less (‘neophobic’) or more curious / interested (‘neophiliac’) towards the novel stimuli.

- 'Vigilance' reflects the behavioral responses presented by the animal in situations that require attention, whether it is in challenging situations or new situations with a certain risk. Usually, this dimension is associated with alert and inactivity behaviors (COUTANT et al., 2018; RAMOS et al., 2020). Depending on the profile, the animal can show more ('vigilant') or less ('indifferent') cautious behaviors.

1.3.7 Methodologies used to assess temperament

In temperament studies different types of methodologies were used (quantitative or qualitative methods). Quantitative methods (also referred as coding) involve the quantification of animals' behavior as frequencies or durations, in specific experimental or observational settings which expresses the dimension to be assessed (GOSLING, 2001). Qualitative analyses, on the other hand, are rating methods that use the classifications of behavioral expressions by observers (VAZIRE and GOSLING, 2004), based on behavioral descriptors (adjectives). In this review, the studies using quantitative methodologies of temperament assessment prevailed (19; 79.17 %), while qualitative methodologies were applied in only three (12.5 %) studies, and both methods were applied in two (8.33 %) articles (Table 1).

Of the behavioral tests used in the quantitative studies, the most used were those involving novel objects or novel food items (17; 70.83 %). Environment exploration tests, like open field, novel environment, and exploration tests were the second most used (7; 29.17 %). Then, came the reaction to humans' tests (familiar or unknown) (6; 25 %). Reaction and exposure to predator tests were used in five (20,83 %) studies. Manual restraint and tonic immobility tests were used in three (12.5 %) publications. Emergence and barrier threat tests were also used in three publications (12.5 %). Sociability tests were used in two studies. Briefly, these tests can be described as:

- Novel object (MEEHAN and MENCH, 2002) / Novel food (MEDINA-GARCIA et al., 2017) / Novel feeder test (KRASHENINNIKOVA and SCHNEIDER, 2014): an unfamiliar object is presented to the animal and its behaviors, such as interactions with the object, are registered. Some variations of this test can involve new food items instead of objects.

- Open field (CALLICRATE et al., 2011) / Novel environment (METTKE-HOFMANN et al., 2012) / Exploration test (MEDINA-GARCIA et al., 2017): the animal is placed in a new environment and its behaviors, such as exploratory acts, states of alertness, movements and walked distance are registered.
- Response to handler (MEEHAN and MENCH, 2002) / Reaction to unknown or familiar person test (COUTANT et al., 2018): a familiar or unknown person to the animal stands close to it and its reactions are registered. Some variations of this test can have physical contact between the evaluator and the animal.
- Predator threat (CALLICRATE et al., 2011) / Predator exposure (KERMAN et al., 2016) / Reaction to potential predator test (RAMOS et al., 2020): a predator model is presented to the animal and its reactions, such as the number of alarm calls and escapes are registered.
- Tonic immobility (CALLICRATE et al., 2011) / Manual restraint (VAN ZEELAND et al., 2013): the animal is restrained by a person and behavioral indicators like duration of tonic immobility, escape attempts, vocalizations, pecking, and respiratory frequency are registered.
- Barrier threat (CALLICRATE et al., 2011) / Emergence test (KERMAN et al., 2016): the animal is placed in a situation in which it needs to cross a barrier and get to an unknown area. Latency to cross the barrier and its levels of activity are registered.
- Novel social situation (FOX and MILLAM, 2010) / Sociability test (MEDINA-GARCIA et al., 2017): the animals are grouped with other animals (familiar or unknown) and their positive and negative social interactions are registered.

From the 21 studies using behavioral tests, most (14, 66.67 %) conducted test repetitions over time. However, there was a large variation in the number of times the test was repeated for the same animals, ranging from 2 to 17 times (Table 1). In seven studies (33.33 %) the tests were not repeated over time. In four of them (19.05 %), multiple tests were applied, with the application of three different tests in these studies. For the remaining three studies lacking repetitions, only one test was applied (novel environment or open field tests) (Table 1).

1.3.8 Subjects investigated in relation to temperament

The publications reviewed can be characterized as observational or experimental studies. Observational studies are empirical observations in which individuals are observed and the outcomes of interest are recorded, without assigning subjects at random to a treatment (ROSENBAUM, 2021). In this review, the majority of the studies were observational (15; 62.5 %), with nine (37.5 %) of them applying experimental settings.

In experimental studies, the aim is to draw inferences logically through data that involve the effect of treatments (independent factor) on a variable of interest (dependent variable) that are investigated in controlled trials in which the subjects are randomly assigned to treatments and control groups (DELANEY, 2021; ROSENBAUM, 2021). Among the nine publications with experimental studies, in seven the temperament was included as dependent variable, investigating the effects of environmental enrichment (FOX and MILLAM, 2007; MEEHAN and MENCH, 2002), rearing methods (FOX and MILLAM, 2004; FUNK and MATTESON, 2004), social context (KERMAN et al., 2018; KRASHENINNIKOVA and SCHNEIDER, 2014), and food supplementation (CALLICRATE et al., 2011), in its expressions. In the remaining two publications, temperament was included as independent variable, evaluating its effects on the expression of abnormal behaviors (feather damaging and stereotypic behaviors) (CUSSEN and MENCH, 2015), and survival rates after release in wild (LOPES et al., 2017).

Among the subjects related to temperament, in the publications, pre-and post-release behavior was the most investigated (5; 20.83), followed by environmental enrichment (4; 16.67 %) and social behaviors (4; 16.67 %). Less studied subjects were temperament comparisons between genus and / or species (3; 12.5 %), effects of rearing methods (2; 8.33 %), cognition (2; 8.33 %), abnormal behaviors (2; 8.33 %), and life history (1; 4.17 %) (Table 1).

1.4 DISCUSSION

This systematic integrated studies on the temperament of Psittaciformes, focusing on methodological aspects. The studies primarily focused on specific groups, such as animals under human care, and on a few species of three families within the Psittaciformes order, highlighting the need of investigating a broader range of species and contexts to enable a deep understanding of Psittaciformes temperament. This field is still evolving, both in theory and in practice. Therefore, it would be beneficial that researchers take initiatives toward a methodological and conceptual standardization.

1.4.1 Methodological aspects

The studies of temperament in Psittaciformes have been concentrated in the American continent, which has the most diversity of representatives from this order (IUCN, 2024). Of the few studies conducted in Europe, the species evaluated were native of other continents, like America (*Amazona amazonica*, *A. aestiva,* and *A. autumnalis*) (COUTANT et al., 2018; KRASHENINNIKOVA and SCHNEIDER, 2014), Africa (*Psittacus erithacus*) (COUTANT et al., 2018; VAN ZEELAND et al., 2013) and Oceania (*Trichoglossus ornatos*, *T. haematodus moluccanus*, *Neopsittacus pullicauda*, *Charmosyna josephinae*, *C. papou goliathina*, *C. pulchella*, *Psephotus chrysopterygius*, *P. varius*, *P. haematonotus*, *Northiella haematogaster*) (METTKE-HOFMANN et al., 2012). The representation of Psittaciformes native from other continents, like Oceania, Asia, and Africa on the temperament studies, is minimal or lacking. Oceania and Asia, just like America, have a great diversity of these species (IUCN, 2024); therefore, this lack of knowledge may result in significant gaps.

All studies about temperament of Psittaciformes were conducted with individuals under human care (captive environments). In temperament studies, the use of animals in captivity tends to be more practical and feasible, as it is easier to observe and test the individuals. However, the aspects evaluated in captivity may not necessarily correlate with the dimensions that would be important for the fitness in wild. Studies on Passeriformes conducted with wild birds (ABBEY-LEE et al., 2016; ARAYA-AJOY and DINGEMANSE, 2017; HUTFLUSS and DINGEMANSE, 2019) should contribute with examples and ideas of methodologies that could be applied to evaluate temperament of Psittaciformes in wild conditions.

Regarding the families of the order Psittaciformes, there is a gap about Cacatuidae, Psittaculidae, and Strigopidae, which are underrepresented in this field of study. Species of Strigopidae family were not investigated yet. For Cacatuidae there was a single species evaluated in two papers (FOX and MILLAM, 2010, 2014), and for Psittaculidae, 12 different species were evaluated in four other papers (CALLICRATE et al., 2011; FUNK and MATTESON, 2004; MEDINA-GARCIA et al., 2017; METTKE-HOFMANN et al., 2012). The genus *Amazona* was the most studied and includes parrots highly sought after as pets in the whole world, given their charisma and adaptability to captivity (SCHUNCK et al., 2011). Such a fact may explain the reason why this genus is highly studied, since the illegal trade and, consequently, the high numbers of seized animals increase their availability in rehabilitation centers. Even so, it is needed to expand the models studied, including other families, genera, and species, so that new comparisons can be drawn, contributing to Psittaciformes temperament knowledge.

The small sample sizes became evident in various of the studies reviewed. It is understandable that, depending on the studied context and species, it can be difficult to obtain a representative sample due to several factors, for instance, the species' conservation status (Birdlife International, 2022). When using methods for reducing data dimensionality, like Principal Component Analysis (PCA), or Factor Analysis (FA), that are statistical approaches commonly used in this field of research, the minimum adequate sample size depends on a number of factors, such as the degree of correlation between variables, data distribution, type and linearity (BUDAEV, 2010; MANLY and ALBERTO, 2019; SHAUKAT et al., 2016). As a general recommendation, Feaver et al. (1986) propose that for temperament studies using methods of data dimensionality reduction (PCA or FA), a minimum sample size of 40 individual desirable (FEAVER et al., 1986). To identify species-specific differences, calculations of statistical power would be needed to evaluate the minimum number of individuals needed per species so that comparisons can be made.

Among the papers included in this review, it was noted a lack of standardization in the number of test repetitions. Whereas some authors used single test and applied it only once (METTKE-HOFMANN et al., 2012; SILVA et al., 2020), others used up to seven different tests (CALLICRATE et al., 2011) or repeated the same test up to 17 times (FOX and MILLAM, 2007). Once temperament has been expected to be consistent over time (RÉALE et al., 2007), researchers should calculate repeatability or consistency, using repeated tests. Applying a temperament test only once may not reflect the animal's temperament. By repeating the tests, the effect from external variables dilutes and it is expected more reliable data, enabling to account for the consistency over time. However, the repetition must be carefully designed because the animals may habituate to the stimuli used (MCLAUGHLIN and WESTNEAT, 2023). Another way to assess temperament consistency across contexts is by using different tests.

1.4.2 Temperament dimensions investigated: cross species comparisons, methods and terminologies

Interindividual variation was mainly reported in 'boldness', 'neophobia / neophilia', 'exploration' and 'vigilance' within the species included in this review. Only three studies by Metke-Hofman (2012), Coutant et al. (2018), and Ramos et al. (2023) have investigated cross-species differences in temperament dimensions. In one of these studies, Metke-Hofman et al. (2012) compared the temperament of 10 species from the tribes Platycercini and Loriini (Psittaculidae), categorizing them as 'resident' or 'nomadic' (displaying migratory habit). Nomadic and resident species differed in 'exploration', with less exploration in species nomadic and with a broader diet. Coutant et al. (2018) compared *Amazona aestiva* and *Psittacus erithacus* parrots, finding that *A. aestiva* were more 'anxious / vigilant' and more 'curious / neophiliac' than the *P. erithacus*. Another study by Ramos et al. (2023) showed that *Amazona aestiva* parrots were less 'vigilant' than *Amazona vinacea* and *Amazona rhodocorytha*. However, due to the low sample size per species (*A. aestiva* = 23; *A. vinacea* = 10; *A. rhodocorytha* = 5) the authors recommended caution to interpret the species differences. It is worth noting that in all these studies comparing species, the sample sizes per species was low. To enable a valid cross-species comparison, larger sample sizes per species assessed under standardized environmental conditions would be necessary, what can be challenging to obtain in research involving these birds. Furthermore, cross-species temperament differences should be better understood if aspects of their ecology were integrated into the studies.

Further comparisons between the results of different papers, whether within the same species evaluated in different publications or in cross-species comparisons, could only be achieved with better standardization of methods and terminologies used to characterize temperament dimensions. Currently, authors have been using the same terms to describe different measures assessed under different contexts. Conversely, different terms have been used to describe the same measures. For example, 'proactivity' (VAN ZEELAND et al., 2013) and 'risk-taking' (FRANZONE et al., 2022; RAMOS et al., 2020) were similar to the dimension 'boldness' of other studies (DE AZEVEDO et al., 2017; LOPES et al., 2017). Thus, we suggest more efforts towards standardize the terminologies for expressing the temperament dimensions of Psittaciformes. We also suggest that future studies should provide the individuals' scores for the dimensions extracted allowing more objective comparisons between the results of different studies.

Attention must be paid to the context in which temperament is evaluated when characterizing each dimension. For example, Meehan and Mench (2002), and Krasheninnikova and Schneider, (2014) regarded as 'fearfulness' the animals' responses when facing novelty (novel objects or novel environments). In its turn, Ramos et al. (2023) related 'fearfulness' to the animals' reactions when being handled by humans. One possibility in this case should be avoid using the term 'fearfulness' in contexts of novelty to distinguish it from 'exploration' and 'neophobia / neophilia'. 'Exploration' should be used in the contexts of exploring novel environments, involving behaviors such as movements and displacements within the environment. Whereas 'neophobia / neophilia' should be used when novelty is related to novel objects, novel foods, or other stimuli rather than the environment. Despite this proposal for more standardization in terminologies, it is important to understand that temperament dimensions can overlap, as they are not exclusive and can be interconnected at behavioral, physiological, and genetic levels (RÉALE et al., 2007). In summary, defining temperament dimensions should be approached as a complex task. One should consider the context of the test, the type of stimuli to which the individuals were exposed, and the terms already used in the literature, trying to align each new finding with existing knowledge.

1.4.3 Topics of investigation and factors related with temperament

With respect to the subjects investigated in relation to temperament of Psittaciformes, the implications on conservation and parrots' releases in wild was the most frequent, with five publications (20.83 %). These studies focused in factors related to pre- and post-release behaviors (DE AZEVEDO and YOUNG, 2021). In only two of the five papers, the birds were, in fact, released (LOPES et al., 2017; SILVA et al., 2020). However, the others related temperament to situations that are embedded in the process of pre-release, such as pre-release training and management (DE AZEVEDO et al., 2017; FRANZONE et al., 2022; RAMOS et al., 2023). Knowing the different temperament profiles in a group, would help planning which animals to release in wild. For example, Lopes et al. (2017) suggested that shyer individuals should be released first because they form a more lasting social relationships with others native conspecifics and learn with them. Bolder individuals should be used to reinforce the reintroduced population because they tend to explore more the environment. The understanding about temperament in the context of conservation have potential to contribute to maintain the populations in wild as shown for other animal species, for which the temperament was related to reproductive success (BOTH et al., 2005; RAZAL et al., 2016). To date, only one study, conducted with cockatiels, related temperament with compatibility and reproductive success (FOX and MILLAM, 2014). Thus, this is a promising area for the study of temperament in Psittaciformes.

In the experimental studies, most of them evaluated temperament as a dependent variable, aiming to investigate how environmental factors such as environmental enrichment (CUSSEN and MENCH, 2015; FOX and MILLAM, 2007; MEEHAN and MENCH, 2002) and rearing methods affected parrots' temperament (FOX and MILLAM, 2004, 2007; FUNK and

MATTESON, 2004). Parrots' responses to novel object tests were modified after they went through an enrichment protocol, making animals less 'neophobic', by displaying shorter latencies to approach the object (MEEHAN and MENCH, 2002; FOX and MILLAM, 2007). They also became more aversive to familiar handlers after going through the enrichment protocol (MEEHAN and MENCH, 2002). Parrots' responses to novel object tests were also modified by the rearing method, with parent-reared birds showing longer latencies to approach a novel object (FOX and MILLAM, 2004) and hand-reared birds showing a tendency to be less fearful (FOX and MILLAM, 2007). Other factors also evaluated in these studies were the assessment of tests in individual and social contexts, with parrots tested in groups displaying more risk-prone behaviors than when those tested individually (KERMAN et al., 2018; KRASHENINNIKOVA and SCHNEIDER, 2014). One study was conducted to assess the effects of a dietary supplement on the 'shy-bold' axis of *Melopsittacus undulatus*, but in this case the treatment did not affect their temperament (CALLICRATE et al., 2011).

Regarding the studies conducted with temperament as independent variable, Cussen and Mench (2015) reported that different temperament dimensions affect the expression of abnormal behavior, with more neurotic birds showing more feather damaging behavior, and more extraverted birds expressing more stereotypic behaviors. Lopes et al. (2017) also tried to investigate the effects of temperament on survival after release of *Amazona aestiva* parrots, but no relationship was found.

Temperament is a phenotype, being shaped by genetic, epigenetic, and environment (GOLDSMITH et al., 1987; GROOTHUIS and CARERE, 2005). However, there are no studies that seek to understand the genetic basis of temperament in Psittaciformes. Evaluating how genotype influences phenotypic variation in temperament is important for understanding how natural selection has shaped the temperament of animals (VAN OERS and MUELLER, 2010). Environmental variations can also be responsible for gene expression modifications, such as methylations, and studies on how these epigenetic factors influence the temperament of animals are still scarce (VAN OERS et al., 2023).

The associations between the temperament and physiology have been studied in vertebrates and invertebrates (MCMAHON et al., 2022; RÁDAI et al., 2022), but no studies have been conducted for Psittaciformes. For example, in a study with pigs, those who resisted less in a backtest had a higher reactivity of the hypothalamic-pituitary-adrenal (HPA) axis than those who resisted more (RUIS et al., 2000). In addition, the relationships between temperament and the propensity to develop pathologies such as cardiovascular diseases, ulcers, stereotypies, and infectious diseases are already known (KOOLHAAS et al., 1999). Therefore, there is still a large field of research on temperament in Psittaciformes, for expanding studies investigating genetic, epigenetic, and physiological mechanisms underlying the behavioral interindividual differences. Understanding temperament, its underlying factors, and implications will be useful not only for scientists and researchers but also for people who work in more practical contexts, enhancing husbandry in zoos, breeding colonies, and wildlife rehabilitation centers, with potential to promoting improvements in animal welfare and conservation strategies.

1.5 CONCLUSION

This study aimed to integrate the studies of Psittaciformes' temperament in a systematized way, trying to understand the current state of this theme and identify gaps that could be investigated in future works. The temperament of Psittaciformes is not a widely investigated field. This can be evinced by the low number of publications on the theme and by the lack of methodological and conceptual standardization. There are no studies with free-living animals, therefore it would be interesting to move forward studies conducted in the wild. Even though 22 temperament dimensions were found for the Psittaciformes, it should be noted that there is a lack of standardization on the terminologies used, and this can cause confusion among researchers, who have been using different terms to describe similar dimensions. Thus, when defining a dimension, it is important to consider the context in which the temperament was evaluated and the existing term used to express this dimension in previous publications. Future comparative studies can help understand the development and evolution of temperament in the order Psittaciformes. Research on the genetic basis, as well as morphophysiological and neuroendocrine mechanisms underlying temperament variation in Psittaciformes should also provide valuable contributions to the field.

3 CHAPTER 2 – BEHAVIORAL VARIATION IN ADAPTATION TO RADIO COLLARS AND ITS RELATIONS WITH TEMPERAMENT IN DIFFERENT PSITTACID SPECIES

1.6 INTRODUCTION

Radiotelemetry is a technology used to assist in the search of free-ranging animals through the transmission and reception of VHS signals from collars that are attached to their bodies (PIOVEZAN & ANDRIOLO, 2004) and is frequently used in translocation studies with parrots (VOLPE et al., 2022; VILARTA et al., 2024; PURCHASE et al., 2024). However,, to our knowledge, there are no previous studies investigating the effects of radio collars or GPS collars on parrots' behaviors. These devices have been reported to cause behavioral, physical, and physiological adverse effects in other animals (BIBIANO et al., 2022; VAN DE BUNTE et al., 2021; STABACH et al., 2020). Even with acute responses to these collars, some studies have documented an adaptation to these devices, but the responses vary depending on the animal studied (WEBSTER & BROOKS, 1980; HAMLEY & FALLS, 1975; DENNIS & SHAH, 2012; LEGAGNEUX et al., 2013). Horback et al. (2012), for example, showed that trained African elephants (*Loxodonta africana*) did not show any behavioral changes when equipped with GPS collars.

Several factors can play a role in the animals' responses to the collars, such as the equipment's weight, as shown by Rasiulis et al. (2014) and Chivers et al. (2016), that demonstrated that heavier collars decreased the survival rate of migratory Caribou (*Rangifer tarandus*) and jeopardized the flight of Black-legged Kittiwakes (*Rissa tridactyla*). Nonetheless, individual aspects of the animals are also worthy of attention. Interestingly, Blanc and Brelurut (1997) reported that some red deers (*Cervus elaphus*) were more sensitive to GPS collars than others. Therefore, a more thorough investigation of interindividual aspects of adaptation to neck collars could provide new and valuable information for conservation and ecological studies. The assessment of temperament, for instance, could be used for that purpose.

Temperament is defined as interindividual behavioral differences that are consistent over time and across situations and contexts (RÉALE et al., 2007). For parrots, differences in temperament have been associated with migratory behavior (METTKE-HOFMANN et al., 2012), breeding success (FOX & MILLAM, 2014), responses to human handling (RAMOS et al., 2023), and expression of abnormal behaviors (CUSSEN & MENCH, 2015). Therefore, a relationship between temperament and the parrots' capacity to adapt to neck collars is expected. Thus, our study aimed to investigate the behavioral effects of neck collars on two captive neotropical psittacid species, the Scaly-headed parrot (*Pionus maximiliani*), and the Blue-winged macaw (*Primolius maracana*), and explore the relationship between temperament and interindividual differences in adaptation to the collars. We hypothesized that the collars would affect their routine behaviors, but they would adapt to the devices within the 7-day observation period by decreasing their interaction with the collars. In addition to it, we hypothesized that parrots with a certain temperament trait would adapt to the collars faster than others.

1.7 MATERIAL AND METHODS

1.7.1 Ethical note, animals used and study area

This study was approved by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute of the Environment and Renewable Natural Resources) - no. 02015.000580/2023-04; the Instituto Estadual de Florestas de Minas Gerais (State Forestry Institute) - no. 2100.01.0004298/2023-69; and the Ethics Committee on Animal Use from the Federal University of Juiz de Fora – n. 008/2023.

The animals used for the assessment of the behavioral effects of neck collars were a subsample of a group of 51 parrots that had their temperament assessed. This major group consisted of 23 Scaly-headed Parrots (*Pionus maximiliani*), 16 White-eyed Parakeets (*Psittacara leucophthalmus*), and 12 Blue-winged Macaws (*Primolius maracana*) (Figure 4). The adaptation to radio collars was assessed in 29 birds (17 Scaly-headed Parrots and 12 Blue-winged Macaws). All animals came from the Wildlife Rehabilitation Center of Juiz de Fora – CETAS/JF, Minas Gerais. Further details about their life history are currently unknown. They were kept in an aviary (12.9m length x 7.0m width x 3.0m height) in a Wild Animal Release Area on private land in Santana do Deserto, Minas Gerais, Brazil. The birds were kept along with other psittacids that were not used in this study and were fed daily by the same carer with banana, apple, mango, papaya, squash, watermelon, beetroot, sweet potato, guava, coconut, aubergine, carrot, corn, boiled egg, sunflower seeds, and fruits from trees next to the release site, depending on their availability. Water was available *ad libitum* through a fountain with running water.

Figure 4 - The three psittacid species used for the temperament assessment. From left to right: the Scaly-headed parrot – *Pionus maximiliani* (12 ♂, 6 ♀, 5 unknown), the Blue-winged macaw – *Primolius maracana* (7 ♂, 5 ♀), and the White-eyed parakeet – *Psittacara leucophthalmus* (9 ♂, 6 ♀, 1 unknown).

Source: Gustavo Nunes (2023).
Note: The animal's chest in the second photo was painted with non-toxic red ink and does not reflect its natural colors.

1.7.2 Temperament tests

To assess temperament, we used a test cage (1.17m length x 0.55m width X 0.50m height) put inside an empty aviary (aviary 'B'), next to the aviary in which the birds were kept daily (aviary 'A'). The back and sides of the cage were covered with a white fabric to limit the animal's visual field during the test. Only the front and the superior parts of the cage were not covered to enable the researchers (outside the aviary) to observe the animals. A camouflage cloth was hung on the aviary's mesh, separating the cage from the researchers (Figure 5).

We used two temperament tests: the 'novel object' test and the 'reaction to a person' test (Table 2), two of the most popular tests used in the literature to assess temperament in Psittaciformes (see section 2.3.7 in Chapter 1). These tests were done individually and repeated three times, with 57 days between the first and second repetitions, and 18 days between the second and third. In each repetition, a different stimulus was used for both tests to prevent possible habituation to the objects or the people (Figure 6).

Figure 5 - Test layout. The researchers would observe the animals from outside the aviary, behind the camouflage cloth.

Source: Gustavo Nunes (2023).

Each animal was moved from aviary 'A' to the test cage that was divided into five 20cm quadrants (Figure 7). They had 5 minutes to habituate inside the cage before the first test started (novel object). After that, the animal had a 3-minute interval before the second test started (reaction to a person). All tests were filmed for later analysis with a Canon® camera (model EOS Rebel T7). Behaviors were recorded using focal sampling every 10 seconds. We collected location, state, and event variables, described in Appendix A. Location and state variables were collected every 10 seconds, during 5 minutes, totaling 31 records in each test; event variables, however, were collected continuously. The latency to touch the object and the person was also recorded; if an animal did not touch the object or did not interact with the person, 'latency to touch' was regarded as 300 seconds (total test time).

Table 2 – Description of the tests used to assess the birds' temperament, and description of the stimuli used in each repetition of each test.

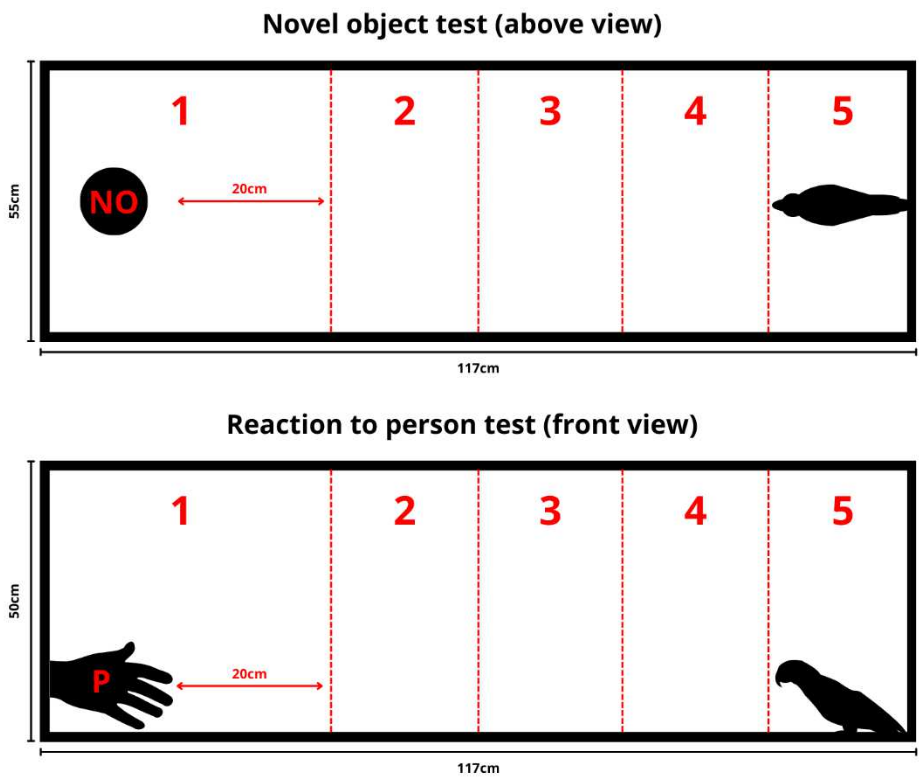
Test	Description	Repetitions	Stimuli
Novel object	A novel object to the animals was put inside the cage test and behaviors were recorded for 5 minutes.	3	For each repetition, three different objects were used in the following order: a yellow hat with colored dots (red, orange, green, and blue); a purple plastic ball; and a basket made of plant material fiber and with colored tapes (yellow, green, blue, and red).
Reaction to a person	A person stood still in the left side of the test cage with their right hand inside the cage and the animal's behaviors were recorded for 5 minutes. Each time the animal tried to interact with the person's hand, they would remove their hand and place it on the other side, and so on.	3	For each repetition, three different people participated in the following order: woman; man; and woman. The animals were familiar with these people because they constantly saw them during the test period.

Source: Elaborated by the author (2023).

Figure 6 - Stimuli used in the temperament tests. On the top row: objects used in the novel object tests for the three repetitions, respectively from the left to the right. On the bottom row: people who participated in the reaction to a person test in the three repetitions, respectively from the left to the right.

Source: Gustavo Nunes and Maria Eduarda Branco (2023).

Figure 7 - Representation of the sizes and distances of the quadrants of the test cage used to carry out the novel object test and the reaction to a person test with 51 individuals of the three psittacid species (*Pionus maximiliani*, *Primolius maracana*, and *Psittacara leucophthalmus*).



Source: Elaborated by the author (2023).
Note: NO = Novel object. P = Person's hand.

1.7.3 Fake radio collars

We used fake radio collars, and not real ones, because we did not want to risk damaging the real collars, that would be used in the release stage of the project. Fake radio collars were built to closely resemble the real radio collars (Nortronic®, model TTE-B1/COM-A1). For that, we used sheathed wire rope (1.75 mm diameter), aluminum pipe (14 mm diameter), and wire rope gland (Figure 8). The mean weight and standard deviation of *P. maracana* and *P. maximiliani* were 242 ± 20.7g and 229 ± 21.1g, respectively. The real collars weighted 16 g, while the fake collar weight was 7 g, corresponding to 2.89% of the mean weight of the Blue-winged Macaws and 3.05% of the mean weight of the Scaly-headed Parrots. Due to the materials used to create the fake collars, we could not match the collars weight. Fake collars were attached to the animals on the day before the beginning of the behavioral observation.

Figure 8 - On the left: neck collars used for the behavioral observations with collars. On the right: attaching a collar in a Blue-winged Macaw. In the photo, the wire rope gland is being compressed by some pliers to be sealed.

Source: Gustavo Nunes and Maria Antônia, respectively (2023).

1.7.4 Behavioral observations in response to the collars

Behavioral observations were conducted inside aviary 'A', which was enriched, and with all animals together. Two observers collected data with a reliability percentage of 91.93% (on average), using focal sampling with instantaneous recordings. We recorded state and event variables (Appendix A), with event variables being collected continuously. Sessions were carried out twice a day: morning sessions began around 09 AM and afternoon sessions began around 02 PM.

Baseline observations were conducted without the collars. At this stage, 20 animals participated (16 Scaly-headed parrots, and 4 Blue-winged macaws). The observation period went over 5 consecutive days, and each session lasted 2.5 hours, totaling 25 hours of observation. State variables were recorded every 10 minutes during the observation period, totaling 16 records for each animal in each session (160 records).

For the observations with fake radio collars, 29 animals participated (17 Scaly-headed parrots, and 12 Blue-winged macaws). The observation period went over seven consecutive days (2 more days than the baseline observation because we also wanted to investigate the adaptation period), and each session lasted 2 hours, totaling 28 hours of observation. These sessions were shorter than the baseline observation because we added two more days, but the total observation time was similar for the two moments. State variables were recorded every 5 minutes during the observation period, totaling 25 records for each animal in each session (350 records). Behaviors such as 'Interaction with collar' and 'Interaction with conspecifics collars' were recorded only during this stage, both as state and event variables. Anytime an animal would remove its collar, a new one would be attached to it before the beginning of the next observation session. If the collar presented any risk to the animal's welfare, like wires hanging out, it would be replaced by a new one before the beginning of the next observation session.

The interval between baseline observation and observation with fake collars was 115 days. During this period, some animals died and new birds joined the group. Thus, the different sample size for the baseline observations and the observations with the fake collars.

1.7.5 Statistical analyses

To extract the temperament dimensions, we calculated the coefficients of variation from the collected categories for all temperament tests for each animal to assess the dispersion degree of the variables. Then, we calculated the mean time spent in each collected variable for all tests for each animal. Mean values from these variables were then converted into z-scores. Lastly, we used a principal component analysis (PCA) to reduce data dimensions and obtain the main temperament dimensions from the animals assessed. Variables considered for naming the dimensions were those with scores equal to or higher than 0.40. To choose the names for the dimensions, we considered the names already existing in the literature and the context in which the tests were done, as suggested in the first chapter's discussion.

The records for the behaviors registered during the observations (baseline and with collars) were transformed into a percentage of the total time observed. To test the hypothesis that the collars would affect the expression of routine behaviors, we used a paired t-test (Student's t-test) to compare the percentage of the behaviors expressed during the behavioral observation without and with collars. For this test, we only included the parrots that participated in both observations ($n = 16$).

To determine whether the parrots would adapt to the collars over the 7 days of observation, we applied the non-parametric Friedman test with a paired Wilcoxon post-hoc test with an adjustment in the p-value using the False Discovery Rate correction (FDR). To examine whether the adaptation could be related to the animal's temperament, we used the parametric two-way repeated measures ANOVA, with temperament categorized in 1 = more negative loadings; 2 = intermediate loadings; and 3 = more positive loadings, for all the dimensions extracted from the temperament analyses. Since the animals were maintained at an outdoor aviary, they were susceptible to environmental conditions. On the third day of observations, it rained, and we could only start our afternoon session at 4 PM, whereas on the other days, we started at 2 PM. We evaluated our data to see the adaptation pattern over time, and we found this change to be enough to vary our data. Therefore, we decided not to include the data from this day in the analysis.

Finally, to investigate the difference between species in the behavior ‘interacting with collar’, we applied a repeated measures ANOVA.

1.8 RESULTS

1.8.1 Temperament analyses

To obtain the main temperament dimensions, the first five principal components (PC) from the principal component analyses (PCA) were retained (eigenvalues > 2). The PCs were named: Activity, Boldness, Anxiety, Neophobia/Neophilia, and Proximity to Humans (Appendix B).

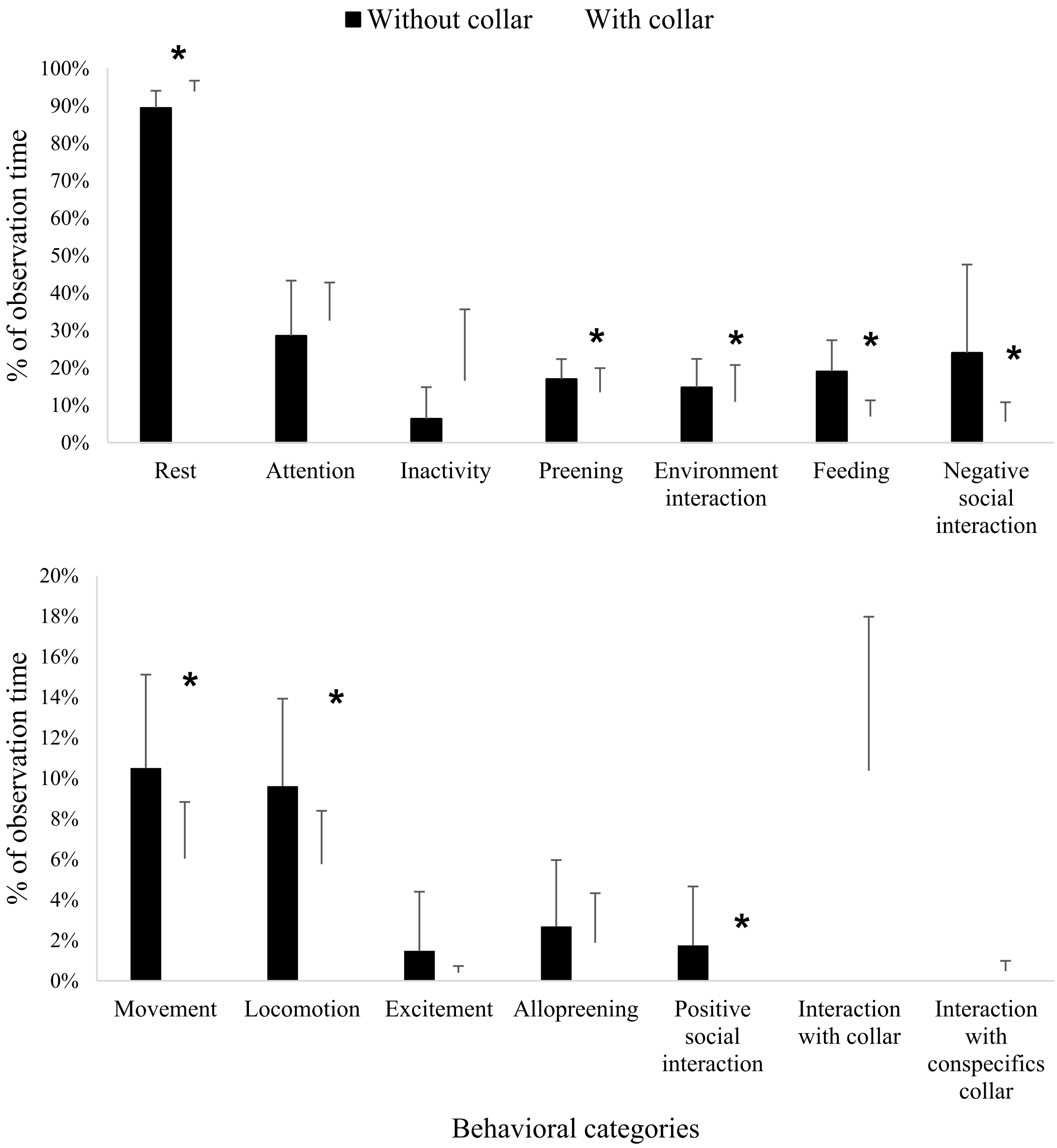
The first PC was characterized as ‘Activity’ and explained 23.11% of the variance with positive loadings for variables that reflected a more active profile, whereas variables with negative loadings reflected a more inactive profile. The second PC (‘Boldness’) explained 17.83% of the variance with positive loadings for variables reflecting a more reactive profile, whereas variables with negative loadings reflect a more proactive profile. The third PC (‘Anxiety) explained 10.74% of the variance with positive loadings for variables reflecting a more anxious profile, whereas variables with negative loadings reflect a less anxious profile. The fourth PC (‘Neophobia/Neophilia’) explained 8.61% of the variance with positive loadings for variables that reflected a more curious profile, whereas the variable latency to touch had high negative loading, reflecting a less curious profile. The fifth PC (‘Proximity to Humans’) explained 7.19% of the variance, with positive loadings reflecting a ‘closer to humans’ profile, whereas variables with negative loadings reflect aversion to humans. The scores for the five temperament dimensions for each bird are presented in Appendix C.

1.8.2 Differences in behavior without collar x with collar

The mean percentages of time spent in the categories ‘rest’ ($t = -4.15$, $p \leq 0.001$), ‘movement’ ($t = 4.26$; $p \leq 0.001$), ‘locomotion’ ($t = 3.88$; $p \leq 0.001$), ‘preening’ ($t = 2.23$; $p = 0.04$), ‘environment interaction’ ($t = 2.35$; $p = 0.03$), ‘feeding’ ($t = 5.25$; $p \leq 0.001$), ‘negative social interaction’ ($t = 3.41$; $p = 0.004$), and ‘positive social interaction’ ($t = 2.41$; $p = 0.03$)

differed significantly for the observations with and without collar. For inactivity, a tendency for significance was observed (t = -2.00; p = 0.06). The animals, when collared, spent less time in ‘movement’, ‘locomotion’, ‘preening’, ‘environment interaction’, ‘feeding’, ‘negative social interaction’, and ‘positive social interaction’, and more time at ‘rest’, and ‘inactivity’ than when they were not wearing the collars (Figure 9).

Figure 9 - Percentage of observation time of behaviors recorded during observations without collars and with collars (n = 16).



Source: Elaborated by the author (2024).
Note: (*) = behaviors with significant differences ($p < 0.05$).

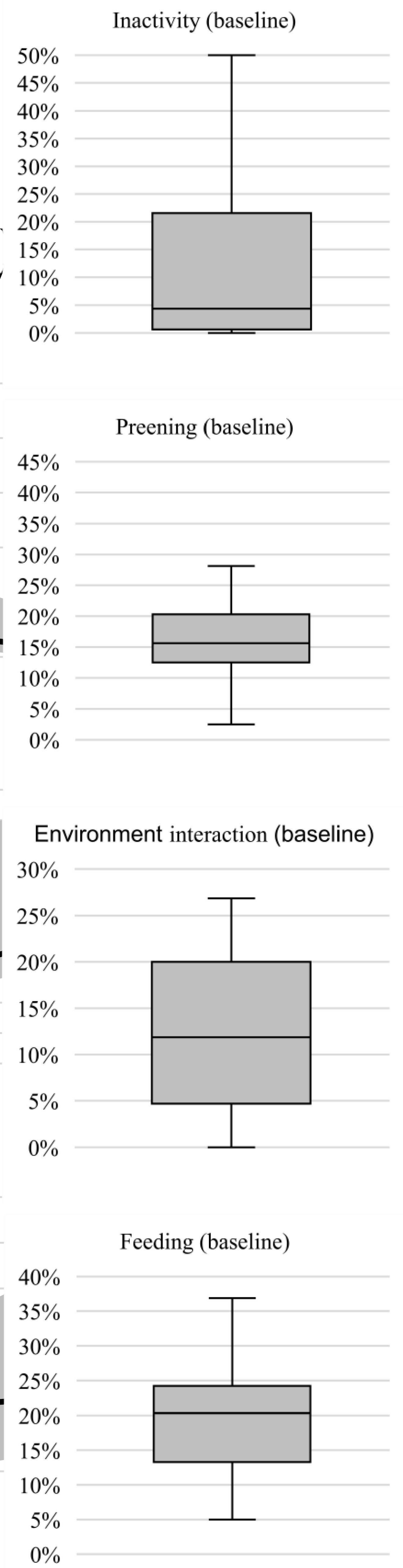
1.8.3 Adaptation to the collar over time

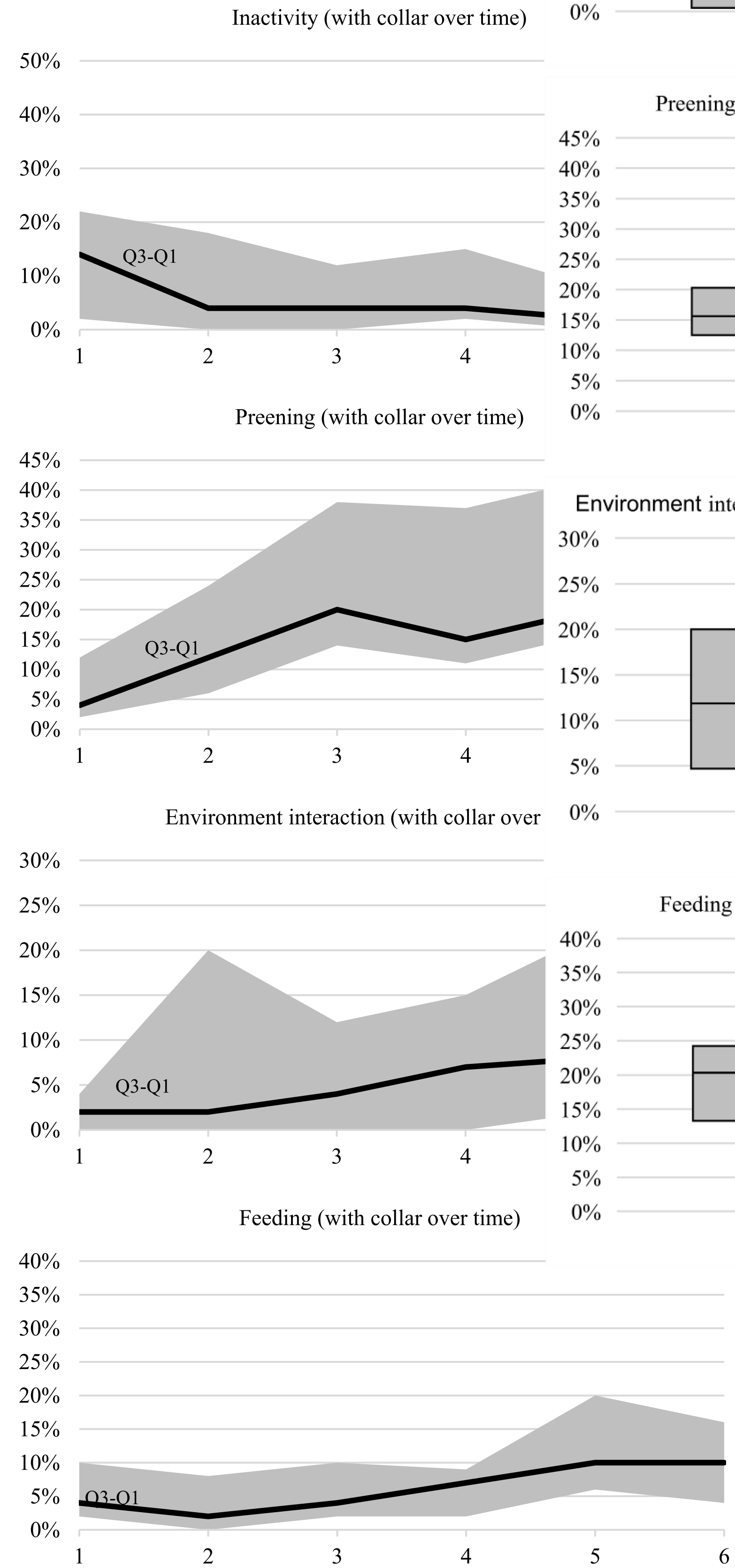
For the non-parametric Friedman test, we found an effect of day in ‘inactivity’, ‘preening’, ‘environment interaction’, and ‘feeding’ ($p < 0.05$). That is, these behaviors changed over time. For ‘inactivity’, the expression decreased over time; and for ‘preening’, ‘environment interaction’, and ‘feeding’, the expression increased (Figure 10).

For the comparison of temperament classes over the adaptation period, we found a significant effect of the interactions Days*Activity for the behavior ‘inactivity’ [$F_{10,130} = 2.10$; $p = 0.03$], Days*Anxiety for the behaviors ‘feeding’ [$F_{10,130} = 2.92$; $p = 0.002$] and for ‘inactivity’ [$F_{10,130} = 1.94$; $p = 0.04$], and Days*Neophobia/Neophilia for environment interaction [$F_{10,130} = 2.09$; $p = 0.03$] (Figure 11). ‘Active’ and ‘anxious’ parrots decreased their expression of inactivity over time. For the dimension ‘Anxiety’, ‘intermediate’ parrots showed an increase in ‘feeding’ on day 5, compared to day 2. Finally, for the dimension ‘Neophobia/Neophilia’, ‘intermediate’ parrots showed an increase in ‘environment interaction’ on the last day of observation, compared to the first day. These differences, however, were not significantly different between the classes of temperament. That is, the behavioral expression of the parrots was not influenced by temperament.

We also found a significant effect of ‘Proximity to humans’ for ‘preening’ [$F_{2,26} = 4.55$; $p = 0.02$] (Figure 12), with ‘less close to humans’ parrots exhibiting more preening than the ‘intermediate’ and ‘closer to humans’ parrots.

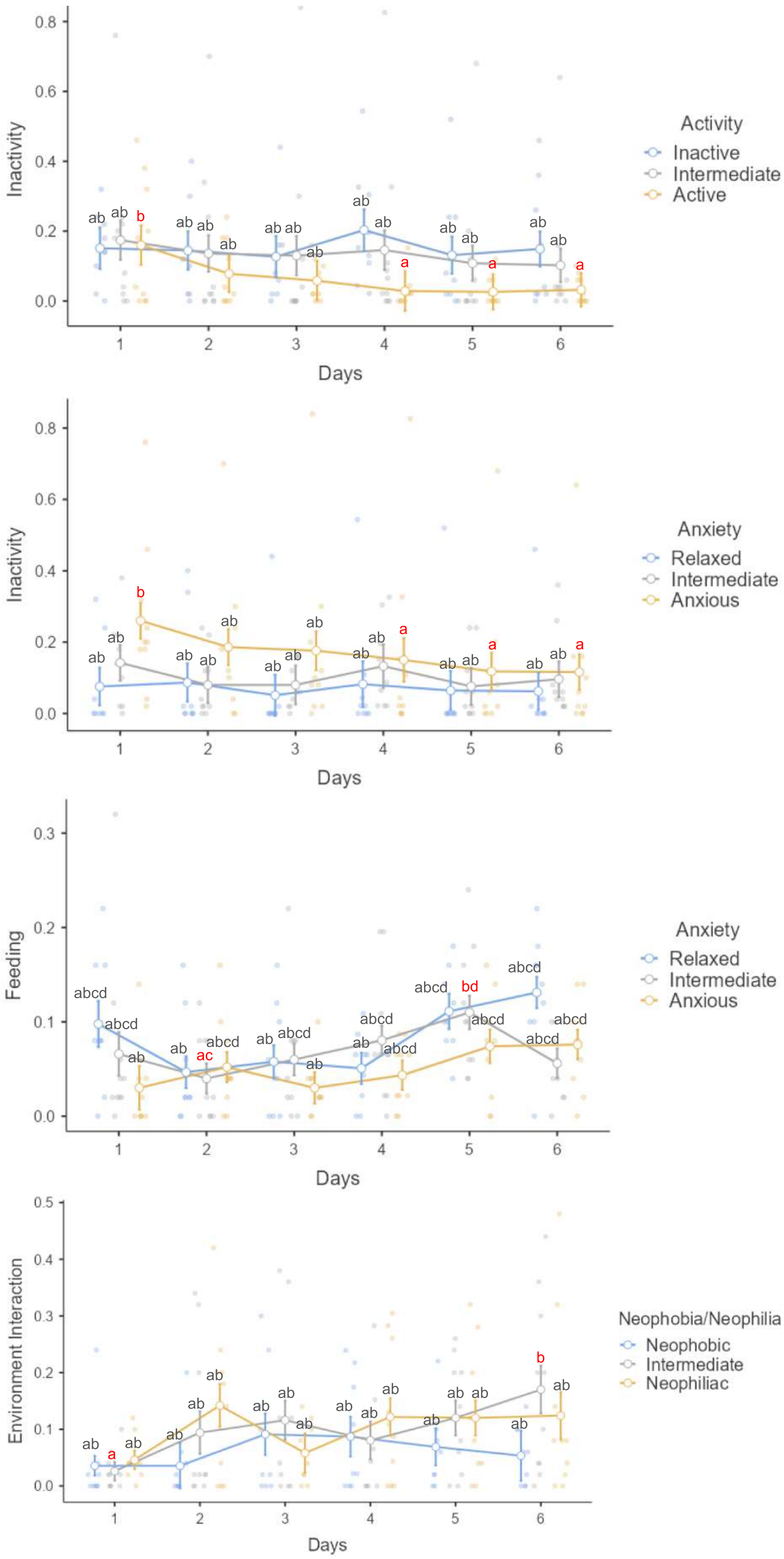
Figure 10 - Temporal variation of 'inacti… …nteraction', and 'feeding' in collared birds over day… (n = 20).





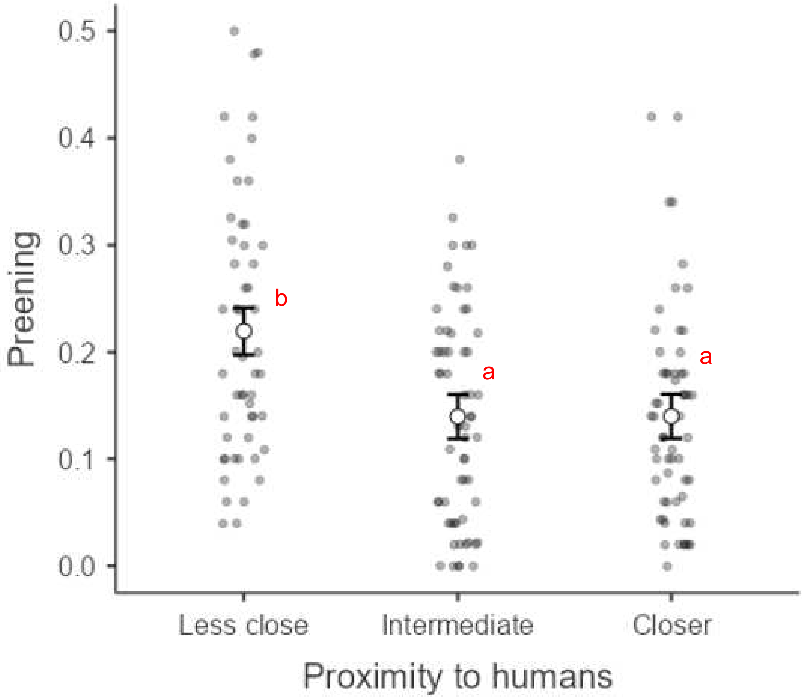
Source: Elaborated by the author (2025).

Figure 11 - Estimated means and standard error of the interactions Days*Temperament for ‘inactivity’, ‘feeding’, and ‘environment interaction’ (n = 29).



Source: Elaborated by the author in JAMOVI (2025).

Figure 12 - Boxplot for the categories of 'Proximity to humans' in 'preening'.



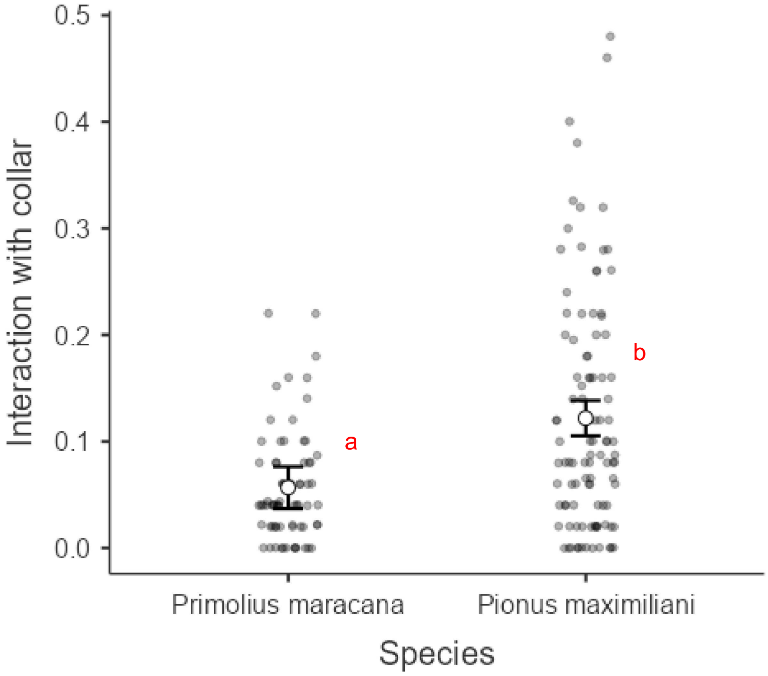
Source: Elaborated by the author in JAMOVI (2024).

1.8.4 Differences between species

Three Scaly-headed parrots (8353, 8241, 4232) managed to remove their own neck collars over time, and one of them removed its collar twice (8241). Four Blue-winged macaws (110, 8266, 8267, 4331) had their collars replaced because they were in conditions that could harm their wellbeing. Of these four, one of them had its collar replaced twice (8266) (Appendix C).

Comparing the adaptation process for the two species, we found a significant difference for species in 'interaction with collar' [$F_{1,27} = 6.4$; $p = 0.02$]. The Scaly-headed parrots interacted with the collars significantly more than the Blue-winged macaws (Figure 13).

Figure 13 - Estimated marginal means of ‘interaction with collar’ for Pionus maximiliani and Primolius maracana throughout the observation days.



Source: Elaborated by the author in JAMOVI (2024).

1.9 DISCUSSION

This study explored the differences in the effects of neck collars on the behavior of two neotropical psittacid species (Scaly-headed parrots and Blue-winged macaws) during a 7-day observation period. It also investigated whether the birds’ temperament was related to adaptation to the collar. We extracted 5 temperament dimensions (Activity, Boldness, Anxiety, Neophobia/Neophilia, and Proximity to Humans). The collars affected the birds' general behavioral budget, but over time they began redirecting some behaviors back to a frequency similar to the pre-collaring phase. Temperament was not associated with adaptation to the fake collars, but the Scaly-headed Parrots interacted more with the collars throughout the observation period.

Extensive literature has shown that attaching devices such as tracking collars to animals’ bodies can cause behavioral, physical, and physiological adverse effects (BIBIANO et al., 2022; VAN DE BUNTE et al., 2021; STABACH et al., 2020). These effects can not only compromise the animal's welfare but also the quality of the data collected (BRUHOLT, 2018). In our study, the collars affected the expression of routine behaviors of the two species evaluated. They spent more time at rest and tended to spend more time inactive. They also spent less time preening, interacting with the environment, feeding, interacting with other animals (positively and negatively), moving, and locomoting.

The increase in the expression of stationary behaviors and the decrease in general activity have been reported in studies with other animals. Meadow voles (*Microtus pennsylvanicus*) equipped with transmitter collars had great reductions in activity (HAMLEY & FALLS, 1975; WEBSTER & BROOKS, 1980). Red deers (*Cervus elaphus*) equipped with GPS collars were less involved in negative and positive social interactions (BLANC & BRELURUT, 1997). Indeed, positive social interactions almost disappeared for the collared deers during the collar observation period, which corroborates our result for the positive social interactions. A decrease in locomotion and an increase in stationary behaviors were also reported for zebras (*Equus burchelli antiquorum*), which had a 50% reduction in locomotion (BROOKS et al., 2018); Black-legged Kittiwakes (*Rissa tridactyla*), which flew less and spent more time at the nest (CHIVERS et al., 2016); and Charolais cows (*Bos taurus*), which had a significant increase in 'standing stationary', also showed locomotion reduction while wearing tracking devices (MANNING et al., 2016). Therefore, our findings are in agreement with the literature.

Some of these studies have also reported an adaptation or habituation to the devices attached to the animals, by documenting behaviors returning to their pre-collaring expression levels (HAMLEY & FALLS, 1975; WEBSTER & BROOKS, 1980; RACHLOW et al., 2014; BRUHOLT, 2018). In our study, during the 7-day observation period, the expression of 'inactivity' decreased whereas the expression of 'preening', 'environment interaction', and 'feeding' increased, reaching levels similar to the behavioral expression of the observation without the collars.

There is no consensus about the adaptation period for animals wearing tracking collars, especially for birds. However, enough evidence shows that animals can habituate to these devices, even though they might suffer acute alterations in the first days or even years. Meadow voles (*Microtus pennsylvanicus*), for example, returned their activity expressions to the basal line after 4 (WEBSTER & BROOKS, 1980) and 10 days (HAMLEY & FALLS, 1975). Legagneux et al. (2013), on the other hand, documented that the body condition of female Greater snow geese only improved after 2 and 3 years. Dennis and Shah (2012) also reported a change in the movement pattern of Brushtail possums (*Trichosurus vulpecula*) that diminished with time. The behavioral responses vary depending on the animal studied, therefore it is paramount for projects that seek to use tracking devices on animals to conduct a thorough investigation of the animal's behavioral responses to not jeopardize their welfare and to ensure the quality of the data collected. Horback et al. (2012), for instance, assessed the behavioral responses of African elephants (*Loxodonta africana*) that were already trained to carry collars and found no difference in behavior expression between the observations without and with the GPS collar. Thus, training the animals beforehand can also guarantee the quality of the data and the success in the translocation of the animals.

In our study, the parrots began redirecting some behaviors such as 'inactivity', 'preening', 'environment interaction', and 'feeding' back to the pre-collaring expression during the 7 days, but they did not stop interacting with the devices. The parrots adapted to the devices only partially. The adaptation process seems to have two distinct behavioral components, one related to the changes in routine behavior, and another related to the animals perception and interaction with the collar. Therefore, they did not completely adapt to the devices during the seven days. Currently, many reintroduction studies with parrots have been carried out (VOLPE et al., 2022; VILARTA et al., 2024; PURCHASE et al., 2024). They often use tracking devices or tags to identify them once released, however, none of them have conducted a thorough investigation on the behavioral alterations that these devices may cause. Studies investigating the effects of transmitters in free-ranging animals have shown that they can jeopardize body condition and reduce body mass (WEBSTER & BROOKS, 1980; CYPHER, 1997; TUYTTENS et al., 2002; LEGAGNEUX et al., 2013), in addition to affecting movement patterns (DENNIS & SHAH, 2012; RACHLOW et al., 2014; CHIVERS et al., 2016; BROOKS et al., 2018), survival rates (WEBSTER & BROOKS, 1980; EAGLE et al., 1984; COTTER & GRATTO, 1995; CYPHER, 1997), and physical integrity (EAGLE et al., 1984; CYPHER, 1997). Massey et al. (1988) even reported a nest deserted by a Least tern (*Sterna antillarum browni*) equipped with a transmitter.

Another aim of this study was to investigate whether temperament was related to the animals' adaptation to the collars. We related temperament to behavioral alterations. However, except for the interaction between days and Anxiety for 'feeding', temperament was not strongly associated with the behavioral changes caused by the fake collars. This is evinced by the few significant results from the ANOVA. Blanc and Brelurut (1997) reported that some individuals of red deer (*Cervus elaphus*) were more sensitive to GPS collars than others. It seems that there are some individual aspects underlying the capacity to adapt to these devices, as we can conclude from the study previously mentioned, however we can infer, from our findings, that temperament may not be one of these aspects. The lack of significant results for the ANOVA may also be a reflection of the short observation period that was not enough to discriminate differences in the behavior based on temperament. As a matter of fact, as explained in Chapter 3, the released parrots only began interacting less with the radio collars from the second month forward.

Even though we did not find significant differences in temperament regarding their behavior toward the collars, we saw that the Scaly-headed Parrots interacted more with their collars throughout all days included in the analysis. Thus, even though temperament was not associated to the adaptation process, there seems to be an underlying aspect influencing the different responses between the two species.

Few studies have measured the levels of glucocorticoid hormones and metabolites in animals with neck collars. Durnin et al. (2004) and Moll et al. (2009) did not find any significant differences in the levels of these hormones for Giant pandas (*Ailuropoda melanoleuca*) and White-tailed deers (*Odocoileus virginianus*), respectively. Stabach et al. (2020), however, reported an increase in fecal glucocorticoid metabolites levels of oryx (*Oryx dammah*). In our study, we did not assess the physiological parameters of the parrots and we deduced that the interaction with the collar was a stressful behavior indicative of non-adaptation. These animals, nonetheless, are very curious by nature and their interaction with the device could also be a response to curiosity. Therefore, for future studies, it would be insightful to include physiological parameters aligned with behavioral observations so that we know for a fact whether they are stressed or just curious. Another limitation was the weight of the fake collars that differed from the real ones. However, even though the fake collars were lighter than the real collars, significant behavioral changes were still found.

1.10 CONCLUSION

This study assessed the effect of fake collars on the behavior of two species (Scaly-headed parrots and Blue-winged macaws) and investigated whether the birds' temperament was related to adaptation to the device. The collars affected the birds' general behavioral budget, and even though they began to redirect their behaviors back to baseline conditions, they did not stop interacting with the collars, adapting only partially until the seventh day. These behavioral changes com jeopardize the adaptation and survival of released birds by reducing exploring behaviors and increasing stationary behaviors, leading to starvation and troublesome social interactions. Temperament seemed not to be associated with adaptation to the fake collars, but Scaly-headed Parrots interacted more with the collars than the Blue-winged macaws throughout the observation period. Our results regarding the behavioral changes agree with the literature; this was the first study that tried to relate these changes with temperament. Even though we did not find any substantial relation, the differences in the behavior of the two species are noteworthy for further investigations.

4 CHAPTER 3 – ASSOCIATING TEMPERAMENT AND BEHAVIOR AFTER BEING RELEASED IN WILD FOR TWO NEOTROPICAL PSITTACID SPECIES

1.11 INTRODUCTION

The success of psittacine releases is dependent on several factors, like method of release, number of individuals released, presence of native parrots (WHITE et al. 2021), presence of predators, availability of supplementary feeding, habitat quality (WHITE et al., 2012), and origin of the animals (BRIGHTSMITH et al., 2005). Some techniques have been studied to aid the success of psittacine releases, such as free flight training (BRIGHTSMITH et al., 2024), antipredator training (LOPES et al., 2017), recognition of native food (VILARTA et al., 2024), and flight and human aversion training (FRANZONE et al., 2022). Recently, other studies have also investigated the relationship between the behavior of parrots and the success of these releases (BUSSOLINI et al., 2024; SILVA et al., 2020; LOPES et al., 2018). Thus, understanding pre- and post-release behavioral patterns can help us identify more suitable animals for release (CORNEJO et al., 2005).

Vilarta et al. (2021), for instance, noted that, when releasing golden conures (*Guaruba guarouba*) during their reproductive season, there were more events of aggressiveness and deaths due to territoriality than when they were released outside their reproductive season. Even though aggressiveness in reproductive seasons may be considered a natural behavior, understanding it can aid in the release success. No wonder they did not record any aggressive behavior when they released a second group outside their reproductive season. Too much aggressiveness, however, could be considered abnormal behavior (WELLE & LUESCHER, 2006) and can be maladaptive for these animals. In Lopes et al. (2018), for example, three released Amazon parrots (*Amazona aestiva*) began attacking people on the release site. In addition, more than 1/3 of the parrots released in this study presented maladaptive behaviors for the wild, and local people even captured three birds.

Consistent interindividual behavioral differences in animals (hereafter: temperament) consist in a consolidated science field that has shown implications for several contexts of animals under human care (RÉALE et al., 2007). Also, we can evaluate temperament in release studies to establish connections between animals' behavioral patterns and what happens to them after release. By way of example, bolder swift-foxes (*Vulpes velox*) died faster than shyer ones after being released (BREMNER-HARRISON et al., 2004). Contrarily, more exploratory turtles (*Emydoidea blandingii*) had higher survival rates than less exploratory ones (ALLARD et al., 2019).

For Psittaciformes, temperament is still not a widely investigated field, and studies focusing on temperament and factors related to pre-and post-release aspects of psittacine reintroductions are still scarce (chapter 1). To illustrate, Silva et al. (2020) stated that shyer Amazon parrots (*Amazona aestiva*) were more dependent on the aviary after release and observed that deaths of bold parrots were associated with exploratory and anthropogenic factors. Related to that, Lopes et al. (2017) claimed that released bolder parrots were less social than shyer ones.

This study investigated the associations between temperament assessed in captivity of two released neotropical psittacid species, the Scaly-headed Parrot (*Pionus maximiliani*) and the Blue-winged Macaw (*Primolius maracana*), and their behavior post-release during five months. We hypothesized that: a) the exit order, dependency on the aviary, and dependency on the supplementary feeding would be related to the parrots' temperament, with shyer birds depending more on the aviary and supplementary feeding, and taking longer times to exit the aviary; b) parrots would express more exploratory behaviors such as movement and feeding in the wild than they did in captivity; and c) behaviors expressed in nature during the five months of monitoring would be associated to the parrots' temperament, like active parrots dispersing sooner, and bold parrots being more susceptible to environmental risks.

1.12 MATERIAL AND METHODS

1.12.1 Ethical note, animals used, and study area

This study was approved by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute of the Environment and Renewable Natural Resources) - no. 02015.000580/2023-04; the Instituto Estadual de Florestas de Minas Gerais (State Forestry Institute) - no. 2100.01.0004298/2023-69; and the Ethics Committee on Animal Use from the Federal University of Juiz de Fora – n. 008/2023.

All animals came from the Wildlife Rehabilitation Center of Juiz de Fora – CETAS/JF, Minas Gerais. In total, we released 17 birds: 10 Scaly-headed Parrots, and 7 Blue-winged Macaws (Table 3). They were selected for release based on their scores from a flight capacity test (1 to 4, being 1 the worst flight condition and 4 the best) and a food offer test (1 to 3, being

1 the less aversive score and 3 the more aversive) carried out after 13 consecutive days of flight training and human aversion training (for more detailed information about the scores, see FRANZONE et al., 2022). Their responses during the training were also considered when deciding which parrots would be released. Before this study, these birds went through a behavioral observation period in captivity, in addition to having their temperament assessed using two different tests: the novel object test and the reaction to a person test (see sections 3.2.2 and 3.2.3). Their scores for the dimensions extracted, as well as their scores for the flight capacity test and food offer test, are presented in Table 3.

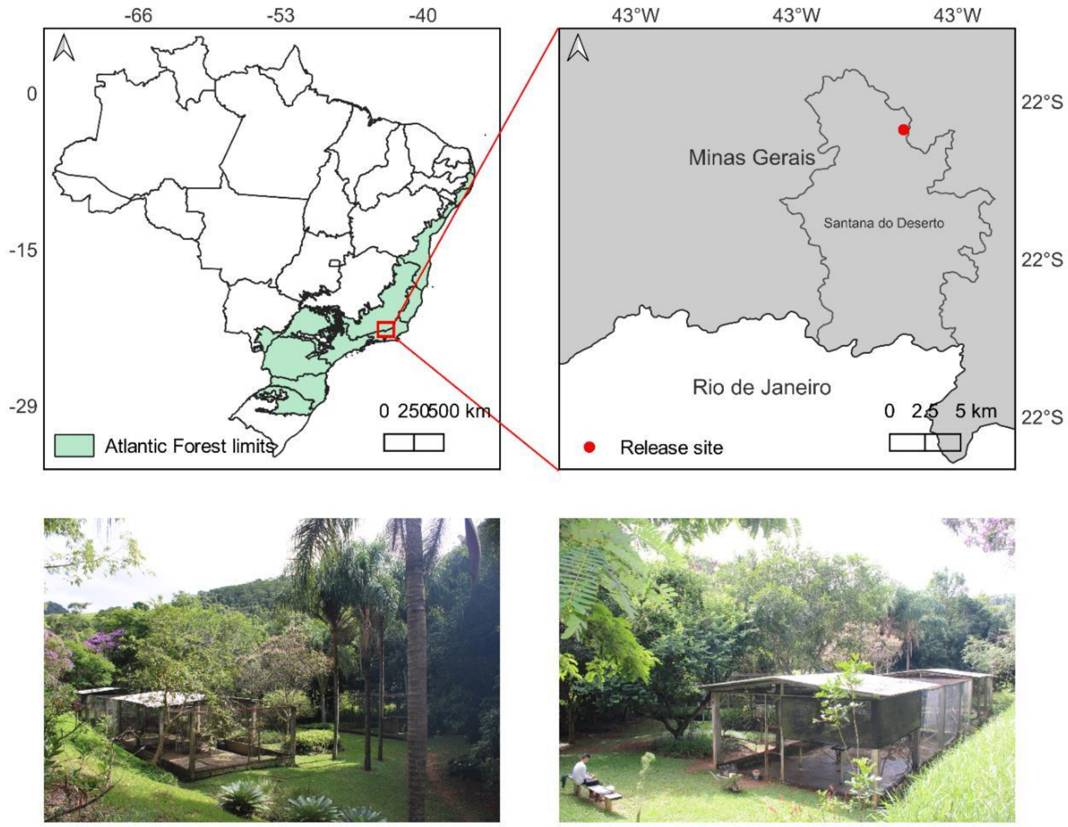
Table 3 - Scores for the five temperament dimensions extracted from the Principal Component Analysis for the parrots selected, as well as their scores for the flight capacity test and the food offer test.

Animal Tag	Sex	Activity	Boldness	Anxiety	Neophobia/Neophilia	Proximity to humans	Flight capacity score	Food offer score
001	♂	-2.38	0.21	0.66	0.38	0.56	4	3
002*	♂	-2.35	-5.53	-0.49	3.7	-0.05	4	2
006*	♂	-3.05	2.73	1.10	-0.33	-0.96	4	3
008	♀	-2.98	1.27	0.5	0.18	0.63	4	3
009*	♀	5.23	-1.94	2.74	-0.02	0.4	4	3
010*	♂	-2.02	-5.63	-2.01	-0.36	3.23	4	3
011*	♂	-2.69	2.62	1.41	-0.51	-0.46	4	3
013*	♀	2.24	-1.11	2.53	-0.73	0.86	4	2
014*	♂	2.22	-0.39	1.65	-0.5	-0.54	3	3
017	♀	-2.92	1.65	0.75	-0.38	0.66	2	3
019	♂	0.63	-0.39	1.57	-0.11	0.59	4	3
020*	♂	1.69	1.73	1.63	0.33	0.96	4	3
021*	♀	0.54	-1.55	-1.86	-0.6	-0.75	4	3
023	♂	0.93	1.09	-0.69	-0.05	0.98	3	1
027*	♀	-0.87	-1.9	-4.53	0.53	-0.92	3	3
028*	♂	-2.64	1.21	0.67	-1.41	0.89	3	3
029	♀	-2.26	-1.71	-0.96	2.7	-0.84	2	3

Source: Elaborated by the author (2024).
Note: Animals with (*) received radio collars. For the definitions of scores from the flight capacity and food offer tests, see Franzone et al. (2022). Animals with scores 3 and 4 for the flight capacity test and with scores 2 and 3 for the food offer test may be better suited for release. 001 to 017 = *Pionus maximiliani*; and 019 to 029 = *Primolius maracana*.

This study was conducted at a Wild Animal Release Area in a private estate in a rural region of Santana do Deserto, Minas Gerais, Brazil (Figure 14). Wild Animal Release Areas are properties registered by IBAMA that can release wild animals (BRASIL, 2021). This release site had two aviaries: ‘A’ (12.9 m length x 7.0 m width x 3.0 m height), and ‘B’ (8.5 m length x 7.0 m width x 3.0 m height). The birds were kept in aviary ‘A’ throughout the acclimatization period (habituation before release) alongside other psittacids, that were not used in this study. They were fed daily by the same keeper with commercial fruits and seeds such as banana, apple, mango, papaya, squash, watermelon, beetroot, sweet potato, guava, coconut, aubergine, carrot, corn, sunflower seeds, and fruits from trees next to the release site, depending on their availability. Water was available at will through a fountain with running water. New psittacids were sporadically added to the aviary during the acclimatization of the parrots of the study.

Figure 14 - Wild Animal Release Area in which the 17 parrots (10 *Pionus maximiliani* and 7 *Primolius maracana*) were released and monitored from march to august 2024. The pictures from below show the aviaries in which the birds were kept, and their surroundings.



Source: Elaborated by the author in QGIS (2024).

1.12.2 Release

The 17 selected birds were transferred into the aviary ‘B’ five days before release and, on this same day, they were marked with non-toxic ink (Walmur Instrumentos Veterinários Ltda®). For the next four days, they received another flight training (as described in FRANZONE et al., 2020), which was done twice a day (one session in the morning and one in the afternoon), but on the fourth day - the day before release - only the morning session was done. During the afternoon of this same day, we attached the radio collars with the ID tags to the birds' necks. In total, 11 animals received the device (Table 3). The decision of which bird would receive the radio collar was based on their temperament scores for the dimensions obtained (animals with the more extreme scores were chosen rather than those with intermediate scores). The birds were released on March 10th, 2024, at 07 AM. As the door of the aviary was left open, the parrots could leave the enclosure feely. However, food was used to lure them out of the aviary (Figure 15). The aviary door was kept open only when the team was monitoring the animals so we would close the door for the lunch break and at the end of the day, avoiding predators entering the aviary (domestic animals such as dogs, birds of prey, and tiger cats). Supplementary feeding was provided in feeders outside the aviary (Figure 15). All these strategies characterize a soft release, method associated with successful releases in previous studies as reviewed by White et al. (2012), and Resende et al. (2021).

Figure 15 - Soft-release: the aviary door was left opened so the birds could leave on their own, and supplementary feeders were made available outside the aviary. To the left, Scaly-headed parrot number 001 leaves the aviary for the first time; and to the right, a feeder with supplementary food outside the aviary.

Source: Talys Jardim (2024).

1.12.3 Short-term post-release monitoring

After the animals were released, they were monitored for 6 consecutive weeks (41 days). During the first week (7 days), they were monitored from 07 AM to 11 AM (4 hours) and from 3 PM to 5 PM (2 hours), totaling 6 hours daily. For the rest of the 34 days, the birds were monitored from 07 AM to 9 AM (2 hours) and from 3 PM to 5 PM (2 hours), totaling 4 hours daily. The observation period was managed when external variables, such as rain, would hinder us from doing the observations. Therefore, on some days we would start the observation period sooner or later, or we could not complete the stipulated time. Behavioral recordings were done by the same person using focal sampling with instantaneous recording at 7.5-minute intervals. In addition to the behaviors recorded (Appendix A), we documented their exit order from the aviary. On the 32nd day post-release, we started directing the remaining birds toward the exit. For that, we used a capture net to make them leave the aviary. At this point, the door was kept open for the whole day and was closed only in the early evening, around 5 PM. This process was repeated until the 41st day – the last day of immediate monitoring after release.

1.12.4 Long term post-release monitoring

At the end of the sixth week, behavioral recordings were done once a week for five weeks and then five more times every two weeks, alternating morning and afternoon periods. The last day of data collection was August 20, 2024, resulting in 5 months and 10 days of monitoring (163 days). Data was collected just like described for the short-term monitoring, but in this stage, we also documented reports from the people who worked at the release site to keep track of the birds' activities. They informed us whether they had seen the birds, the sighting location, whether they were wearing the radio collar, the species, whether they entered houses or came close to people and if they were feeding on anything. We only used in our analysis reports that we could identify the bird.

1.12.5 Statistical analyses

Exit order was divided into three categories: 1 = parrots that left on the first day; 2 = parrots that left on the second day; and 3 = parrots that left from the third day until the 32nd day. To investigate if temperament dimensions differed between the categories of the exit order, first, we used a one-factor variance analysis (Oneway ANOVA Welch), with temperament dimensions as the dependent variables and the exit order as the independent variable. After that, we used a multiple comparisons test (Tukey Test) to identify which categories of exit order were different.

The records for the behaviors registered during the observations were transformed into percentages of the total time observed. To test the hypothesis that the birds' behavior would change after release, we used a paired samples t-test (Student's t) to compare the percentages of the behaviors expressed during the behavioral observation in captivity and nature. This analysis used the behaviors registered during the first six weeks after release.

We used a two-way ANOVA for repeated measures to investigate whether animals with distinct temperaments would behave differently after release. This analysis was run to search for effects of days during the first 7 days, weeks during the first 6 weeks, and months during the six months.

A logistic regression was run to explore an association between temperament and events that occurred during the post-release monitoring of these animals. Table 4 describes such events.

Table 4 - Description of the events recorded during the monitoring of the 17 parrots released in Santana do Deserto, from march to august 2024.

Event	Description
Walking on the floor	The parrot lands on the ground/ walks on the ground.
Interacting with animals outside the released group	The animal interacts with other parrots present in the vicinity that were not released with the group of this study.
Returning to captivity	The animal is captured and returned to captivity because it did not show adaptative skills.
Removing the radio collar	The animal managed to remove its radio collar.
Entering or coming close to inhabited houses	The animal entered houses or stood very close to houses with people.
Allofeeding	The animal allofeeds. This event was recorded for both the giver and the receiver.
Trying to copulate	The animal tries to copulate. This event was recorded for both animals involved in the attempting.
Feeding on natural items	The animal eats fruits, seeds, or flowers available around the release site.
Returning to the release aviary	The animal returns willingly to the aviary.
Disappearing	The animal is not seen at the release site.
Remaining close to the release site until the last day of monitoring	The animal is seen at the release site until the last monitoring day.

Source: Elaborated by the author (2025).

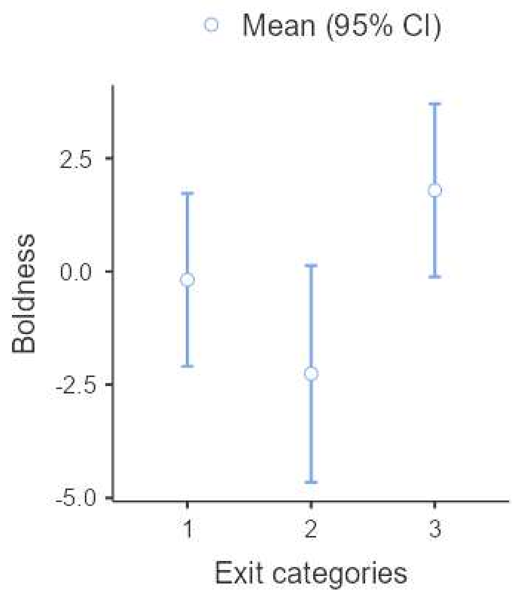
1.13 RESULTS

1.13.1 Exit order

The first animal to leave the aviary was a Scaly-headed parrot (010) only seven minutes after the aviary was opened. In total, nine (52.94%) animals left the aviary on the first day within two and a half hours after the door was opened (010, 001, 008, 006, 019, 020, 028, 029, 013). On the second day, five (29.41%) new parrots left the aviary within the first 4 hours (009, 027, 021, 002, 014), and, by the end of the day, only the three parrots that had not left yet were kept inside. Therefore, by the end of the second day, 82.35% of the birds had left the aviary. On the ninth day, another bird left the aviary (011), and the remaining two (017, 023) did not leave at any moment until the 32nd day, when we began directing them toward the exit.

Assessing the effect of temperament on exit order, we observed that only 'Boldness' was significant ($p = 0.009$). We found a tendency for category 3 to be different than 2 ($p = 0.055$) with a mean difference value of -4.05. In other words, parrots that took longer to leave the aviary (category 3) were shyer, compared to those that left on the second day (category 2), which were bolder. However, categories 1 and 3 did not differ, and neither did categories 1 and 2 ($p > 0.05$) (Figure 16).

Figure 16 - Relation between the exit categories (1 = animals that left in the first day; 2 = animals that left in the second day; and 3 = animals that left from the third to 32nd day) and the temperament dimension 'Boldness' (n = 17).



Source: Elaborated by the author in JAMOVI (2024).
Note: The bolder the animal, the lower the score. The shyer the animal, the higher the score.

1.13.2 Differences in behavior captive x nature

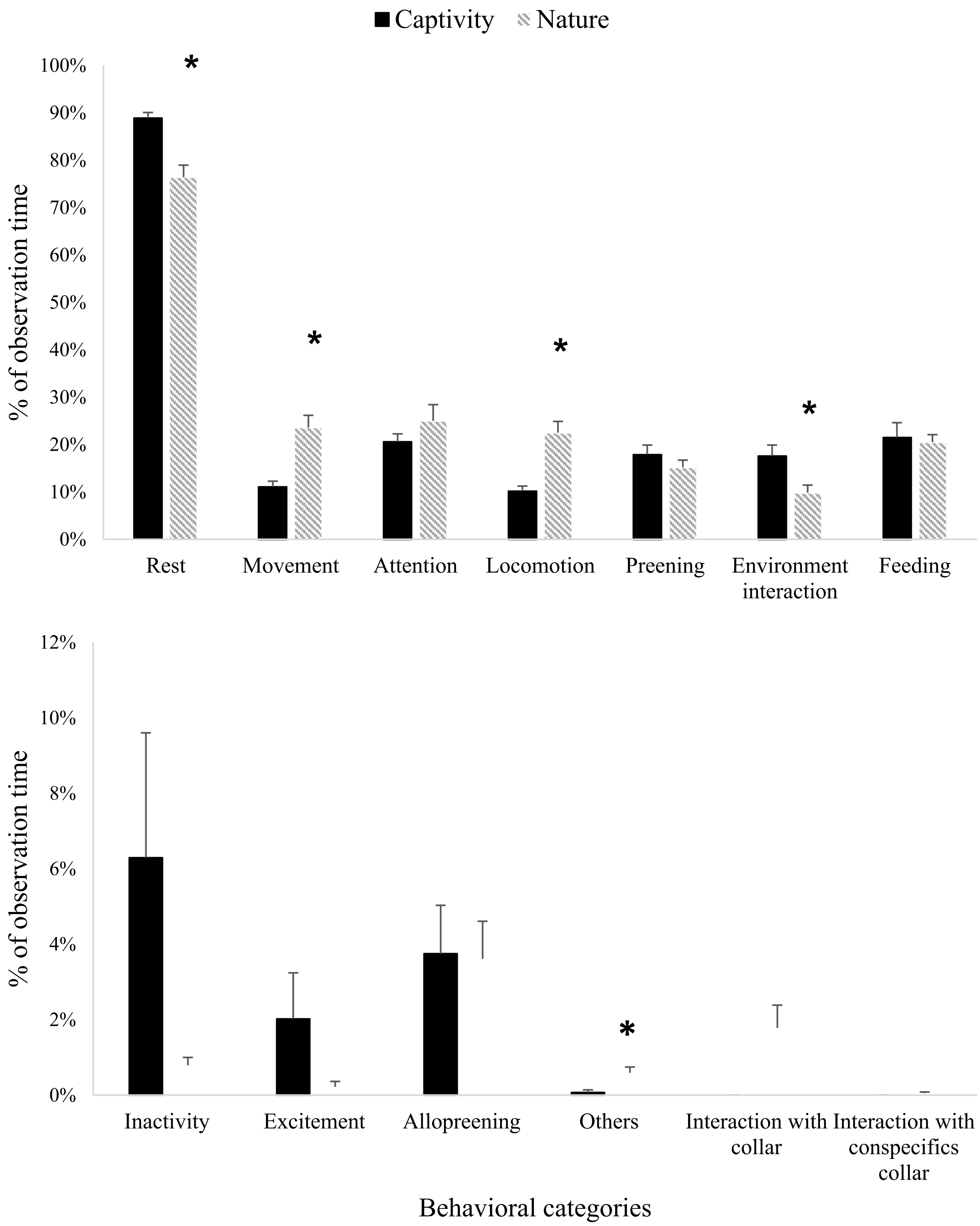
Mean percentages of time spent in the categories 'rest' ($t = 4.79$; $p \leq 0.001$), 'movement' ($t = -4.79$; $p \leq 0.001$), 'locomotion' ($t = -4.96$; $p \leq 0.001$), 'interaction with environment' ($t = 2.94$; $p = 0.02$), and 'others' ($t = -2.83$; $p = 0.02$) differed significantly for pre- and post-release ($p < 0.05$). After being released into the wild, the animals spent less time at 'rest' and 'interacting with the environment', and more time in 'movement', 'locomotion', and 'other' behaviors than in the pre-releasing period in captivity (Figure 17).

1.13.3 Behavior immediately after being released (7 first days post-release)

At the end of the first week, compared to the first days after release, we noted that the birds had already begun exploring more distant areas. More specifically, on the third day, we noted that they started exploring the canopy of the trees and made longer flights. During the first week, two Scaly-headed parrots and one Blue-winged macaw were even seen approximately 300 m and 220 m from the release aviary, respectively, but they could not be identified. Two parrots (001, 009) had already shown great independence, even though they kept feeding on the supplementary feeders. Others kept coming back into the aviary frequently. Some would come back to spend the night and others would come back for a few minutes to eat the food inside or follow another bird. Some parrots began disappearing for longer periods during the day, like 009 and the paired couple 019 and 020, which would show up together flying from farther distances.

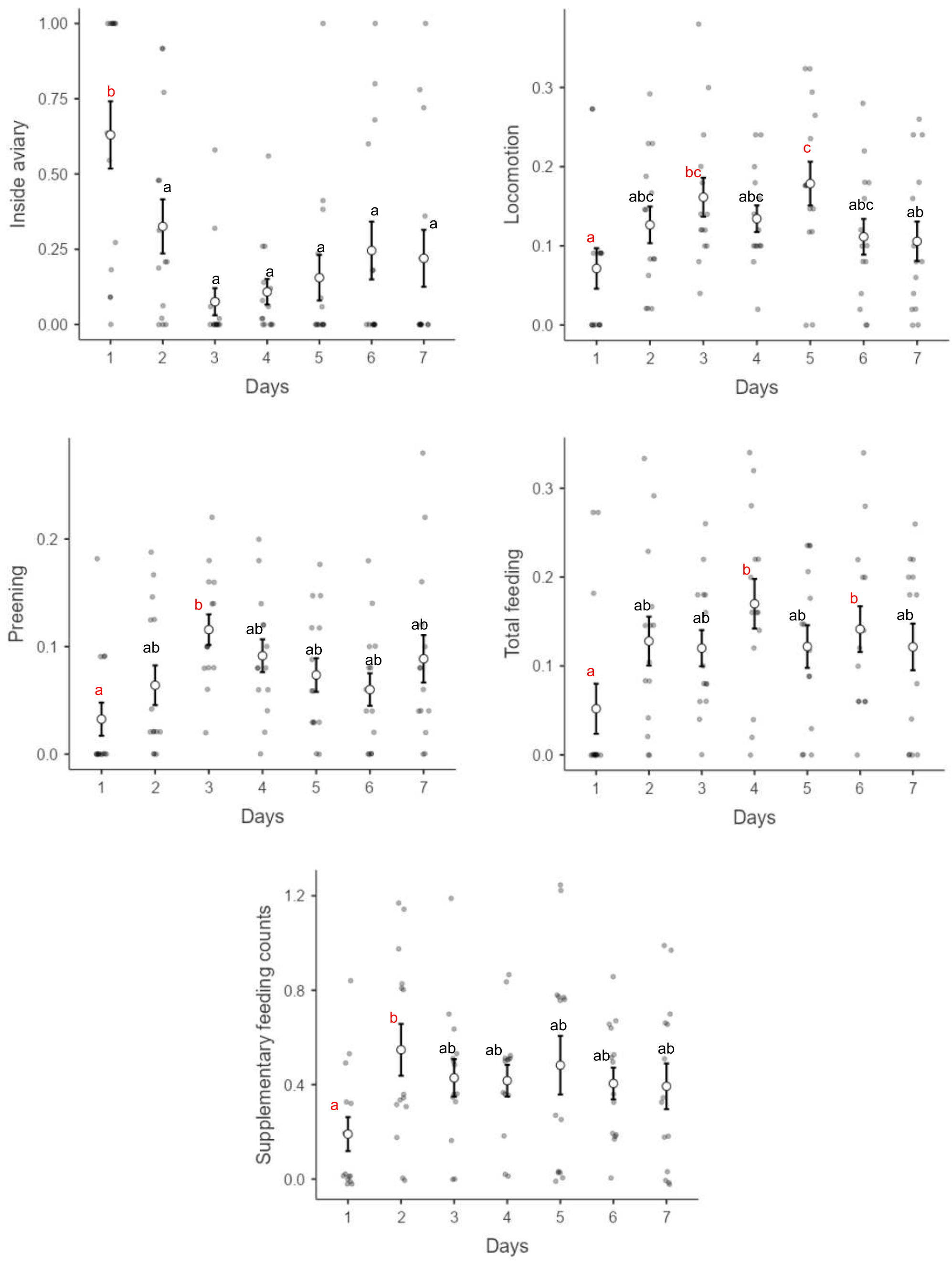
For the evaluation of the behavioral changes over the first week (7 days) of monitoring, we found a significant effect of the days for the categories 'inside aviary' ($F_{6,78} = 10.3$; $p < 0.001$), 'locomotion' ($F_{6,78} = 5.11$; $p < 0.001$), 'preening' ($F_{6,78} = 3.01$; $p = 0.01$), 'total feeding' ($F_{6,78} = 3.72$; $p < 0.003$), and 'supplementary feeding counts' ($F_{6,78} = 2.5$; $p = 0.03$) (Figure 18). 'Rest' ($F_{6,78} = 3.42$; $p = 0.005$), 'movement' ($F_{6,78} = 3.25$; $p = 0.007$), 'supplementary feeding' ($F_{6,78} = 2.21$; $p = 0.05$) and 'allopreening' ($F_{6,78} = 2.63$; $p = 0.02$) were influenced by days. However, there were no significant p-values in the post-hoc comparisons. None of the behavioral categories above was associated with any of the five temperament dimensions ($p > 0.05$).

Figure 17 - Percentage of observation time of behaviors recorded during captivity and during the first 6 weeks post-release. Feeding in nature consisted of 9.61% natural feeding and 10.91% supplementary feeding.



Source: Elaborated by the author in EXCEL (2024).
Note: The percentage of time interacting with collar and with conspecifics collar was measured only for the parrots that were released with a radiocollar (n = 11).

Figure 18 - Estimated marginal means for the behaviors post-release: ‘inside aviary’, ‘locomotion’, ‘preening’, ‘total feeding’, and ‘supplementary feeding counts’ during the first 7 days post-release.



Source: Elaborated by the author in JAMOVI (2024).

In the analysis of the effect of temperament on behavior throughout the first seven days post-release, we found a significant effect for the interactions days*Anxiety for ‘inactivity’ ($F_{12,66} = 2.261$; $p = 0.02$), days*Activity for ‘environment interaction’ ($F_{12,66} = 2.04$; $p = 0.03$), days*Proximity to humans for ‘interacting with collar’ ($F_{12,66} = 1.93$; $p = 0.05$), and days*Boldness' for 'returns to aviary' ($F_{12,66} = 2.07$; $p = 0.03$). However, we did not find any significant p-values in the post-hoc comparisons for all interactions above.

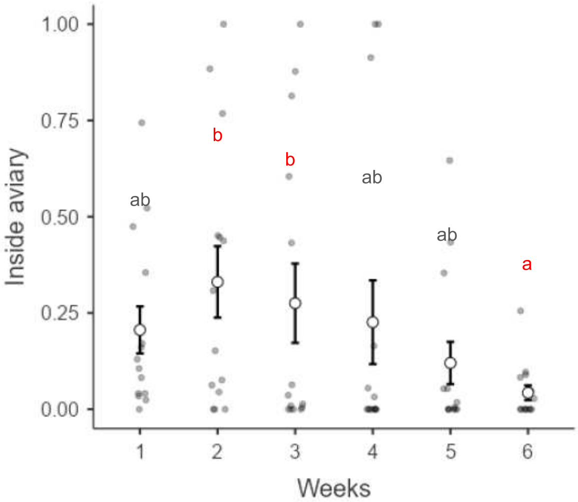
Other differences were found for the categories of 'Activity' in 'excitement' ($F_{2,11} = 4.3$; $p = 0.04$), and for the categories of 'Neophobia/Neophilia' in 'inactivity' ($F_{2,11} = 4.25$; $p = 0.04$). However, these differences seemed to be influenced by their few records since there was no statistical difference between the categories in the post-hoc comparisons.

1.13.4 Behavior during 6 weeks post-release (41 days)

At the end of six weeks post-release, some parrots kept entering the aviary frequently. We even noted that more parrots would seek shelter inside the aviary on wetter and cloudier days. Some native macaws even appeared and interacted with others from the release group. We would see some parrots flying away from the release site in the morning, around 07 AM. On the 15th day, we recorded a first attempted copulation between 008 and 010 and, on this same day, 009 disappeared during the whole day and appeared back again only on the 34th day (19 days gone), remaining there until the 38th day, when it disappeared again until the end of the sixth week. On the 18th day, 001 disappeared too and two days later, we were notified that it had entered an employee's house, approximately 2 km from the release site. We could adequately identify this parrot because the employees were instructed to photograph it. On the 21st day, 001 returned to the release site, and 027 managed to remove its radio collar. The Scaly-headed parrot 006 showed some aggressive behaviors towards the Blue-winged macaws when they landed on the supplementary feeders, scaring them away and not letting them feed on it. Some parrots that would be gone for most of the day would return to the release site and spend a considerable amount of time eating from the supplementary feeders. On the 32nd day, we began directing toward the exit the animals that were still inside the aviary (017, 023) and, by the 35th day, 023 disappeared. We saw it for the last time approximately 300 m away from the release site on this same day after finishing the afternoon behavioral observations. During the few days it remained at the release site, this macaw was seen in the canopies and most of its recordings were non-visible because we could not locate the bird up there. The parrot 017 was not adapting well so, at the end of the sixth week, we decided to send it back to the rehabilitation center. The macaw 029 also disappeared on the 35th day and was never seen again.

In the analysis of the effect of temperament on behavior throughout the first 6 weeks (41 days) post-release, we found a significant effect of the weeks for 'inside aviary' ($F_{5,65} = 4.07$; $p = 0.003$), but this difference was not associated with any of the five temperament dimensions ($p > 0.05$) (Figure 19). There was a decrease in time spent inside the aviary in week 6, compared to weeks 2 and 3. 'Returns to aviary' had an effect on the interactions between weeks and 'Activity' ($F_{10,55} = 2.41$; $p = 0.02$), and weeks and 'Anxiety' ($F_{10,55} = 2.43$; $p = 0.02$) (Figure 20). Less anxious parrots returned significantly less to the aviary in the fourth and sixth weeks than in the first week. Our analyses, however, did not result in any significant p-values in the post-hoc comparisons for 'Activity', even though the interaction week*Activity was significant ($p = 0.02$).

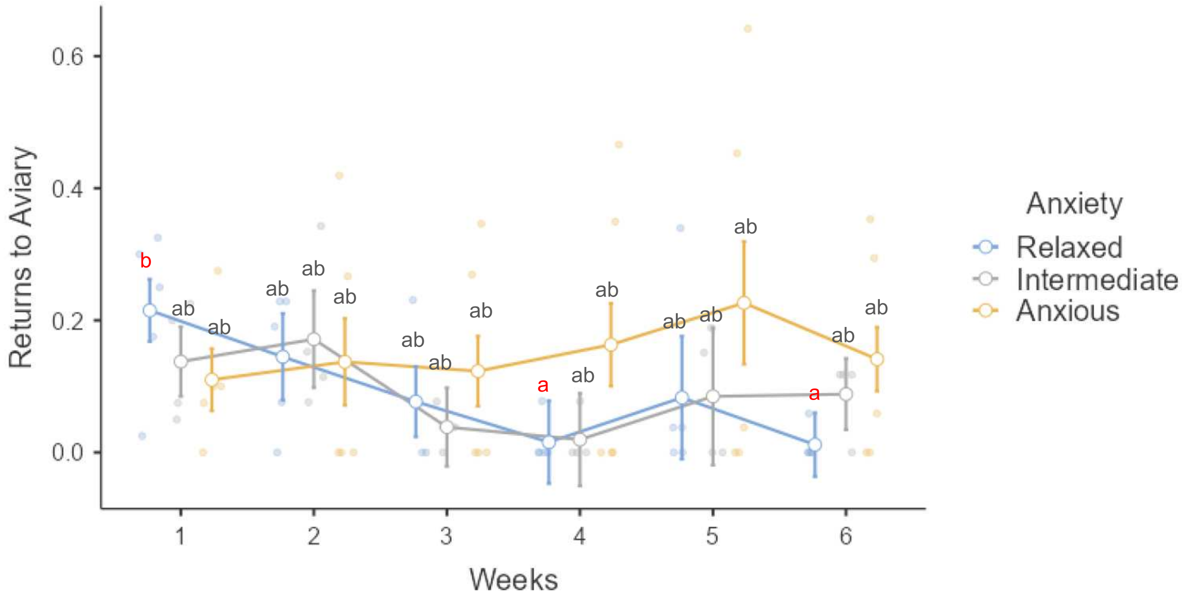
Figure 19 - Estimated marginal means for 'inside aviary' during the first 6 weeks post-release.



Source: Elaborated by the author in JAMOVI (2024).

We also found a significant effect for the interaction weeks*Neophobia/Neophilia for 'natural feeding' ($F_{10,55} = 2.26$; $p = 0.03$). However, this analysis also did not result in any significant p-values in the post-hoc comparisons.

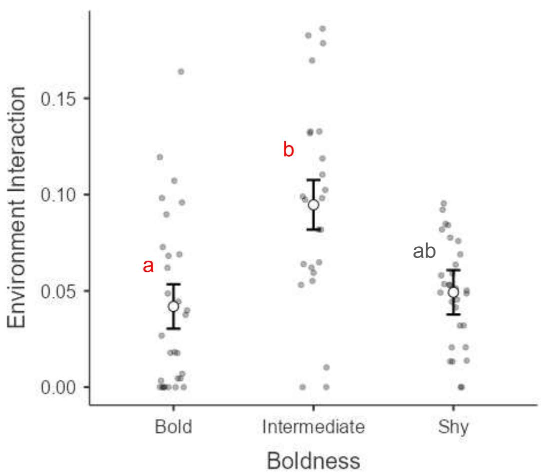
Figure 20 - Estimated marginal means for the interaction weeks*anxiety in 'returns to aviary'.



Source: Elaborated by the author in JAMOVI (2024).

A difference in the categories of 'Boldness' was found for 'environment interaction' ($F_{2,11} = 5.29$; p = 0.02) (Figure 21). Intermediate parrots interacted more with the environment than bolder animals (p = 0.03) throughout the 6 weeks and tended to interact more than shyer individuals (p = 0.06).

Figure 21 - Estimated marginal means for the categories of 'Boldness' in 'environment interaction'.



Source: Elaborated by the author in JAMOVI (2024).

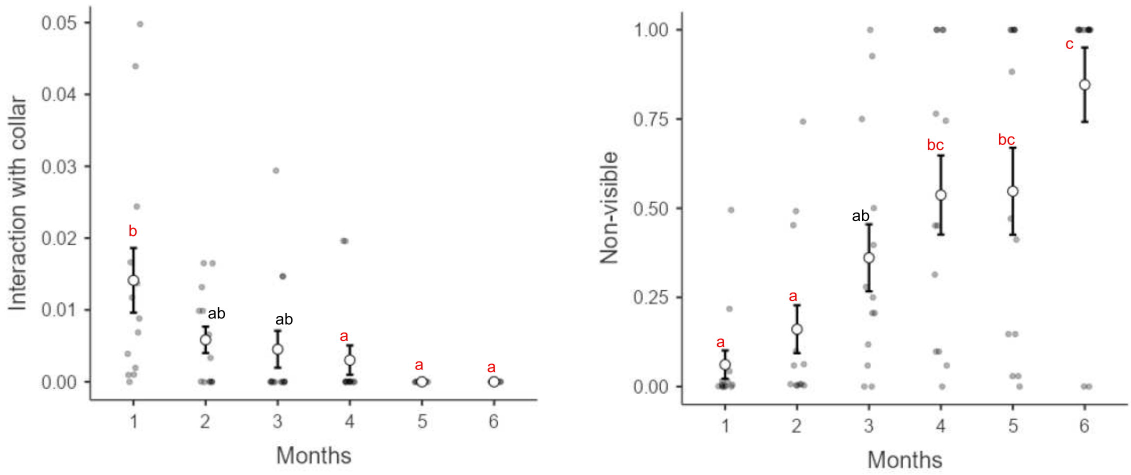
1.13.5 Behavior during 6 months post-release (163 days)

At the beginning of the third month, all animals were still at the release site (except 023 and 029), but soon after, 006, 008, and 028 also disappeared and were never seen again. The paired macaws 019 and 020 paired with other birds: 019 paired with another macaw from the release group, 021, and 020 paired with a White-eyed parakeet (*Psittacara leucophthalmus*) that was probably released by the rehabilitation center in a city close to the release site of the study because the parakeet also had a leg ring. From this point, the parrots spent less time at the release site, returning more during feeding time. We also identified a communal roosting tree with the help of an employee who noticed fresh feces every morning under a tree on his way to the aviary.

In the fourth month, 009 disappeared again. We began seeing these parrots flying approximately 1 km away from the release site more frequently. At the end of the fifth month, nine parrots were still at the release site (002, 010, 011, 013, 014, 019, 020, 021, 027 = 52.94%), six disappeared (006, 008, 009, 023, 028, 029 = 35.29%), and two were sent back to the rehabilitation center (001, 017 = 11.77%). For the monitoring trip of the sixth month, we only saw two parrots (002, 010) in the afternoon. On the morning of this same day, the team of the rehabilitation center had been at the release site to collect some birds from the aviary. Probably, this movement scared the released parrots away. We registered the first confirmed death for 014, which had spent considerable time walking over the aviary. The cause of death was predation, but we were not able to identify the animal. We could identify the bird because we found its tag, together with feathers, one of its feet, and its leg ring.

In the analysis of the effect of temperament on behavior throughout 6 months post-release (163 days), we found a significant effect of the month for 'supplementary feeding' ($F_{4,48} = 2.71$; $p = 0.04$), but there were no significant p-values in the post-hoc comparisons. 'Interaction with collar' was also affected by months ($F_{5,60} = 5.24$; $p < 0.001$) (Figure 22). However, none of these behaviors was associated with the five temperament dimensions. 'Non-visible' was also influenced by months ($F_{5,60} = 15.81$; $p < 0.001$) (Figure 22).

Figure 22 - Estimated marginal means for ‘interaction with collar’ and ‘non-visible’.



Source: Elaborated by the author in JAMOVI (2024).

‘Rest’ ($F_{10,50}$ = 3.71; p < 0.001), ‘movement’ ($F_{10,50}$ = 2.68; p = 0.01), ‘attention’ ($F_{10,50}$ = 3.61; p = 0.001), ‘locomotion’ ($F_{10,50}$ = 2.78; p = 0.008), ‘preening’ ($F_{10,50}$ = 1.99; p = 0.05), ‘environment interaction’ ($F_{10,50}$ = 2.77; p = 0.008), ‘natural feeding’ ($F_{10,50}$ = 3.09; p = 0.004), and ‘total feeding’ ($F_{10,50}$ = 2.60; p = 0.01), were significant for the interaction months*Boldness. Descriptives for these behaviors are found in Table 5.

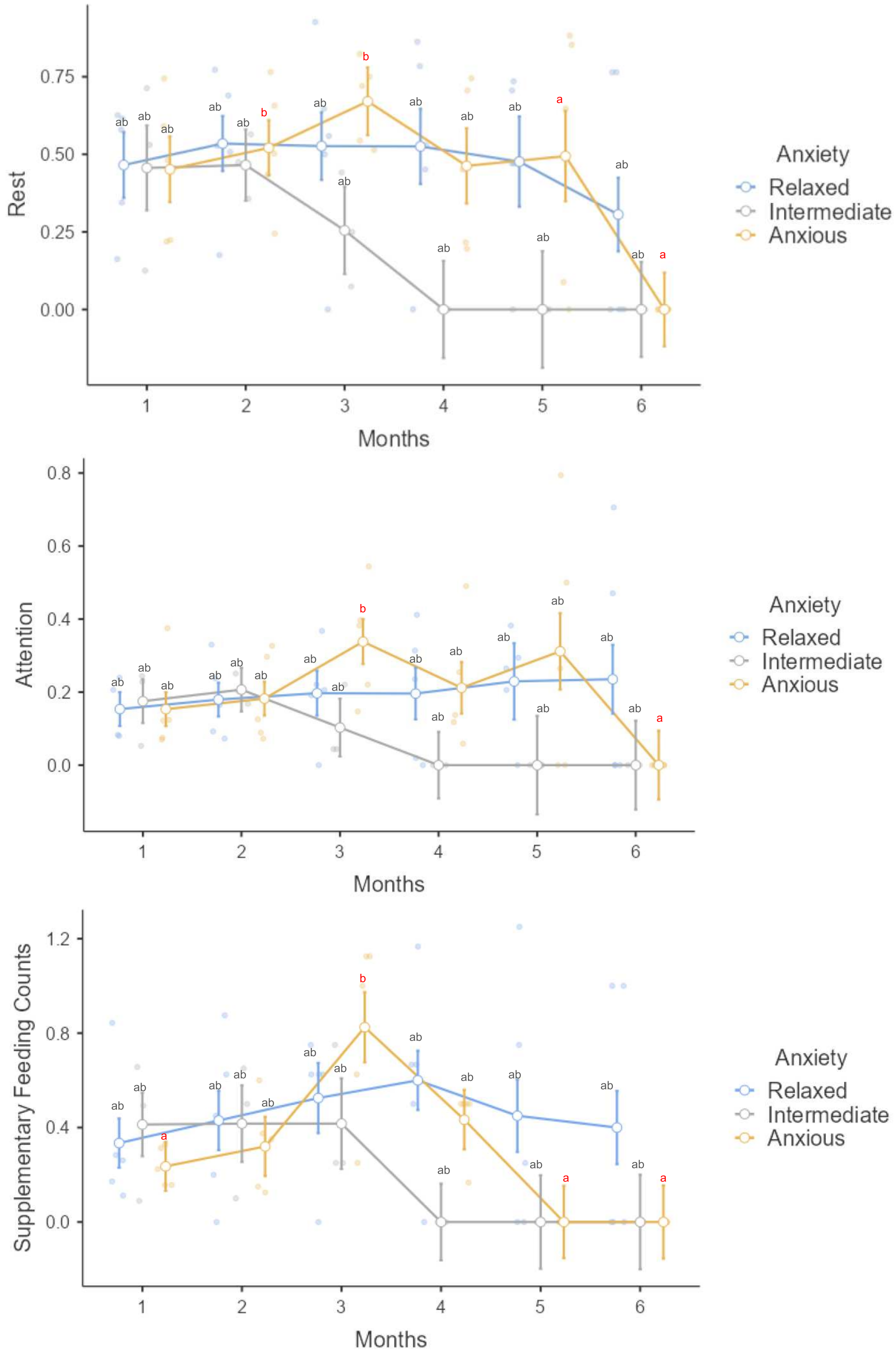
‘Rest’ ($F_{10,50}$ = 1.89; p = 0.07), ‘attention’ ($F_{10,50}$ = 2.21; p = 0.03), and ‘supplementary feeding counts’ ($F_{10,50}$ = 3.04; p = 0.004) were significant for the interaction months*Anxiety (Figure 23).

Table 5 - Estimated means and standard error of the interactions between months and 'Boldness' for the behaviors 'rest', 'movement', 'attention', 'locomotion', 'preening', 'environment interaction', 'natural feeding', and 'total feeding'.

Behavior	Boldness	1	2	3	4	5	6
Rest	Bold	0.39 ± 0.11 ^{abcd}	0.45 ± 0.12 ^{abcd}	0.56 ± 0.11 ^{abcd}	0.48 ± 0.11 ^{abcd}	0.34 ± 0.11 ^{abcd}	0.31 ± 0.11 ^{abcd}
	Intermediate	0.54 ± 0.12 ^{bcd}	0.65 ± 0.12 ^{bcd}	0.67 ± 0.12 ^{cd}	0.59 ± 0.12 ^{bcd}	0.77 ± 0.12 ^{d}	0.002 ± 0.12 ^{a}
	Shy	0.46 ± 0.12 ^{abcd}	0.46 ± 0.12 ^{abcd}	0.32 ± 0.12 ^{abcd}	0.06 ± 0.12 ^{abc}	0.02 ± 0.12 ^{abc}	0.002 ± 0.12 ^{ab}
Movement	Bold	0.1 ± 0.03 ^{abcd}	0.11 ± 0.03 ^{abcd}	0.06 ± 0.03 ^{abcd}	0.1 ± 0.03 ^{abcd}	0.09 ± 0.03 ^{abcd}	0.08 ± 0.03 ^{abcd}
	Intermediate	0.15 ± 0.03 ^{abcd}	0.2 ± 0.03 ^{bd}	0.15 ± 0.03 ^{abcd}	0.13 ± 0.03 ^{abcd}	0.14 ± 0.03 ^{abcd}	-0.0005 ± 0.03 ^{ac}
	Shy	0.15 ± 0.03 ^{abcd}	0.2 ± 0.3 ^{cd}	0.05 ± 0.03 ^{abcd}	0.01 ± 0.03 ^{ab}	0.01 ± 0.03 ^{ab}	-0.0005 ± 0.03 ^{ab}
Attention	Bold	0.15 ± 0.07 ^{ab}	0.18 ± 0.07 ^{ab}	0.24 ± 0.07 ^{ab}	0.22 ± 0.07 ^{ab}	0.17 ± 0.07 ^{ab}	0.24 ± 0.07 ^{ab}
	Intermediate	0.16 ± 0.08 ^{ab}	0.2 ± 0.08 ^{ab}	0.32 ± 0.08 ^{ab}	0.23 ± 0.08 ^{ab}	0.46 ± 0.08 ^{b}	0.002 ± 0.08 ^{a}
	Shy	0.16 ± 0.08 ^{ab}	0.19 ± 0.08 ^{ab}	0.13 ± 0.08 ^{ab}	0.02 ± 0.08 ^{a}	0.002 ± 0.08 ^{a}	0.002 ± 0.08 ^{a}
Locomotion	Bold	0.09 ± 0.03 ^{abcd}	0.10 ± 0.03 ^{abcd}	0.06 ± 0.03 ^{abcd}	0.1 ± 0.03 ^{abcd}	0.09 ± 0.03 ^{abcd}	0.08 ± 0.03 ^{abcd}
	Intermediate	0.14 ± 0.03 ^{abcd}	0.19 ± 0.03 ^{cd}	0.15 ± 0.03 ^{abcd}	0.13 ± 0.03 ^{abcd}	0.14 ± 0.03 ^{abcd}	-0.0004 ± 0.03 ^{ab}
	Shy	0.14 ± 0.03 ^{abcd}	0.19 ± 0.03 ^{bd}	0.04 ± 0.03 ^{abcd}	0.009 ± 0.03 ^{ac}	0.007 ± 0.03 ^{ac}	-0.0004 ± 0.03 ^{ac}
Preening	Bold	0.07 ± 0.04 ^{abcd}	0.09 ± 0.04 ^{abcd}	0.19 ± 0.04 ^{bd}	0.11 ± 0.04 ^{abcd}	0.06 ± 0.04 ^{abcd}	0.01 ± 0.04 ^{ac}
	Intermediate	0.12 ± 0.04 ^{abcd}	0.13 ± 0.04 ^{abcd}	0.16 ± 0.04 ^{cd}	0.19 ± 0.04 ^{cd}	0.14 ± 0.04 ^{abcd}	0.0004 ± 0.04 ^{ab}
	Shy	0.09 ± 0.04 ^{abcd}	0.08 ± 0.04 ^{abcd}	0.07 ± 0.04 ^{abcd}	0.01 ± 0.04 ^{abcd}	0.008 ± 0.04 ^{abcd}	0.0004 ± 0.04 ^{abcd}
Environment interaction	Bold	0.05 ± 0.02 ^{ab}	0.04 ± 0.02 ^{ab}	0.02 ± 0.02 ^{ab}	0.06 ± 0.02 ^{ab}	0.005 ± 0.02 ^{a}	0.02 ± 0.02 ^{ab}
	Intermediate	0.09 ± 0.02 ^{ab}	0.12 ± 0.02 ^{b}	0.03 ± 0.02 ^{ab}	0.05 ± 0.02 ^{ab}	0.11 ± 0.02 ^{b}	-0.0004 ± 0.02 ^{a}
	Shy	0.05 ± 0.02 ^{ab}	0.05 ± 0.02 ^{ab}	0.003 ± 0.02 ^{a}	-0.0004 ± 0.02 ^{a}	-0.0004 ± 0.02 ^{a}	-0.0004 ± 0.02 ^{a}
Natural feeding	Bold	0.02 ± 0.01 ^{ab}	0.01 ± 0.01 ^{ab}	-0.001 ± 0.01 ^{a}	-0.001 ± 0.01 ^{a}	-0.001 ± 0.01 ^{a}	-0.001 ± 0.01 ^{a}
	Intermediate	0.08 ± 0.01 ^{bc}	0.12 ± 0.01 ^{bc}	-0.001 ± 0.01 ^{a}	0.009 ± 0.01 ^{ab}	-0.001 ± 0.01 ^{a}	-0.001 ± 0.01 ^{a}
	Shy	0.05 ± 0.01 ^{abc}	0.03 ± 0.01 ^{abc}	0.003 ± 0.01 ^{ab}	-0.001 ± 0.01 ^{ab}	-0.001 ± 0.01 ^{ab}	-0.001 ± 0.01 ^{ab}
Total feeding	Bold	0.07 ± 0.02 ^{abc}	0.09 ± 0.02 ^{abc}	0.07 ± 0.02 ^{abc}	0.06 ± 0.02 ^{abc}	0.07 ± 0.02 ^{abc}	0.03 ± 0.02 ^{ab}
	Intermediate	0.12 ± 0.03 ^{bc}	0.19 ± 0.03 ^{c}	0.08 ± 0.03 ^{abc}	0.07 ± 0.03 ^{ab}	0.0002 ± 0.03 ^{a}	0.0002 ± 0.03 ^{a}
	Shy	0.11 ± 0.03 ^{abc}	0.09 ± 0.03 ^{abc}	0.06 ± 0.03 ^{abc}	0.005 ± 0.03 ^{ab}	0.0002 ± 0.03 ^{ab}	0.0002 ± 0.03 ^{ab}

Source: Elaborated by the author (2024).

Figure 23 - Estimated marginal means for the interaction months*Anxiety in ‘rest’, ‘attention’, and ‘supplementary feeding counts’.



Source: Elaborated by the author in JAMOVI (2024).

1.13.6 Description of the events and associations with temperament

Of the original released group, eight (47.06%) animals were still seen and alive at the release site until the last day of monitoring, one (5.88%) Scaly-headed parrot died, two others (11.76%) had to be retrieved and sent back to captivity because they were showing maladaptive skills, and six parrots (35.29%) disappeared from the release site (three Scaly-headed parrots and three Blue-winged macaws).

Nine parrots (52.94%) returned, at least once, to the aviary after leaving it. Nine parrots (52.94%) were seen feeding on natural items. Seven parrots (41.18%) were involved in allofeeding events. Three parrots (17.65%) were seen interacting with birds besides their released group.

Four Scaly-headed parrots (23.53%) entered houses and got too close to inhabited houses. Three Scaly-headed parrots (17.65%) were involved in copulation attempts. Two Blue-winged macaws (11.76%) removed their own radiocollars.

We only found a relationship between ‘Activity’ and ‘Anxiety’ with ‘allofeeding’, and ‘Boldness’ with ‘entering or coming close to inhabited houses’. The descriptives for these analyses are in Table 6

‘Allofeeding’ was associated with the temperament dimension of ‘Activity’ (Table 6). That is, as ‘Activity’ increases, the probability of allofeeding happening also increases.

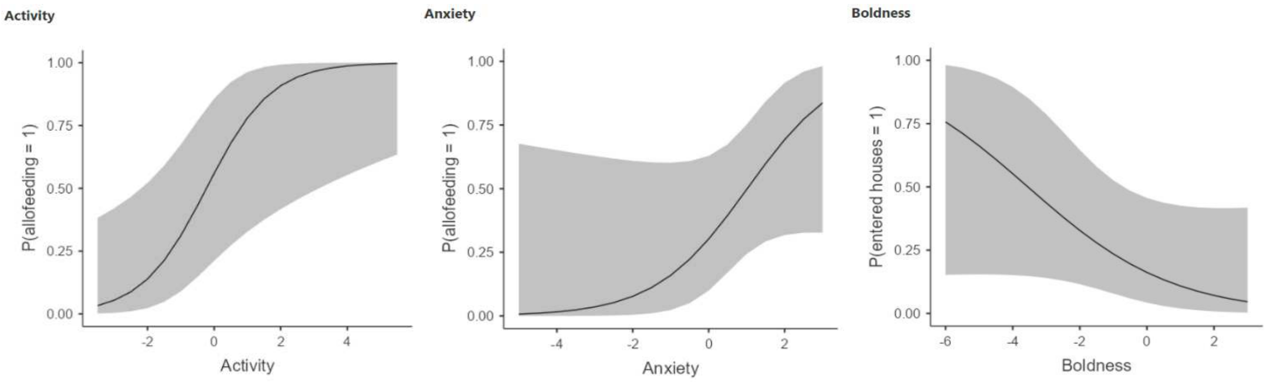
Table 6 - Descriptives for the binomial logistic regression for ‘allofeeding’ and ‘entering or coming close to inhabited houses’.

Event	**Predictor**	**Estimate**	**Standard Error**	**Z**	**p**	**Odds Ratio**	**Confidence Interval (Lower-Upper)**
Allofeeding	Activity	1.03	0.43	2.38	0.02	2.80	1.20 - 6.53
	Anxiety	0.82	0.49	1.69	0.09	2.28	0.87 - 5.95
Entered houses	Boldness	-0.46	0.28	-1.65	0.098	0.63	0.36 - 1.09

Source: Elaborated by the author (2024).

‘Allofeeding’ was also associated with ‘Anxiety’; however, this was a tendency (Table 6). A tendency was also found for ‘entering or coming close to inhabited houses’ and ‘Boldness’ (Table 6). In other words, more anxious birds tended to do more allofeeding than less anxious ones, and bolder birds tended to enter or come closer to houses more often than the shyer ones (Figure 24).

Figure 24 - Estimated marginal means for the events ‘allofeeding’ with ‘Activity’ and ‘Anxiety’, and ‘entering or coming close to houses’ with ‘Boldness’.



Source: Elaborated by the author in JAMOVI (2024).

1.14 DISCUSSION

1.14.1 Exit order

In total, nine (52.94%) animals left the aviary on the first day. This rate is lower than from most other psittacine releases: 100% (SILVA et al., 2020), 81.25% (PURCHASE et al., 2024), and 78.78% (FRAGA et al., 2023), but Lopes et al. (2018) documented a rate of only 20% of parrots leaving the aviary on the first day. Some parrots still returned to the aviary after leaving, a common behavior of released parrots (SILVA et al., 2020; FRAGA et al., 2023; PURCHASE et al., 2024). On this first day, some birds were already feeding on supplementary feeders and natural items (*Plinia cauliflora*). By the end of the second day, 82.35% of the birds had left the aviary. On this day, a Blue-winged macaw (020) flew far away from the release site but returned after some time.

One parrot left on the ninth day and two others had to be directed to the exit on the 32nd day. It is common for some parrots to take longer to leave the aviary (LOPES et al., 2018; FRAGA et al., 2023), however, institutions like rehabilitation centers for wild animals that use the release as a destination usually do not have the time nor infrastructure to wait long periods for a bird to leave the aviary. The exit order and dependency on the aviary can be associated with the parrot’s temperament (SILVA et al., 2020), hence understanding more about the mechanisms underlying this behavior should contribute to finding new ways to facilitate their exit from the aviary.

Individuals categorized in different levels of the dimension ‘Boldness’ differed in the means across the exit categories. It has been theorized that ‘Boldness’ is a dimension that should reflect an animal’s response in a challenging context and measures its propensity to take risks in situations that are likely to happen frequently during the lifetime of an animal, like foraging or escaping a predator (RÉALE et al., 2007). The animals of our study spent several months inside the aviary in the release site before release and, therefore, were already habituated to their surroundings (acclimatization period). This is important to note because we get a broader sense of why ‘Boldness’ was the only dimension that differed in the exit order in this analysis; the animals already knew the place (even though they had not explored it yet) so it was not a context of novelty. They had, however, to leave the aviary (a place they felt safe) and start exploring, a behavior that requires a propensity to take risks. Bolder animals have a higher tendency to take risks whereas shyer ones have lower, so we expected that bold parrots would leave the aviary first and shy parrots would take longer. In our study, shyer individuals tended to exit the aviary later than bolder ones. Even though Silva et al. (2020) did not find differences between bold and shy parrots leaving the aviary, they reported that shyer parrots were more dependent on the aviary. Although the means of the parrots that left the aviary on the first day did not account for the bolder animals, the first parrot to exit was the boldest one. We only had three animals in the third category and yet their mean was the highest (shyest) compared to the means of the first and second categories, that had nine and five animals respectively. Future studies should manage to gather a greater sample size, what should be challenging in studies with animals from wildlife rescue centers.

Social conformity is a phenomenon that occurs when an individual shifts their behavior according to their social environment to match the responses of others (CIALDINI; GOLDSTEIN, 2004). Kerman et al. (2018) investigated the presence of social conformity for the dimension ‘Boldness’ in *Myiopsitta monachus* and found that shy males became bolder when conspecifics were close. Social conformity in ‘Boldness’ has also been described for other species, such as snakes (SKINNER et al., 2024), and fish (MAGNHAGEN; STAFFAN, 2005), and, interestingly, shyer individuals conformed more and showed the largest changes in behavior compared to the bolder ones. This may explain the fact that, in this study, some shyer and intermediate parrots left on the first day (001, 006, 008, 013, 019, 020, and 028), and, in agreement with Kerman et al. (2018), five out of the seven were also males. These animals were given a score for ‘Boldness’ based on tests of individual settings; however, they were released as a group and it is possible that they presented social conformity, changing their propensity to take risks and exploring the outdoor environment as a group.

1.14.2 Differences in behavior captive x nature

In our study, parrots spent less time at 'rest' and 'interacting with the environment' after release, but 'locomotion', 'movement', and 'other' behaviors increased compared to the time they were in captivity. It is not a surprise that animals in the wild will behave differently from those in captive environments since they face unpredictable environmental conditions like exposure to predators (SCHEUERLEIN et al., 2001), and they also have to fly for kilometers to search for food and resources (VAN ZEELAND et al., 2013). However, it is well-documented that poor housing conditions can compromise the welfare of captive birds due to physical restriction, lack of natural stimulus, or lack of proper socialization with conspecifics (VAN HOEK & TEN CATE, 1998). Hence, comparisons of time budgets between captive and wild animals have been helping us meet their needs when they are under human care. For example, Rozek et al. (2010) demonstrated that, when offering over-sized pellets to captive Orange-winged Amazon parrots (*Amazona amazonica*), they spend foraging time more closely resembling activity budgets of wild parrots. Similarly, van Zeeland et al. (2013) documented that enrichment items significantly increase foraging time in Grey-parrots (*Psittacus erithacus erithacus*), yet this increase was not comparable to the feeding time of wild conspecifics.

The physical restriction and predictability of the aviary can explain why the parrots spent more time at 'rest' and less time in 'locomotion' and 'movement' in the captive environment. Rose et al. (2022) attributed the behavior of resting in captive ducks as a response to a more controlled environment where food is available, and they do not need to search for it. The wild, on the other hand, is challenging and animals must constantly adapt to it by doing activities that are energetically demanding such as foraging (GOYMANN et al., 2017) and thermoregulation (JIMENO et al., 2017), thus the changes in behavior. Cornejo et al. (2005) also attributed the decrease in resting and sleeping of released scarlet macaws (*Ara macao*) to the unpredictability of the environment, however, no differences were observed in the number of flights between the captive and the released macaws, which resembled the flight budget of free-living macaws. This was probably due to the size of the aviary in which these animals were kept (30m x 4.5m x 6m), indicating that greater dimensions of an enclosure can elicit behavioral budgets more similar to the ones of wild animals.

We expected that the birds would spend more time feeding in the wild than in captivity, as Rose et al. (2022) and Cornejo et al. (2005) found. However, we encountered no differences between the percentage of feeding behavior expressed: the time spent eating was similar in both contexts (21.51% in captivity and 20.52% in the wild). Wild Galahs (*Cacatua roseicapilla*), for example, spend 50% of their time foraging, whereas red-rumped parrots (*Psephotus haematonotus*) can range from 40% to 75% (WESTCOTT & COCKBURN, 1998), thus we have reason to believe that the feeding budget of our released parrots does not correspond to the feeding budget of their wild counterparts. This can be understandable when we take into account that they had been kept inside an aviary for several months before the release and were still adapting to the wild, thus they were dependent on supplementary feeding. This can be corroborated by our analysis which showed no differences in supplementary feeding during the first 6 weeks of monitoring, and by personal observations (we noted that some parrots would show up only when the caretaker restocked the supplementary feeders).

Another factor that may have contributed to the evenness of the time spent feeding in both contexts is the type of food provided. We offered the same food they were eating when they were captive: pieces of commercial fruit and sunflower seeds. Sunflower seeds are known for their great amount of protein and fat, and high digestibility (SAAD et al., 2007), thus the birds would eat the supplementary food and feel satiated. The sunflower seeds probably met their energetic needs, so they did not have to spend more time foraging. It appears that the type of food offered in release projects has not been of major concern to scientists because it is not well-documented in the papers. Nevertheless, the nutritional aspects of supplementary food for released parrots should be further investigated so we understand what types of food are better suitable for them when they are reintegrating nature.

We also expected that the parrots would interact more with the environment once released, but the opposite happened. The birds interacted less with the environment once released. We did not even observe any difference when we clustered the percentages of ‘environment interaction’ and ‘natural feeding’ from the observations in the wild (because natural feeding could also be interpreted as an environment interaction) and compared to ‘environment interaction’ inside the aviary ($p > 0.05$). Interestingly, this finding agrees with the one from Cornejo et al. (2005) who also reported that released scarlet macaws spent less time handling objects (environment interaction). It has already been said that the captive environment is predictable and, depending on the stimuli provided, parrots can redirect their behavior to environment interaction or even preening (CUSSEN & MENCH, 2015). Thus, it is possible that our result could be explained by a possible trade-off that these animals face in the wild since it is an unpredictable environment and the birds must balance their behaviors between staying alert to environmental stimuli and engaging in other routine behaviors, such as interacting with the environment and feeding (RAMOS et al., 2021, 2023).

For the behavioral category 'others', we recorded any behavior that did not fit the rest of the categories and most of the recordings for 'others' were social behaviors such as interacting with birds from inside the aviary, interacting with birds from the released group, trying to copulate, soliciting allopreening, allofeeding, and fighting. In our analysis, this category significantly increased during the observations in nature. Our result aligns with another result from Cornejo et al. (2005) in which they reported an increased time spent socializing from released macaws. Captive environments present few opportunities for social learning (HARRISON et al., 2011; SPIEZIO et al., 2018) and still, the expression of social behaviors is of paramount importance for some released species because they need to create social bonds and socialize with native animals to facilitate their adaptation and learning (ELGAR., 1989; SNYDER, et al., 1994; BRAKES et al., 2019). We found this difference in the comparison between the time budget of the behavioral observations in captivity and during the first 6 weeks post-release however, when we compared the time budget during captivity with the time budget of the first week of monitoring, this category did not differ ($p > 0.05$). This suggests that released parrots will not adapt socially during the first week of release, but until the sixth week, their social behaviors will increase significantly.

Comparisons between behavioral budgets of captive and wild animals can assist us in understanding the adaptation process of released animals, however, we must interpret these results carefully when addressing their welfare. The greater or lesser expression of a behavior in the wild does not necessarily mean that the animal is in better welfare and, reciprocally, the greater or lesser expression of a behavior in captivity does not necessarily mean that the animal is in poorer welfare. For instance, Vidal et al. (2019) documented that wild Blue-fronted parrots (*Amazona aestiva*) have higher GC levels than those in captivity. That is, wild parrots are more stressed. In our study, the changes in behavior in the wild may reflect a stress response, thus knowing more about the behavior of parrots in the wild can guide us in conducting behavioral analysis to identify better-suited animals for release and propose the adjustment of enclosures that will allow them to express a behavioral time budget similar to what they would in the wild to facilitate their adaptation when released, since translocation projects often keep the birds acclimatizing in an aviary for months before release.

1.14.3 Behavior immediately after being released (7 first days post-release)

During the first seven days of monitoring, the expression of ‘inside aviary’, ‘locomotion’, ‘preening’, ‘total feeding’, and ‘supplementary feeding counts’ changed over days. These differences, however, were not associated with any of the five temperament dimensions.

On the first day, the birds spent significantly more time inside the aviary because it was the first day of release and it was expected that some of them would not leave the aviary that day. On the second day, time spent inside the aviary decreased significantly because other parrots left during the morning, and, up to the seventh day, time spent inside remained constant, with few variations that were not significant. From the third day up to the seventh, time spent inside was recorded for three parrots that did not leave during the first week and others that kept entering the aviary after exiting on the first or second days. Locomotion increased gradually from day 1 to day 2, but it was only on days 3 and 5 that we had a significant increase, compared to the first day. This analysis corroborates our observations that, on the third day, we noticed the parrots had begun to fly for longer distances and explore the canopies. Preening reached its peak on day 3. The birds fed significantly more on days 4 and 6, compared to the first day, and fed significantly more on supplementary food on day 2 compared to day 1.

The first week post-release can be challenging for these animals because they must explore a new environment in search of new sources of food and shelter. In this study, the parrots had no trouble feeding; on the second day, the birds fed more on supplementary feeding and on the fourth and sixth days, their total feeding time increased compared to day 1. The third day highlights an activity increase, with animals locomoting more and engaging more often in preening behaviors. We could say that the parrots began feeling more comfortable on the third day and forward due to increased exploratory (locomotion), and laid-back behaviors (preening), which also matches the days they began spending less time inside the aviary.

1.14.4 Behavior during 6 weeks post-release (41 days)

From our analyses during the first six weeks of monitoring, we found an effect of weeks for ‘inside aviary’, but this difference was not associated with any of the five temperament dimensions. We also found an effect of weeks*Anxiety for ‘returns to aviary’, with relaxed parrots showing a decrease in the expression of this behavior on the fourth week compared to the first; and an effect of the categories of ‘Boldness’ for ‘environment interaction’, with intermediate animals interacting more with the environment than both shyer and bolder ones.

The parrots spent significantly less time inside the aviary in week 6 than weeks 2 and 3. Even though we did not find any differences between the first 5 weeks, we can see that the variation decreases gradually. The difference in the sixth week probably was influenced by the fact that we began to direct the remaining birds to the exit of the aviary in the middle of the fifth week (which also shows a decrease in the range of variance compared to the previous weeks). Up until the fourth week, this variable was not influenced by the handling of the birds, and we can infer that even though the time spent inside decreased slowly, the animals were still quite dependent on the aviary.

The dimension 'Anxiety' can be linked to 'Neuroticism' in some papers (CUSSEN & MENCH, 2014, 2015; COUTANT et al., 2018) and, in this study, it was characterized by behaviors such as vocalization, excitement, rest, and closeness to people for the less anxious; and movement, locomotion, and longer latencies to come closer to people for the more anxious ones (see results in chapter 2). Less anxious parrots returned significantly less to the aviary on the fourth and sixth weeks than the first week. We could infer that less anxious parrots became less dependent on the aviary throughout the six weeks since they decreased their returns to the aviary. Previous studies conducted in captivity have revealed that, under experimental settings, more anxious/neurotic parrots are more attentive to environmental stimuli, showing more vigilant (COUTANT et al., 2018) and exploratory behaviors (PAULINO et al., 2018), whereas less anxious/neurotic parrots show a more passive reaction. It could be misleading to acknowledge that only vigilant and exploratory behaviors should be enough for an animal to quickly adapt to a new environment. In fact, this was not the case in our study, where less anxious parrots became more independent in the aviary. Cussen and Mench (2014) demonstrated that more neurotic parrots showed a greater attention bias for environmental stimuli. That is, the animals assessed the environmental conditions way more than the less anxious parrots and, consequently, had a poorer performance during the spatial foraging task with the presence of an passive observer. The attention bias may explain why the more anxious parrots did not become independent in the aviary as the less anxious parrots did. On top of having to explore the new environment, a new team member was present on the site helping the first author every week. Thus, the anxious parrots probably felt overwhelmed and could not become independent from the aviary, like the less anxious did.

For organizations that use parrot releases as a conservation tool, releasing animals that will take longer to become independent from the aviary is not ideal because releases take time and money. Notably, our study shows that less anxious birds become less dependent from the aviary throughout the course of six weeks, and this difference was not found for more anxious and intermediate parrots. Therefore, the assessment of ‘Anxiety’ could be used to select parrots that probably will adapt quickly to the wild. However, the selection criteria should not be strictly based on the parrots' low anxiety level. A cohesive group should be gathered with intermediate and highly anxious birds too because a selection of only one temperament trait could lead to artificial selection. These, however, should account for the minority of the group because they might take longer to adapt.

1.14.5 Behavior during 6 months post-release (163 days)

From our analyses during the first six months of monitoring, we found a significant effect of months for ‘interaction with collar’, which significantly decreased in the fourth, fifth, and sixth months, compared to the first month. In chapter 2, we assessed the behavioral changes and habituation to fake collars within 7 days while the parrots were in captivity and we could not conclude that they habituated to the collars within this period, even though they began to redirect some of their routine behaviors back to the normal standard (without collars) throughout the observation period. In this study, however, we found that the interaction with the collar decreased gradually throughout the months, and it was only in the fourth month that this difference was significant. Having an object attached to their bodies can be stressful, leading to behavioral changes (STABACH et al., 2020) and, in the case of free-ranging animals, increasing predation rates (WEBSTER & BROOKS, 1980; COTTER & GRATTO, 1995; CYPHER, 1997). Therefore, translocation projects that will attach objects to the animals’ bodies should conduct a careful monitoring at least up until the fourth month, while the animals are habituating to the object, and try to assess the effects of the device on parameters such as behavior, survival and dispersion. Otherwise, it would be prudent to attach the object to animals’ bodies months before release so they can habituate to it.

The dimensions ‘Boldness’ and ‘Anxiety’ were associated to several behaviors during these 6 months. For the dimension ‘Boldness’, ‘rest’, ‘movement’, ‘attention’, ‘locomotion’, ‘preening’, ‘environment interaction’, ‘natural feeding’, and ‘total feeding’ had significant differences throughout the months, however most of the differences highlighted a decrease in the expression of the behavior. This is probably because the parrots had been dispersing and the records for non-visible were increasing. In fact, there was a gradual significant increase for ‘non-visible’ starting in the third month and increasing up until the sixth month, which matches our description in previous paragraphs and the months that had shown significant differences for the behaviors mentioned above. Therefore, these results should be interpreted with caution.

For the dimension 'Anxiety', whereas the intermediate and more anxious parrots had variations in the expression of some behaviors (rest, attention, supplementary feeding counts) during the months, the less anxious ones remained constant, with no differences throughout the months. Changes in the expression of a behavior can be associated with an animal's evaluation of a new stimulus, leading to habituation or sensitization (EISENSTEIN et al., 2012). Thus, the variation in the expression of these behaviors for the intermediate and more anxious parrots may reflect a process of adaptation to the new environment, in which the animal changes its behavior to maximize readiness and cope with any external stimulus (behavioral homeostasis) (EISENSTEIN et al., 2012). Therefore, we could infer that more anxious and intermediate parrots "performed" better than less anxious parrots that, on the other hand, kept a constant behavioral expression.

1.14.6 Events associated with temperament

From all the events registered during the monitoring of the birds, only the occurrence of allofeeding and entering houses were related to some temperament dimensions. Allofeeding is an affiliative behavior in which one animal regurgitates food to another animal, and it is closely associated with courtship and parental care in birds but, in some species, this behavior can happen year-round (SEIBERT, 2006). Some authors believe that allofeeding may play a role in forming social networks between unrelated individuals (BAYERN et al., 2007). Despite having many sources investigating the role of allofeeding in contexts of courtship and parental care in parrots, its role in sociality remains pending validation. We have reason to believe that the allofeeding events recorded in our study were not driven by courtship instincts because the release and monitoring period did not coincide with the reproductive season of parrots, which is during the rainiest part of the year (JUNIPER & PARR, 2010) ranging from November and March in Brazil. Thus, it would be important for future studies to investigate the role of allofeeding in parrots' hierarchy and social structure.

'Activity' and 'Anxiety' were related to the probability of allofeeding occurring (even though for 'Anxiety' there was only a tendency). The more active and anxious the animal was, the more likely it was to allofeed. These two dimensions were similar regarding the behaviors used to describe them (see 3.3.1), however, none of those behaviors was related to sociability. In fact, the tests used to extract the temperament dimensions for these animals were done individually and there was no behavioral category which referred to sociability. Even so, we found an association between these two dimensions and allofeeding. If this behavior promotes the formation of social networks between unpaired parrots, the temperament assessment could predict the strength of social bonds in released parrots. Lopes et al. (2017) found that shyer Amazon parrots (*Amazona aestiva*) interacted more with native parrots and parrots from the release group and suggested that, in a release, shyer birds should be released first because they would be capable of establishing social bonds easier with native animals and animals from the released group. From this result and ours, it appears that social behaviors are strongly related to temperament dimensions assessed in captivity; even if the dimensions were not assessed in social contexts.

Temperament tests are often done individually because of the concept of temperament: individual behavioral differences that are consistent over time and/or across situations (RÉALE et al., 2007). However, we seem to neglect an important aspect of their behavior that could be paramount to their adaptation in the wild when we submit animals to these individual tests, their sociability. Releasing socially compatible animals can enhance their survival rate and, consequently, lead to more successful reproduction events (BRIGHTSMITH et al., 2005; PLAIR et al., 2008). As mentioned in the first paragraphs, these animals can conform socially and, sometimes, it can be difficult to understand the relation between a temperament dimension extracted by individual testing and a category assessed in a social context. Thus, we suggest that future studies include sociability tests to try to find a stronger relation between temperament assessed in captivity and social behaviors expressed after release.

We also extracted the dimension 'Boldness' but we did not find any association between this dimension and a sociability behavior, like Lopes et al. (2017) did. Instead, we found a relation between 'Boldness' and the probability of entering or getting close to inhabited houses and people. The bolder the animal was, the more likely it was to enter or come close to houses. In our study, four animals exhibited this behavior (001, 002, 008, 010), all of which were Scaly-headed parrots. As mentioned in the methodology, the birds used in this study came from a rehabilitation center and we did not have information on their life histories but, for birds that were ex-pets or raised in captivity, it can be difficult to adapt to the wild because of maladaptive behaviors. In the study of Lopes et al. (2018), done with Amazon parrots (*Amazona aestiva*) also from a rehabilitation center in Brazil, 42% of the released animals exhibited inappropriate behaviors for nature, such as interacting with humans more than with wild parrots. In this same study, three released birds were, in fact, captured by local residents because, allegedly, they got close to them searching for food, and seven others were believed to have also been captured by locals. Evangelista-Fraga et al. (2023) also reported an Amazon parrot (*Amazona aestiva*) being captured by a local resident, as did Brightsmith et al. (2024) with a macaw (*Ara ararauna*) that had been constantly getting close to humans searching for food or looking for interaction.

The capture of released birds by people living near release sites could threaten the success of psittacid releases and, therefore, a careful selection of birds should be conducted to minimize the probability of these animals coming close to people. For example, human aversion training has successfully increased the aversion of humans in Amazon parrots (FRANZONE et al., 2022) and should be a protocol adopted in release projects to select more suitable individuals. In our study, we trained the birds with the human aversion training for 13 consecutive days and assessed their scores according to Franzone et al. (2022). Of the parrots that entered houses in our study, none accepted the food from the food offer test, and three had the highest aversion score, fledging when the person offered the food. Our findings suggest that coming close to people's houses may not be related to aversion to humans, but can be related to temperament, since bolder animals were more associated with this behavior. Interestingly, Silva et al. (2020) also related the deaths of bold parrots to anthropogenic factors. Once more, the temperament assessment during captivity could help us predict which animals are more prone to get close to people and inhabited houses. Thus, temperament could be used as an auxiliary selection criterion for parrot candidates for release. However, we should not select animals based only on one temperament trait since it is a phenotype that is also shaped by genetic factors, and if we do so, we could be artificially selecting a population of released animals (GROOTHUIS & CARERE, 2005).

We can also address this situation from the perspective of the people living near the release sites. If bolder parrots will, inevitably, come closer to people's houses, it is important to focus on local people's attitudes since it can undermine the efforts of conservation projects. From our experience, we saw that communicating and informing local residents of the project and explaining to them how to proceed when encountering any of the birds helped us gather more information on the birds' whereabouts, and consequently, we did not have any animal captured during the monitoring period. They were instructed not to feed and to scare away these birds whenever they got close to them but, even so, one parrot (001) kept entering houses frequently and, unfortunately, it had to be captured by the research team and sent back to the rehabilitation center. It was not an objective of this work to actively involve the local residents in the ongoing project, but social engagement associated with environmental education can play a key role in the management of release projects, as evidenced by Purchase et al. (2024).

During the behavioral observations in the wild, most of the time we could not find all animals on time to record their behavior for every recording, so we recorded them as a non-visible category. From the third month on, the amount of 'non-visible' records increased significantly because the parrots began dispersing and disappearing more often. Therefore, the differences found for the effects of months and temperament throughout the months could be due to the increase of this variable. We had to rely on the signal emitted by the collars for long-term monitoring because the batteries of the radio collars died. These collars were supposed to last for six months, but they were bought almost three years prior to the project execution. Thus, we believe this long waiting time may have damaged the batteries. However, this did not jeopardize the observations because the birds that were still in the release site were always visible and we were able to record their behaviors normally. On the fifth day post-release, we found one Blue-winged macaw (028) with a frayed antenna end, which was getting stuck on the aviary mesh. Coincidently, this macaw was the same that damaged its fake collar during the habituation observations in captivity (Chapter 2). We decided to capture the bird and remove this part of the antenna so as not to cause more damage to the animal. This situation highlights the importance of selecting animals adapting to the radio collars. We applied flight tests following Franzone et al. (2022), however we suggest that the execution of the test must be adapted. One Blue-winged macaw (029) scored 2 in the flight test. This animal did not take off flight from the ground and not even from the mesh when we stimulated it; however, when this bird left the aviary, it flew right above the trees. This macaw was selected for release because it was paired with another macaw (028) that scored 3 in the flight test and we did not want to separate them. For the human aversion training, we advise careful interpretation for future studies since, of the parrots that entered houses or came close to people, none accepted the food from the food offer test, and three had the highest aversion score, fledging when the person offered the food.

1.15 CONCLUSION

This study investigated the associations between temperament assessed in captivity of two released neotropical psittacid species (Scaly-headed parrots and Blue-winged macaws) with their behavior monitored for five months after release. Temperament was, in fact, related to some aspects of their behaviors. Shyer parrots showed a greater dependency on the aviary by taking longer times to exit, whereas bolder parrots tended to come closer to people by entering houses. More active and anxious animals were more likely to allofeed. After release, the birds spent more time moving and engaging in social interactions than when they were in captivity. In the first week post-release, some parrots were already comfortable on the outside and this is highlighted by the increase in exploratory and laid-back behaviors, and the decrease in time spent inside the aviary. However, they were still quite dependent on the aviary for at least until the first 4 weeks. Less anxious parrots returned less to the aviary on the fourth and sixth weeks post-release. 'Boldness' and 'Anxiety' were associated with several behaviors for the analysis during the 5 months of monitoring, but these results should be interpreted with caution since they can be an effect of the increase of the recordings for 'non-visible'.

5 GENERAL CONCLUSIONS

This study aimed to understand the implications of psittacine temperament in pre- and post-release contexts within translocation projects by reviewing the literature on Psittaciformes temperament, assessing their adaptation to neck collars before release and monitoring their behavior after release.

From Chapter 1, we conclude that the temperament of Psittaciformes is not a widely investigated field. There are no studies on free-living animals; therefore, it would be interesting to move forward with studies conducted in the wild. Even though 22 temperament dimensions were found for the Psittaciformes, it should be noted that there is a lack of standardization on the terminologies used, and this can cause confusion among researchers, who have been using different terms to describe similar dimensions. Thus, when defining a dimension, it is essential to consider the context in which the temperament was evaluated and the existing term used to express this dimension in previous publications. Future comparative studies can help understand the development and evolution of temperament in the order Psittaciformes. Research on the genetic basis and morphophysiological and neuroendocrine mechanisms underlying temperament variation in Psittaciformes should also provide valuable contributions to the field.

From Chapter 2, we conclude that the neck collars affected the birds' general behavioral budget, and they habituated partially to the device during the 7-day observation period. The habituation process seems to have two distinct behavioral components, one related to the changes in routine behavior, and another related to the animals' perception and interaction with the device. Temperament seemed not to be associated with adaptation to the fake collars, but the Scaly-headed Parrots interacted more with the collars throughout the observation period.

From Chapter 3, we conclude that temperament was, in fact, related to some aspects of the birds' behaviors. Shyer parrots showed a greater dependency on the aviary by taking longer times to exit, whereas bolder parrots tended to come closer to people by entering houses. More active and anxious animals were more likely to allofeed. After release, the birds spent more time moving and engaging in social interactions than when they were in captivity. In the first week post-release, some parrots were already comfortable on the outside, what was evinced by the increase in exploratory and laid-back behaviors, along with the decrease in time spent inside the aviary. However, they were still quite dependent on the aviary for at least until the first 4 weeks. Less anxious parrots returned less to the aviary on the 4th and 6th weeks post-release. ‘Boldness’ and ‘Anxiety’ were associated with several behaviors for the analysis during the five months of monitoring, but these results should be interpreted with caution since it can be an effect of the increase of the recordings for ‘non-visible’.

We suggest that future monitoring projects start assessing behavioral changes caused by tracking devices before releasing the animals, since the device can alter their behavior, leading to biased results. In our study, we did not assess the physiological parameters of the parrots and we deduced that the interaction with the collar was a stressful behavior indicative of non-adaptation, therefore it would be interesting to understand the adaptation process from a physiological perspective. The tendency found for bold parrots entering houses and getting close to people after release is noteworthy of attention, thus we also suggest that future studies explore this association with more focus. The translocation of wild animals is a process that demands efforts that go beyond releasing the animals. Some measures and initiatives could be implemented parallel to the release to facilitate the animals’ adaptation, based on knowing their temperament. Such measures could include direct actions, such as providing nest boxes and supplementary feeding for shy parrots that were more dependent on the aviary, and indirect actions, such as environmental education that would create awareness on the people living close to the release site that some parrots could enter their homes.

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APPENDIX A – CATEGORIES RECORDED IN THE TWO TEMPERAMENT TESTS (NOVEL OBJECT AND REACTION TO A PERSON), AND IN THE BEHAVIORAL OBSERVATIONS (WITHOUT AND WITH FAKE COLLARS, AND POST-RELEASE)

LOCATION CATEGORIES	
Place[no+rp]	Place where the animal is: top grid, bottom grid, or side grid.
Quadrant[no+rp]	Quadrant where the animal is. The animal can be at the 1st (0-20 cm), 2nd (21-40 cm), 3rd (41-60 cm), 4th (61-80 cm), or 5th (81-117 cm) quadrant. The distances of the quadrants were given in relation to the position of the stimulus in the tests.
ACTIVITY CATEGORIES	
STATES	
Rest	The animal remains at the same spot. It can stand using both feet, just one foot or its beak while other body parts remain still or agitated. The animal may be spinning without changing places. There is no locomotion of the animal.
Movement	The animal changes its position, moving from one spot to another. It can move by flight, walking, or using its beak to climb the cage bars, branches, and perches.
Attention	The animal is attentive to the novel object or person and external stimuli (such as observers, other birds in the aviary, predators flying over the aviary, dogs, and keepers). The animal stays alert. The bird can quickly move his head in different directions or remain with his head still with its neck stretched, while focusing on the stimulus. One or both eyes open. The animal can move its feet without leaving the spot. Not accounted for when the bird is expressing another behavior.
Inactivity	The animal rests. It can have its feathers ruffled, one foot tucked, or its head turned back, tucked between its wings. The animal sleeps, not attentive to any stimuli, whether from the test or the environment, and has both eyes closed.
Locomotion	The animal moves from one spot to another, walking, or flying. It can use its beak to help in locomotion while walking on the cage grid, perches, or on the ground.
Excitement	The animal moves any part of its body but stays at the same spot, swinging, turning, or flapping its wings. It can use the beak as a support while shaking its body. It can remain with its feet still and its body slightly lowered while its wings tremble. The animal raises and lowers its body quickly.
Preening	The animal adjusts its feathers using its beak, stretches its wings, stretches its legs, ruffles its feathers, yawns, scratches itself, or cleans its beak. In the aviary, the bird can take a bath.
Environment interaction	The animal interacts with the cage, pecking at the paint used to mark the quadrants of the enclosure, the grid, or the cloth used to cover the sides of the cage. It can interact with elements of the environment that were picked up by the beak ("chewing"). In the aviary, it can interact with environmental enrichments (perches and leaves) and other objects in the enclosure.
Novel object interaction[no]	The animal interacts with the novel object by pecking it or touching it with the foot.

Person interaction[rp]	The animal interacts with the person by attempting to peck them or touch them with the foot.
Feeding	The animal eats fruits or sunflower seeds from feeders or the ground. The animal can feed on enrichments, but only if they are fruits or flowers.
Suplementary feeding	The released birds feed on the supplementary feeder.
Natural feeding	The released birds feed on natural items in the wild.
Allopreening	One animal cleans and preens the feathers of another. Not accounted as a positive social interaction.
Interaction with collar	The animal beaks its collar or touches it with its foot.
Interaction with conspecifics collars	The animal beaks or touches with its foot the collar of another bird.
Others	The animal does not perform any of the activities above. The animal interacts positively or negatively with another animal. Allofeeding. Attempted copulation. The animal performs stereotypical behaviors.
Inside aviary	The released bird is inside the aviary during the post-release monitoring.
Non-detectable	The bird is nowhere to be seen. It disappeared.
EVENTS	
Latency to touch the novel object[no]	Time (in seconds) to touch the novel object for the first time.
Latency to try to touch the person[rp]	Time (in seconds) to try to touch the person's hand for the first time.
Touch in the novel object[no]	Number of touches in the new object, either with the beak or feet.
Attempts to touch the person[rp]	Number of attempts to try to touch the person's hand, either with the beak or feet.
Vocalizations	The animal vocalizes, including human vocalizations (whistles, songs, etc.)
Abnormal behavior	The animal exhibits stereotypical behavior or any other behavior that is not like the species.
Aggressive conduct[no+rp]	The animal displays aggressive behavior, ruffling its feathers, opening its wings and beak advancing towards the object/person, and/or retreating.
Reaction to attempts to capture	The animal runs away from the person (1), remains still in the same spot (2), or tries to attack the person (3) when being captured at the end of the reaction to person test.
Positive social interactions	The animal tries to mate with another or allofeeds.

Negative social interactions	The animal pecks and kicks or threatens to peck and kick another individual. There is usually a winner and a loser in the interaction. The one who loses leaves the spot, and the other who wins stays in the same place.
Human vocalizations	The animal emits vocalizations of human nature, such as whistles, songs, and words.
Interaction with fake collar	The animal beaks its collar or touches it with its foot.
Interaction with conspecifs fake collars	The animal beaks or touches with its foot the collar of another bird.
Supplementary feeding	The released birds feed on the supplementary feeder.
Returns to aviary	The released bird returns to the aviary.

Source: Elaborated by Gustavo Nunes, Larissa Gomes, and Maria Eduarda Branco (2023).
Note: (no) = variables recorded only for the novel object test. (rp) = variables recorded only for the reaction to a person test.

APPENDIX B – RESULTS FROM THE PRINCIPAL COMPONENT ANALYSIS FOR THE NOVEL OBJECT AND REACTION TO A PERSON TEST APPLIED TO 51 ANIMALS (*Pionus maximiliani*, *Primolius maracana*, and *Psittacara leucophthalmus*).

Variables/Dimensions	Activity	Boldness	Anxiety	Neophobia/ Neophilia	Proximity to Humans
Top grid^{no}	**0.63**	0.24	0.3	0.21	0.3
Side grid^{no}	**0.71**	0.36	-0.27	0.05	0.06
Bottom grid^{no}	**-0.81**	-0.38	0.08	-0.13	-0.17
Quadrant 1no	0.28	**-0.56**	-0.26	**0.52**	-0.06
Quadrant 5no	0.05	**0.5**	0.04	-0.24	**-0.47**
Rest^{no}	**-0.7**	**0.44**	**-0.41**	0.17	-0.06
Movement^{no}	**0.7**	**-0.44**	**0.41**	-0.17	0.06
Attention^{no}	**-0.47**	**0.46**	-0.07	-0.37	0.22
Locomotion^{no}	**0.7**	**-0.44**	**0.41**	-0.17	0.06
Excitement^{no}	**0.56**	0.23	**-0.56**	0.26	-0.03
Preening^{no}	-0.27	0.17	0.01	-0.09	**-0.46**
Novel object interaction^{no}	-0.36	**-0.52**	-0.01	**0.63**	-0.01
Latency to touch novel object^{no}	0.39	**0.55**	-0.08	**-0.52**	0.004
Touch in novel object^{no}	-0.38	-0.39	0.05	**0.67**	-0.04
Vocalization^{no}	0.31	-0.12	**-0.59**	-0.35	-0.34
Top grid^{rp}	**0.57**	0.27	0.05	0.3	0.28
Side grid^{rp}	**0.68**	0.38	-0.3	0.11	0.14
Bottom grid^{rp}	**-0.75**	**-0.4**	0.22	-0.19	-0.21
Quadrant 1^{rp}	-0.15	**-0.5**	**-0.61**	-0.23	0.09
Quadrant 5^{rp}	0.05	0.38	0.31	0.12	**-0.4**
Rest^{rp}	**-0.51**	**0.71**	-0.12	0.17	0.13
Movement^{rp}	**0.51**	**-0.71**	0.12	-0.17	-0.13
Attention^{rp}	-0.21	0.23	0.31	0.13	**0.49**
Locomotion^{rp}	**0.55**	**-0.67**	0.11	-0.19	-0.12
Excitement^{rp}	**0.48**	0.05	**-0.66**	0.17	-0.13
Preening^{rp}	-0.09	-0.17	0.01	-0.38	0.08
Person interaction^{rp}	-0.25	-0.26	-0.31	-0.28	**0.57**
Latency to touch person^{rp}	0.23	**0.46**	**0.44**	0.12	-0.22
Touch in person^{rp}	-0.26	-0.35	-0.31	-0.22	**0.54**
Vocalization^{rp}	0.06	-0.3	**-0.5**	0.04	-0.36
Eigenvalue	6.93	5.35	3.22	2.58	2.15
Variance (%)	23.11	17.83	10.74	8.61	7.19

Source: Elaborated by the author (2023).

Note: no = novel object test; rp = reaction to a person test. In bold: the most significant variables for each dimension.

APPENDIX C – SCORES FOR THE FIVE TEMPERAMENT DIMENSIONS EXTRACTED FROM THE PRINCIPAL COMPONENT ANALYSIS FOR THE BIRDS IN THE STUDY (N = 51).

Animal ID	Species	Sex	Activity	Boldness	Anxiety	Neophobia/Neophilia	Proximity to humans
31	*P. maracana*	♂	3.56	-6.34	0.95	-2.37	-1.87
39	*P. maximiliani*	.	-3.10	-0.01	2.09	3.44	-0.14
63	*P. maximiliani*	♀	2.24	-1.11	2.53	-0.73	0.86
64	*P. maximiliani*	.	0.39	-2.95	2.06	0.57	-0.75
65	*P. maracana*	♀	-2.26	-1.71	-0.96	2.70	-0.84
77	*P. maximiliani*	♀	-2.63	0.87	0.19	-0.43	-0.16
104	*P. maracana*	♂	0.63	-0.39	1.57	-0.11	0.6
110	*P. maracana*	♀	0.54	-1.55	-1.86	-0.60	-0.75
183	*P. maracana*	♀	2.48	0.47	0.43	-0.05	0.26
2008	*P. leucophthalmus*	♂	1.56	2.22	-2.99	0.88	-1.03
2009	*P. leucophthalmus*	♀	1.73	2.01	-1.14	-0.72	-0.58
2168	*P. leucophthalmus*	♂	4.33	-0.12	-1.94	-0.64	-1.96
2381	*P. leucophthalmus*	♀	-2.41	-1.00	-1.21	-1.99	0.37
2396	*P. leucophthalmus*	♂	-1.74	0.14	-1.6	-2.99	0.21
4232	*P. maximiliani*	♂	-2.02	-5.63	-2.01	-0.36	3.23
4234	*P. maximiliani*	♂	-1.22	0.66	2.13	-0.17	0.37
4294	*P. maximiliani*	♀	5.23	-1.94	2.74	-0.01	0.4
4303	*P. maximiliani*	♂	-0.42	-2.4	1.21	-0.66	-0.56
4331	*P. maracana*	♂	-2.64	1.21	0.67	-1.41	0.89
4334	*P. maximiliani*	.	-2.97	2.96	0.55	-1.36	-0.99
4498	*P. maximiliani*	♀	-2.60	-0.41	0.69	1.93	-0.39
7257	*P. leucophthalmus*	♂	2.41	1.29	0.93	-0.11	0.39
7267	*P. leucophthalmus*	♀	3.79	4.23	-3.47	2.68	1.33
7275	*P. leucophthalmus*	♂	3.07	3.06	1.04	0.74	2.38
7277	*P. leucophthalmus*	♂	4.09	-0.04	2.54	0.001	1.51
7281	*P. leucophthalmus*	♀	4.56	2.50	-0.58	1.25	0.97
7283	*P. leucophthalmus*	♂	3.63	2.28	0.16	2.73	1.66
7293	*P. leucophthalmus*	♀	-1.18	1.82	-0.6	-0.58	0.32
7927	*P. leucophthalmus*	♀	2.45	-1.92	1.3	-2.38	-1.25
7931	*P. leucophthalmus*	♂	-1.04	-0.38	-3.08	-1.72	-2.04
8241	*P. maximiliani*	♂	-3.37	1.38	-0.41	-0.97	0.76
8259	*P. maximiliani*	.	-2.94	3.31	1.37	-0.61	-4.70
8266	*P. maracana*	♀	1.74	-2.47	1.43	0.17	-0.25
8267	*P. maracana*	♀	-0.87	-1.90	-4.53	0.53	-0.93
8268	*P. maximiliani*	♂	2.22	-0.39	1.65	-0.5	-0.54
8275	*P. maximiliani*	♂	-2.69	2.62	1.41	-0.51	-0.46
8287	*P. maximiliani*	.	-3.21	-2.39	-0.44	4.65	-0.53
8328	*P. maximiliani*	♂	-2.66	1.03	1.41	0.63	0.55
8341	*P. maracana*	♂	0.93	1.09	-0.69	-0.05	0.98
8352	*P. maximiliani*	♂	-0.29	-1.86	0.77	1.21	-1.43
8353	*P. maximiliani*	♂	-2.35	-5.53	-0.49	3.7	-0.05

8354	*P. maximiliani*	♀	-2.98	1.27	0.50	0.18	0.63
8358	*P. maximiliani*	♂	-2.38	0.21	0.66	0.38	0.56
8359	*P. maximiliani*	♂	-3.05	2.73	1.10	-0.33	-0.96
8978	*P. maracana*	♂	-3.39	-0.05	-2.39	-2.66	4.74
8980	*P. maximiliani*	♀	-2.92	1.65	0.75	-0.38	0.66
8990	*P. maracana*	♂	3.00	-0.45	-4.26	0.69	-1.60
8993	*P. maximiliani*	♂	-0.52	-2.63	0.28	-2.40	1.41
9087	*P. maracana*	♂	1.69	1.73	1.63	0.33	0.96
10511	*P. leucophthalmus*	♂	2.31	0.04	-2.60	-0.64	0.18
10562	*P. leucophthalmus*	.	1.27	2.78	0.49	-0.92	-2.42

Source: Elaborated by the author.
Note: (.) = sex unknown.

Gustavo Nunes de Almeida

Temperament of Psittaciformes and its implications in pre- and post-release stages of translocation projects

Dissertação apresentada ao Programa de Pós-Graduação em Biodiversidade e Conservação da Natureza da Universidade Federal de Juiz de Fora como requisito parcial à obtenção do título de Mestre em Biodiversidade e Conservação da Natureza. Área de concentração: Comportamento, Ecologia e Sistemática.

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