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Behavioral Variations in Ara Parrots in Response to Enrichment in Individual Dormitories: A Case Study at Ambue Ari Rescue Center

Relatore

Prof. Paolo Mongillo

Laureanda

Lorena Bordino

Matricola n. 2033614

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1. SUMMARY

Enrichment items have been proven to significantly enhance the well-being of captive birds by engaging them in both mental and physical activities. In rescue centers such as Ambue Ari, where the parrots originate from the wild, the introduction of daily enrichment activities is crucial. Without such stimulation, the birds are at risk of developing abnormal behaviors due to boredom, stress, and the limited space available in captivity. However, as demonstrated in this study, to fully optimize the benefits of enrichment, it is essential to consider factors such as the duration of exposure to enrichment items, the combinations of different enrichment tools, and the individual preferences the parrots might have for certain items.

The study, conducted on four blue-and-yellow macaws and one chestnut-fronted macaw aimed to observe whether placing enrichment in the parrots' dormitories increased their willingness to return to their cages after having spent time outside in a communal area, as well as to notice any behavioral change. For this study, six types of enrichment items and later a combination of them have been tested. The ultimate goal was to develop an enrichment program tailored to the parrots' needs, enhancing their care routines.

For instance, one of the key findings revealed that offering multiple enrichment items at once, significantly enhanced the parrots' engagement compared to providing a single item. By increasing the environmental complexity—through a combination of varied enrichment types—items that were previously less favored became more appealing, leading to greater interaction and stimulation.

Through this study, the management routine of the parrots can be optimized by providing specific, data-driven insights into individual subjects' preferences and behavioral responses, rather than relying solely on general guidelines. At the same time, it serves as a comprehensive assessment of the current management practices and highlights areas for improvement.

2. INTRODUCTION

2.1. Background

Illegal trafficking threatens thousands of parrots every year, including those in Bolivia. Between August 2004 and July 2005, a comprehensive survey was conducted at the Santa Cruz Los Pozos pet market, documenting a total of 7,279 individuals belonging to 31 species. Notably, among these species, 306 were macaws from three different genera. After this period of recording, no further data have been apparently collected. However, there is no evidence to suggest that the trade in these species has decreased (Herrera & Hennessey, 2007).

The species endangered by trade are invariably colorful, large, or good talkers (Luescher, 2006) and the *Ara* genus encompasses all of these desirable traits, making it a popular choice among parrot enthusiasts.

Rescue centers like Ambue Ari provide animals that have been confiscated from illegal trade with a life that meets their ethological needs. However, the lack of funds and personnel puts a strain on these efforts. Therefore, optimizing management strategies is crucial to ensure the best possible care for all animals.

2.2. Biology of the *Ara ararauna*

The blue-and-yellow macaw (*Ara ararauna*) is one of the most popular and marketed species of the Psittacidae family in the world (Bianchi, 1998). Although categorized as Least Concern (IUCN, 2019), the species is vulnerable and virtually extinct in some areas of its distribution (Miglioli & Vasconcellos, 2021). Blue-and-yellow macaws grow up to 86 cm in length and weigh between 0.9 and 1.5 kg. They are distinguished by bright blue feathers on the back and head, a deep yellow underside, and a black beak and chin.

This species is found throughout South America. Their distribution range extends from eastern Panama through Colombia (excluding the Cauca Valley and western Nariño), into eastern and western Ecuador, and possibly northern Peru. They are also present in Venezuela (mainly south of the Orinoco River), the Guianas, Trinidad, and further south through Brazil (to São Paulo and Rio de Janeiro), Bolivia, Paraguay, and potentially northern Argentina (Forshaw, Joseph Michael). These parrots inhabit diverse lowland

tropical environments, including humid forest edges, swamplands, open woodlands, and savannas. They are frequently found near water sources like rivers and streams (Blue-and-yellow Macaw (*Ara ararauna*) - Avian HQ, n.d.). Blue-and-yellow macaws are monogamous, forming lifelong pair bonds. The female lays 2 to 3 eggs in tree cavities, with both parents participating in nesting, incubating, and feeding the young. In the wild, they have a lifespan of approximately 30-35 years, which significantly increases in captivity. Socially, these macaws are gregarious and gather in groups of 25 individuals or more characterized by strong social bonds and communicating with each other with loud vocalizations. They typically forage early in the morning; the main food sources of these parrots are nuts, seeds, and occasionally flowers, leaves, and small insects. When possible they integrate minerals through clay, in fact large flocks can be observed along riverbanks to consume nutrient-rich clay soils (Blue-and-yellow Macaw (*Ara ararauna*) - Avian HQ, n.d.).

2.3. Biology of the *Ara severus*

The chestnut-fronted macaw *(Ara severus)* is a smaller bird compared to other macaws species, reaching a maximum size of 46 cm and weighing 400-500 grams. These features make it more manageable for some pet owners, while still retaining the distinctive macaw characteristics, such as eye-catching green plumage, talking ability, and keen intelligence. The distribution of the chestnut-fronted macaw ranges from eastern Panama to Guianas and South to northern Bolivia up to Bahia and Brazil. These parrots can be observed in palm swamps and well-vegetated forests along rivers and streams.

The species forms lifelong bonds with a single partner, with the male attracting a female mate through a courtship ritual. Once the pair is formed, the couple selects a tree cavity where the female lays 2 to 4 white eggs. Both parents are involved in incubating the eggs and raising the chicks.

As the blue-and-yellow macaws also the chestnut-fronted macaw is a gregarious species forming flocks of about 30 individuals. They are very versatile foragers, feeding on a diverse mix of rainforest fruits, nuts, seeds, and vegetation. They consume softer foods such as flowers, buds, and berries as well. These birds can spend up to 80% of daylight hours foraging and eating, often interrupting the feeding session only with social grooming (Chestnut-fronted Macaw (*Ara severus*) - Avian HQ, n.d.). The lifespan in the

wild seems to be longer than 30 years and, also in this case, significantly longer in captive conditions.

2.4. The Importance of Enrichment in the Captive Setting

In the wild, a wide variety of behavioral skills have to be used to gather food, avoid predators, create or find shelter, and attract mates, while in captivity, most of these needs are met without direct participation: food is provided regularly, the social group is preselected by humans, the shelter is built by humans, and predators are kept away by physical barriers. If, on one hand, the controlled environment might seem ideal, on the other hand, it can result in limitations concerning complexity and opportunities for behavioral expression, which represents a significant risk of developing abnormal behaviors.

The concept of environmental enrichment evolves from the need to cope with the impairment of behavioral development caused by a captive environment. Shepherdson (1994) defines environmental enrichment as "an animal husbandry principle that seeks to enhance the quality of the captive animal care by identifying and providing environmental stimulation necessary for optimal physiological and psychological well-being". Birds, especially parrots, have high cognitive abilities and need stimulation to maintain proper neural function. Olkowicz et al. (2016) found that many bird species have brains with a greater number and density of neurons than those of mammals of comparable size. This neural complexity makes captive birds more prone to boredom and stress when their environment lacks sufficient cognitive stimulation. Little is known about effective strategies to improve the well-being of captive avian species and in particular parrots (e.g. Birchall 1990; Shepherdson 1993; King 1993) but what is clear is that to be effective an enrichment must address those behaviors that are most important for optimal behavioral development (Luescher, 2006). In most cases, the individual differences can be highly significant, impacting the effectiveness of the enrichment strategy. A variety of enrichment types can be applied to parrots: common strategies involve changing delivery methods for food, social stimulation or changing the structures of the enclosure to promote locomotion and exploration.

To better address the enrichment strategies, it is of key importance to examine the main species-specific behavioral characteristics including social behavior, aggressive behavior

and dominance, comfort behavior and sleep, feeding behavior and communication with conspecifics.

Social organization: most psittacines exhibit complex social organization. The most relevant aspects of social dynamics involve flock formation, dominance hierarchies, and affiliative relationships. The formation of a flock plays a crucial role in various aspects of a parrot's life, including foraging efficiency, territory defense, and the detection and avoidance of predators. The size of these flocks varies significantly depending on the specific needs and social structures of each species, and in some instances, flocks can even comprise multiple species. This diversity in flock composition and size highlights the adaptability and complex social dynamics that different parrot species employ to enhance their survival and overall well-being in their natural habitats (Luescher, 2006).

Dominance and aggressive behavior: within the flock, dominance relationships function to reduce the occurrence of conflicts and competition between the members of the group. Dominant individuals assert their authority through aggression, while subordinate individuals respond with appeasement and submissive postures, thereby avoiding fights. Agonistic interactions have been observed more frequently when the relationship between the individuals is unclear such as when a new individual joins the flock. In most parrots' species, males show more frequent aggressive behaviors than females (Jackson 1991; Nol et al.1996; Seibert & Crowell-Davis 2001; Wilson 1992; Wingfield et al.1987; Woolfenden & Fitzpatrick 1977). Some of the most frequently used indicators of dominance are the frequency of attacks to access resources or agonistic encounters with the whole flock. Examples of aggressive behaviors are: turning toward the opponent with head and neck extended, opening the beak toward the opponent, beak spars, wing flapping, flying and rushing approach toward the opponent (Luescher, 2006).

Affiliative behaviors: affiliative behaviors in parrots consist of maintenance of close proximity, pair bonding and allopreening, the latter meaning using the beak to groom another individual, usually happening in the head, wings or tail and being one of the most important mechanisms for maintenance of the pair bond (Luescher, 2006).

Comfort behavior and sleep: sleeping and resting occupy the majority of the day (Rowley 1990; Snyder 1987; Wirminghaus et al 2001). A parrot typically sleeps while perching upright, with one or both feet touching the perch, with the eyes closed. They can tuck the head under the scapular feathers during prolonged sleep. In addition to sleep, parrots spend a good proportion of the day in grooming. Preening is essential for the health of

the plumage, which in turn is essential for thermoregulation, waterproofing and flight. Other grooming behaviors can be considered also cleaning legs and feet with the beak, scratching, yawning, beak-rubbing. Grooming behavior tends to be common to all species independently from the geographical distribution and habitat diversity (Luescher, 2006).

Feeding behavior: most parrots' diet is composed of fruits, seeds, nuts, flowers, and occasionally small insects. Many species forage in flocks, enhancing efficiency in locating food sources and providing protection against predators. Foraging can take up to 40% of the daytime (4 to 8h) and often involves traveling long distances in search of food (e.g., Snyder et al., 1987; Gilardi and Munn, 1998; Wirminghaus et al., 2001; Symes and Perrin, 2003). Foraging behaviors include not only the search for food but also the food selection and procurement, manipulation and consumption (e.g., Magrath and Lill, 1985; Snyder et al., 1987; May, 2001). Parrots are, in fact, well known for their ability to open hard seeds and nuts using a morphologically well-adapted beak. The process of manipulating and breaking the nuts usually involves an initial selection and grasping of the nut, applying pressure to crack the shell at its weakest point, peeling, and finally, consuming the edible pulp (Luescher, 2006).

Vocalization: for wild parrots, vocalizations are essential for survival and social interaction. Vocalizations help in maintaining group cohesion, facilitate social bonding and mating and coordinate activities such as foraging. Several different types of vocalizations have been observed in wild parrots: alarm calls, contact calls, food-begging calls and interspecific agonistic calls.

As for the captive birds, the vocalization represents a paradox in their attractiveness as pets. If on one side their ability to mimic human voices makes them highly desirable to pet owners, on the other side, this same trait can complicate their management. Vocalizations are, in fact, a powerful form of behavioral expression for these animals, which in conditions of stress or boredom, can become extremely noisy, often leading the owner to surrender them. Moreover, as outlined above, vocalization evolved mainly as a means of communication among the flock and in captivity parrots are rarely kept in flocks, so often what happens is that they create inappropriate bonds with the human owner and when separated from them, they vocalize; initially with contact calls and possibly progressing to more distressed and anxious vocalizations in case they do not receive the desired response. Alarm calls serve in the wild to notify the members of the

flock of the presence of a predator or another threat, but in captivity, they can be expressed in response to any unfamiliar person or situation.

Many parrots are prone to learn and mimic voices, being especially attracted by dramatic tones of voice. The repetition of learned sounds occurs after prolonged exposure (Luescher, 2006).

2.5. Objectives of the Study

Considering that often most keepers at the Rescue Center are non-professional volunteers, providing precise guidelines based on actual behavioral observations is essential to ensure animal welfare. Additionally, existing literature reports that environmental enrichment, especially when tailored to the species' natural behaviors, improves overall well-being and reduces stress.

My research has been conducted with the aim to observe if placing enrichment in the individual dormitories of the studied parrots increased their willingness to go back inside their cages after having spent part of the day free in the communal area, as well as to notice any relevant behavioral change in response to the tested enrichment items. By introducing previously absent enrichment in the dormitories, I aimed to observe changes in their behavior and see if the time required to return to their dormitories decreased. This would not only enhance their well-being by reducing boredom and stress when housed in the cages but also improve handling efficiency for the staff.

The primary goal of this study was to develop and implement an effective enrichment program tailored to the specific needs of those parrots. By closely monitoring their behavioral responses to the enrichment, I hoped to identify strategies that could minimize stress during re-entry into their dormitories and provide a more stimulating environment. These insights could then be used to formulate practical guidelines for volunteers, ensuring that the daily care routines align more closely with the natural behaviors and needs of the parrots, ultimately enhancing their quality of life.

3. MATERIALS and METHODS

3.1. The Rescue Centre

Ambue Ari, one of the parks managed by the Comunidad Inti Wara Yassi NGO in Bolivia, spans approximately 1,000 hectares and serves as a sanctuary for over 50 animals (of which 20 threatened species). Located north of Ascensión de Guarayos between Santa Cruz de la Sierra and Trinidad *[-15.674910, -63.505815]* , the sanctuary is staffed by permanent personnel and supported by Bolivian and international volunteers committing to at least two weeks of service. Veterinarians, biologists, and animal keepers oversee the daily care of the animals.

3.2. Animals

Among the 14 birds housed in the rescue center, this study was conducted on four blue-and-gold macaws (*Ara ararauna*) and one chestnut-fronted macaw (*Ara severus*). The animals involved in the study were all confiscated or voluntarily surrendered after being kept illegally as pets.

Cusiblue (*Ara ararauna*): Cusiblue is a female adult parrot arrived in the Sanctuary in 2018. She was taken as a chick from the nest together with her brother who died after being confiscated. She is the mate of Romeo. She is in good health and goes along well with the other birds in the area. Her personality is rather whimsical, resulting in sporadic management issues.

Romeo (*Ara ararauna*): Romeo is an adult parrot who has been kept as a pet in Villa Tunari (Cochabamba) he was rescued and brought to Machia sanctuary before arriving at Ambue Ari in 2006. Following a period of depression due to the loss of his first mate, he was introduced to his current mate, Cusiblue. Romeo has a deformed and non-prehensile right foot, a permanently injured right eye impairing his vision, and limited flight abilities. He gets along well with other birds in the area, although he tends to be quite solitary and does not engage extensively with others.

Sanderson and Brandon *(Ara ararauna):* They are young parrots who arrived together at the sanctuary in 2021. They were confiscated by the authorities from a house in Cabeceras, Nueva Jerusalén, Cochabamba, after being kept as pets. Initially, they shared

a cage, but they were recently separated since their play often became too rough. They both get along well with the other birds in the area and usually spend the majority of their time together.

Troy (*Ara severus*): Troy was voluntarily surrendered to the Machia sanctuary after being presumably found in the street, and transferred in Ambue Ari in 2020. He displays very aggressive and territorial behavior toward other birds, so despite attempts of socialization, he now remains solitary. He seems to seek often human attention, nonetheless, he can be sometimes aggressive, especially when approached with the hands.

3.3. Housing

The aviary structure where the study was led, includes a large communal area with six smaller, individual dormitories (Fig.1)

Fig.1 communal area and dormitories (blue arrows)

Birds were allowed access to the communal area in shifts based on their social affinities. Feeding routines were structured with meals delivered at 7:00 AM, 12:00 PM, and 5:00 PM. The chestnut-fronted macaw, Troy, was freed according to the following routine: released into the communal area from 7:00 AM to 9:00 AM, returned to the dormitory until 12:00 PM, then released again until 2:00 PM.

The blue and gold macaws had their turns in the communal area from 9:00 AM to 12:00 PM and from 2:00 PM to 5:00 PM. Everyone was returned to the dormitory for the night. Enrichment in the communal area consisted primarily of permanent fixtures such as large branches, platforms, bushes, swings, and daily additions of fresh green branches and various materials coming from the surrounding forest area. Individual dormitories contained green branches, perches, and, for two of the blue and gold macaws, a pool.

3.4. Study Design

The experiment consisted of the following parts:

- Observing the parrots' behavior in relation to individual enrichment items (these observations were conducted in individual cages), followed by a comparison of combined enrichments to assess their effects on the parrots' behavior and determine the most effective or preferred combinations.
- Latency: measuring the time it took for the parrots to return to the dormitories after the time spent in the common area when additional enrichment was provided or not provided in the common area, to assess the impact of enrichment on their behavior.

Six types of enrichment items have been administered individually and placed in the dormitories just before calling the birds inside: at 12 AM for the four blue-and-gold macaws and at around 15:30 for the chestnut-fronted macaw.

The types of enrichment employed were as follows:

1. Motacu: The fruit of *Attalea phalerata*, known locally as 'Motacu', features a fleshy pulp varying in color from yellow to orange and a flattened oval shape. Its seeds are encased in an extremely rigid endocarp, surrounded by a fibrous shell. Each infructescence can yield between 300 to 500 fruits annually, easily accessible to various animals such as macaws (Freitas de Lima, Lescano, & Pires de Oliveira, 2020). This type of enrichment aims to stimulate manipulation and the prolonged use of the beak for foraging and handling behaviors in the parrots.

2. Pineapple Head: We utilized pineapple tops as they were readily available food waste, and observed that parrots enjoyed spending time picking through them, thus stimulating beak utilization and manipulation behavior.
3. Lianas Balls: Lianas were readily available in the surrounding area of the forest and suitable for manipulation and rearrangement. Additionally, we contributed to forest management by removing them, as they can smother trees. The vines were rolled into balls approximately 10 cm in diameter, leaving one end free for hanging and incorporating various types of seeds inside, although not always.
4. Patuju Flowers: *Heliconia rostrata* is an herbaceous perennial plant, the national flower of Bolivia. We utilized the Patuju Flowers almost daily due to its abundant availability in the surrounding area, as well as its appealing color and texture.
5. Fresh Coconuts: Fresh coconuts have been employed because their fresh, unripe husks were fibrous and sweet, thus keeping the parrots engaged for extended periods.
6. Snail Shells: Snail shells have been chosen because the sound they produce when pierced and threaded onto vines provides auditory and tactile enrichment. In this experimental setting they have been tied to create necklaces holding 5-6 individuals. Seeds were not inserted inside.

Fig.2 enrichment items: a – Motacu, b –Lianas Balls, c – Pineapple Head, d – Fresh Coconut, e -Snail Shells, f – Patuju Flowers

About the tests in the individual dormitories, each enrichment item was initially placed singularly in the cage, just before calling the birds inside. Items that could not be hung, such as Motacu and Fresh Coconut, were placed on the platform. The Lianas Balls, Snail Shells, and Patuju Flowers were hung on the perch in various locations.

After conducting observations with the single enrichment items, combinations of these items were introduced to determine the parrots' subjective preferences and to compare the features of the enrichment items. Initial observations indicated a preference for the Motacu and the Snail Shells. Therefore, these items were included in all the combinations with the other enrichments.

The combinations tested were as follows:

- Motacu + Lianas Balls
- Motacu + Patuju Flower
- Motacu + Pineapple Head
- Snail shells + Motacu
- Snail shells + Patuju Flowers
- Snail shells + Pineapple Head

In the common area, enrichment items were provided on alternating weeks. When enrichment items were not present, fixed structures were always available. When enrichment items were introduced in the communal area, they were shown to the birds and placed in different locations. Multiple items, equal in number to the subjects, were administered.

3.5. Data Collection

Two monitoring efforts were conducted: as previously mentioned, the first experiment focused on variations in animal behaviors in response to the six types of enrichment. The subjects were observed in 30-minute sessions using a focal animal, continuous recording method, collecting behaviors according to the working ethogram listed in Table 1. The recording session started in the moment in which all the birds were inside their cages. For the blue-and-yellow macaws this coincided with the noon feeding period, while for the chestnut-fronted macaw, it was recorded in the afternoon at around 15:30.

The recorded behaviors were the following:

Feeding	F	Consumption of the provided food
Drinking	D	Consumption of water
Resting	R	State of inactivity. It may include the parrot perching on a surface, closing its eyes, and in general appearing relaxed without any specific interest in the surrounding objects
Perching on platform	PP	Leaning on a platform where the food was placed
Moving on branches	MB	Movement of the parrot along the branches placed in the cage
Moving (other)	M	Forms of movement not involving branches, such as walking on the cage floor or moving along the net
Hanging on net	H	Hanging on the cage wall using its feet or beak to maintain the still position
Biting net	BN	Behavior where the parrot bites or pecks at a net or other cage surface
Looking outside	LO	Directs the gaze toward the outside of the cage indicating interest to the external environment
Vocalization	V	Any sound produced by the parrot, such as chirps, squawks, or repetition of words.
Urination / Defecation	UD	Elimination of urine and feces
Self-grooming	SG	Preening, cleaning, and alignment of feathers using the beak
Stereotypical behavior	SB	Any repetitive unnatural behavior, in this case mainly wings flapping and head bobbing
Interacting with enrichment	IE	Manipulating, biting or using the 6 tested items provided daily
Interacting with permanent enrichment	IPE	Manipulating, biting or using the fixed enrichment structures always present inside of the cage
Overturning bowl	OB	Tipping over the bowl with water or food to empty its content or letting it purposely fall on the ground

Tab 1

The second experiment involved monitoring the time required to recall the birds to their individual cages under two different conditions: in alternating weeks, enrichment items were put outside the dormitories in the communal area, and in the following week only permanent structures were left outside. This cycle was repeated twice, for a total of four weeks. For time monitoring, only the latency in minutes was recorded. The recording started when I started to call the birds inviting them to enter the cage and ended when all the doors were closed. Typically, the timing was consistent for all four blue-and-yellow macaws, as they generally moved together as a group. However, I made a point to record if any individual subject took a longer time to enter. The recorded time primarily reflects the duration needed for the birds to be persuaded to move towards the cages, as the actual

time required for them to enter or reach the cages is only a few seconds and it was always the same.

3.6. Statistical Analysis

A generalized estimating equations (GEE) model was used to assess the effect of the provision of different types of enrichments on different behaviors expressed by the birds. The models included the relative duration of the behavior as a dependent variable and the presence/absence of each different enrichment as explaining factors. Subsequently, a GEE model was used to assess the effects of the provision of one or two enrichments on the behavior of the parrots. The model used behaviors as dependent variable and the number of enrichment provided (1 or 2) as explanatory factors. Finally, a last GEE model was run on behaviors for which a significant effect of the number of enrichment provided had a significant effect, to investigate whether enrichments had different effects on such behavior, depending on whether the enrichment was provided alone or in pair with another one. The model included the duration of expression of behavior as dependent variable, the number of enrichment and the type of enrichment and their interaction as explanatory variables.

4. RESULTS and DISCUSSION

4.1. Descriptive Statistics

Table 2 reports descriptive data on the duration of expression of different behaviors by the parrots. The most expressed behaviors were resting, eating, perching on the platform, hanging on the net, interacting with permanent enrichment and interacting with enrichment.

The data are largely consistent with expectations: behaviors anticipated to be most frequent were indeed observed frequently. However, I did not expect certain behaviors to be so infrequent. For instance, I anticipated a higher frequency of 'Moving on branches' while 'Perching on the platform' was expected to be less common than it actually was.

	Minimum	Maximum	Mean	St. Deviation
Eating duration	0	1755	284,02	340,339
Drinking duration	0	242	7,91	33,498
Resting duration	0	1800	379,21	615,105
Perching on platform	0	1800	448,44	534,719
Moving on branches duration	0	552	66,73	113,847
Hanging on net duration	0	1800	199,81	364,452
Biting net duration	0	310	5,91	34,981
Self grooming duration	0	625	34,64	109,995
Stereotypical behavior duration	0	487	18,40	71,770
Interacting with permanent enrichment	0	1800	101,30	253,310
Interacting with enrichment	0	1824,00	719,6083	577,47732

Tab 2. Minimum, maximum, average and standard deviation of the duration of expression of different behaviors by parrots (seconds).

4.2. Evaluation of Enrichment Impact on Significant Behaviors

Eating

The results of the model investigating the effect of enrichment on eating behavior are presented in Table 3. The statistical analysis revealed that only two types of enrichment, namely Lianas Ball and Fresh Coconut, significantly affected the time spent foraging. The provision of Liana led to a lower expression of eating behavior (estimated marginal means ± SE = 176.4 ± 67.4 s) compared to when it was not provided (342.6 ± 93.2 s). In contrast, the provision of Fresh Coconut resulted in a higher expression of eating (344.3 ± 98.8 s) compared to when it was not provided (174.7 ± 67.5 s).

	Chi-Square	Sig.
Lianas ball	6,467	0,000
Motacu	0,328	0,567
Coconut	11,069	0,001
Pineapple head	0,012	0,913
Patuju Flower	1,217	0,270
Snail Shell	3,597	0,058

Table 3. Results of the GEE model, assessing the effect of the presence of different enrichments on the duration of eating.

With the Lianas Ball in the cage, the time spent eating decreased, whereas the Fresh Coconut led to an increase in eating time. One possibility for the reduction in eating time when the Lianas Ball is present could be that this type of item is particularly effective in engaging the parrots in alternative activities, which in turn might reduce the time they spend eating. The interaction with this enrichment may divert the attention away from feeding. Moreover, the Lianas Ball is a hanging object, that attracts the parrot away from the platform where the food is placed. The Pineapple Head is a suspended object as well; however, as I will discuss later, it degrades rapidly, which accounts for its lack of effect in this case. On the other hand, the Fresh Coconut, appears to complement the eating behavior, possibly by providing a stimulating foraging experience or by being, among all items, the most palatable, thus increasing the time spent eating.

Resting

No enrichment had a significant effect on resting (Table 4).

	Chi-Square	Sig.
Liana	0,048	0,826
Motacu	1,026	0,311
Coconut	0,286	0,593
Pineapple head	2,584	0,108
Patuju Flower	0,015	0,904
Snail Shell	1,466	0,226

Tab 4. Results of the GEE model, assessing the effect of the presence of different enrichments on the duration of resting.

Hanging on net

With regard to the behaviors hanging on net, as showed in table 5 it was observed that no enrichment had a significant effect.

	Chi-square	Sig.
Liana	0,418	0,518
Motacu	2,442	0,118
Coconut	0,039	0,843
Pineapple head	0,003	0,956
Patuju Flower	0,369	0,544
Snail Shell	0,059	0,809

Tab 5. Results of the GEE model, assessing the effect of the presence of different enrichments on the duration of hanging on net.

Perching on platform

Results of the model exploring the effect of enrichment on perching on platform are reported in Table 6. The time spent perching on the platform was significantly influenced by the presence of several enrichment items: the Patuju Flower, the Snail Shell, the Pineapple Head, and the Fresh Coconut. The provision of Patuju Flower resulted in higher expression of this behavior (estimated marginal means ± SE = 935.89 ± 334.69s) compared to when it was not provided (791.57 ± 274.89s). Similarly, the provision of Snail Shell led to an increased expression of perching on platform (968.73 ± 344.44s) compared to when it was not provided (758.72 ± 267.72s). The Pineapple Head also resulted in a greater amount of time spent perching (997.40 ± 363.89s) compared to when it was absent (730.05 ± 246.19s). Finally, the Fresh Coconut almost doubled the time

spent perching on the platform (1112.40 ± 398.47s) compared to when it was not provided (615.06 ± 214.42s).

	Chi-Square	Sig.
Liana	1,367	0,242
Motacu	1,602	0,206
Coconut	6,295	0,012
Pineapple head	4,515	0,034
Patuju Flower	4,206	0,040
Snail Shell	4,236	0,040

Tab 6. Results of the GEE model, assessing the effect of the presence of different enrichments on the duration of perching on platform.

The increase in perching time observed when Fresh Coconut was present can be related to the fact that it was also responsible for an increase in time spent eating, an activity that is performed almost exclusively on the platform.

Similarly the Snail Shells were often placed on the platform or very close to it, alongside the food, which could explain the increased permanence on the platform. The birds likely remained there not only to eat but also to interact with the shells afterward.

Interaction with enrichment

Results of the model exploring the effect of enrichment on the interaction with enrichment are reported in Table 7. The interaction with enrichment items was significantly influenced by the presence of Motacu and Snail Shells. These two enrichment items led to a significantly greater amount of time spent interacting with enrichment which was not observed with other items.

The provision of Motacu resulted in a higher expression of this behavior (estimated marginal means ± SE = 1086.57 ± 215.60s) compared to when it was not provided (659.57 ± 172.80s). Similarly, the provision of the Snail Shell led to an increased expression of the interaction with enrichment (981.51 ± 205.45s) compared to when it was absent (764.64 ± 171.54s).

	Chi- square	Sig.
Liana	1,049	0,306
Motacu	12,091	0,001
Coconut	0,271	0,603
Pineapple head	0,033	0,857
Patuju Flower	0,044	0,833
Snail Shell	8,427	0,004

Tab 7. Results of the GEE model, assessing the effect of the presence of different enrichments on the duration of interaction with enrichment.

The variation in interaction times with different enrichment items reflects the birds' preferences for certain properties: both the Motacu and the Snail Shells are small and can be held in the birds' paws easily, making them very easy to manipulate. They both engage the birds in biting and offer a hard texture (especially the Motacu). The Motacu is particularly engaging because it involves a first peeling action and then the extraction of the almond, providing a complex interaction. The Snail Shell also offers auditory stimulation when degrading.

4.3. Comparative Analysis of Behavioral Responses to Single and Combined Enrichments

The simultaneous presence of one or two enrichment items demonstrated varying effects on the performance of different behaviors. The behaviors that were significantly impacted by the number of enrichments were 'interaction with permanent enrichment' and 'interaction with enrichment', as illustrated in Table 8.

	Chi-square	Sig.
Eating	2,848	0,092
Perching on platform	1,776	0,183
Hanging on net	0,011	0,916
IPE	11,852	0,001
IE	14,442	0,000

Tab 8

The interaction with permanent enrichment decreased when two enrichments were provided (estimated marginal means ± SE 54.38s ± 34.578s) as compared to when only one item was present (148.22s ± 58.185s). As for the duration of the interaction with

enrichment, it increased when two enrichments were provided (862.27s ± 168.785s) as compared to when only one was present (576.95s ± 129.754s).
It can be hypothesized that the presence of multiple items in the cage causes a dispersion of attention, therefore, having more stimuli, the parrots have less time to spend with the permanent structures. It is also likely that the subjects prioritize the interaction with the daily introduced enrichment, since these represent a novelty for them in contrast to the always present permanent structures.

More items led to longer periods of engagement with enrichment as well. It was predictable that the parrots would spend more time interacting with enrichment when presented with two enrichment items as opposed to just one, as this results in a cumulative effect where the time allocated to each individual object contributes to a greater overall interaction duration. However, it could also have been possible to observe no variation in interaction time if the parrots were only interested in one of the two presented objects. Yet, the data demonstrates the opposite, indicating that the parrots generally interact with both objects, thereby increasing the overall time spent on enrichment.

For the following analysis, only one behavior will be considered: namely, interacting with enrichment. This is motivated by the fact that interacting with enrichment is the only variable directly impacted by the quantity of enrichment items available.

Lianas Balls

Table 9 reports the results of the model exploring the effect of the number of enrichments and the provision of Lianas Balls on the interaction with enrichment. The model showed that the provision of Lianas Balls significantly increased the interaction with the enrichment, if two enrichments were provided, but not if it was the only enrichment (Fig. 3).

Factor	Wald Chi-Square	Sig.
Number of enrichments	18,09	< 0.001
Provision of Liana	1,07	0,301
Number of enrichments*Provision of Liana	4,59	0,032

Tab 9

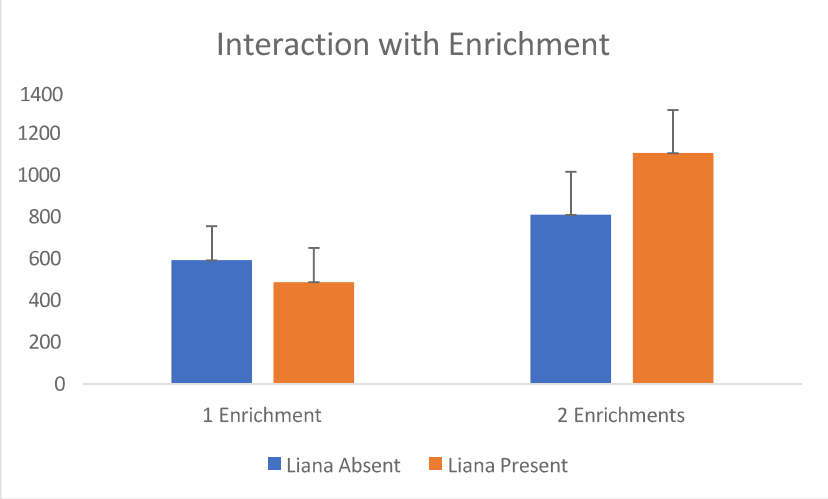

Fig 3

When the Lianas Ball is the only enrichment item, interaction time is lower compared to when it is combined with another enrichment option. This might be explained by its fast degradation. In the absence of the Lianas Balls, interaction time is similar whether only one or two types of enrichment are provided, with a modest increase when two items are used. It is worth highlighting here how this item increases the time spent interacting with enrichment, particularly when included in a dual setup. When the Lianas Ball is provided alongside another enrichment item, it may be perceived as more valuable due to its ability to make a more complex and varied environment in the cage: a key factor is that it is suspended, whereas most other enrichment items are not. This hanging feature adds richness to the environment, making the Lianas Ball more appealing and encouraging greater exploration and interaction.

Motacu

Table 10 reports the results of the model exploring the effect of the number of enrichment and the provision of Motacu on Interaction with Enrichment. The results show that the provision of Motacu increased interaction with the enrichment, only if Motacu was the only enrichment provided, but not if two enrichments were provided.

Factor	Wald Chi-Square	Sig.
Number of enrichments	1,365	0,243
Provision of Motacu	6,692	0,010
Number of enrichments*Provision of Motacu	17,830	0,000

Tab 10

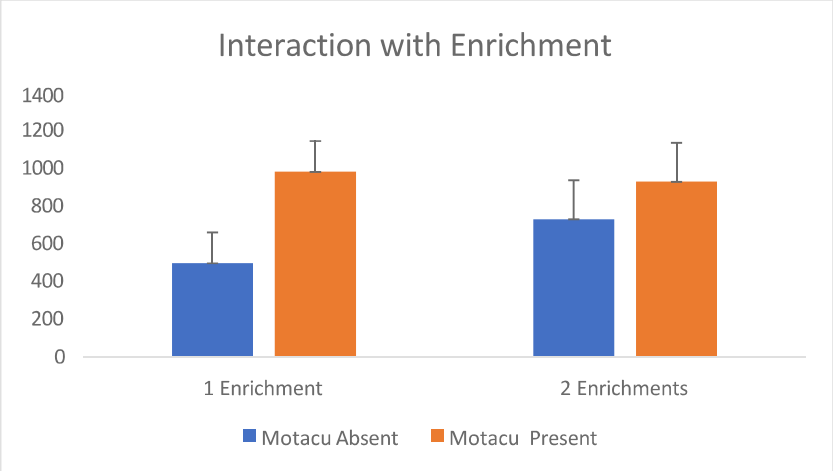

Fig 4

When a single Non-Motacu enrichment is provided, interaction time is lower compared to when Motacu is the single enrichment. The presence of Motacu as one of two enrichment items also results in a higher interaction time compared to having two Non-Motacu enrichments. The extended interaction time with this item when it is provided as a single enrichment suggests that it has intrinsic properties that make it particularly appealing to the birds. Additionally, the presence of the Motacu enhances the overall attractiveness of the enrichment setup, even when it is paired with another item. This can be explained by the fact that the Motacu engages the birds for a prolonged period on its own. As previously discussed, it represents a notably engaging object for avian subjects due to its characteristics. Its small oval size facilitates easy handling by birds, allowing them to grasp and manipulate it with their claws. It offers a complex interaction: birds first engage in peeling its outer layer, which provides a tactile challenge, and subsequently access the almond within, thereby extending the complexity of their interaction. Furthermore, the Motacu is a fruit that birds naturally consume in their habitats, thereby promoting the expression of natural foraging behaviors and reinforcing their instinctual feeding practices. As a result, even if the interaction time with the other item is relatively

short, the total interaction time with the entire setup remains high because a significant amount of time is spent interacting with the Motacu.

Pineapple Head

Table 11 reports the results of the model exploring the effect of the number of enrichment items and the provision of Pineapple Head on interaction with enrichment. This type of enrichment was found to have no effect, neither as the only item nor in combination with another item.

Factor	Wald Chi-Square	Sig.
Number of enrichments	10,319	0,001
Provision of Pineapple head	16,420	0,000
Number of enrichments*Provision of Pineapple head	0,498	0,481

Tab 11

The only statistically significant results indicate that, whether the single enrichment is Pineapple or not, the parrots interact for a longer duration with the enrichment when two items are provided, even if they are different from Pineapple. This suggests that neither Pineapple alone nor any other single item is capable of attracting the parrots more effectively than the combination of two items.

Patuju Flower

Table 12 reports the results of the model exploring the effect of the number of enrichments and the provision of Patuju Flowers on the interaction with enrichment. The model showed that the provision of the Patuju Flower significantly decreased the interaction with the enrichment in a single-item setup, while it didn't have any effect when provided as part of a combination (Fig. 6).

Factor	Wald Chi-Square	Sig.
Number of enrichments	27,854	0,000
Provision of Flower	2,823	0,093
Number of enrichments*Provision of Flower	5,105	0,024

Tab 12

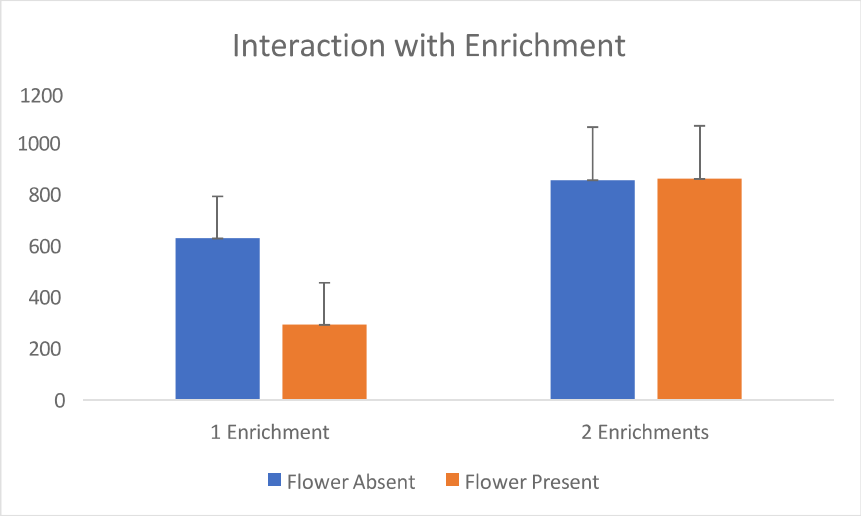

Fig 6

The data suggest that when only one item is present parrots interact for less time with the enrichment when it is a Flower, compared to when the enrichment is not the Flower. Conversely, the presence of the Flower among two enrichment items results in a slightly increased interaction time compared to the single Flower. However, comparing a dual setup with a Flower and a dual setup without Flower there seems to be no significant difference in interaction time. These results might be explained by the fast degradability of the item, which doesn't allow for a sufficiently substantial interaction time to significantly impact the mean interaction times in a statistically meaningful way.

Snail Shell

Table 13 reports the results of the model exploring the effect of the number of enrichments and the provision of Snail Shells on interaction with enrichment. The model showed that the provision of Snail Shells significantly increased the interaction with the enrichment in a single-item setup and decreased the interaction in a dual setup (Fig. 7).

Factor	Wald Chi-Square	Sig.
Number of enrichments	9,839	0,002
Provision of Snail shell	0,346	0,556
Number of enrichments*Provision of Snail shell	9,553	0,002

Tab 13

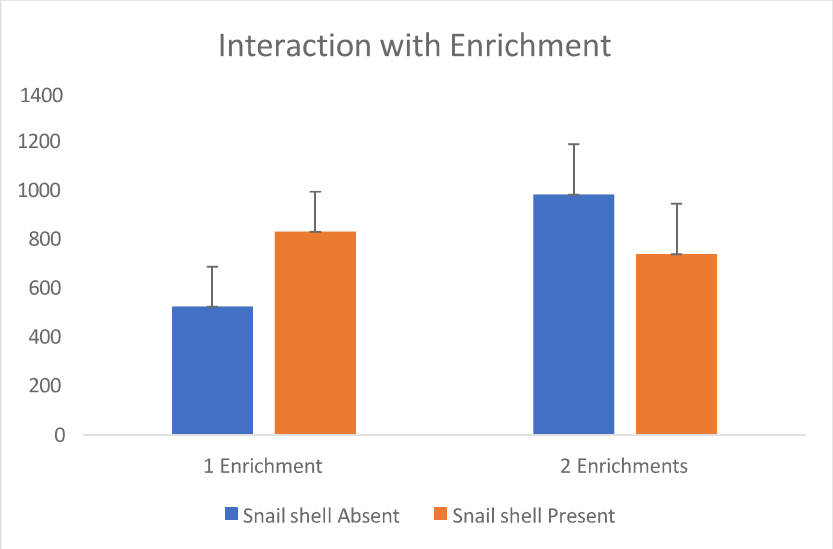

Fig 7

The results indicated that the Snail Shell is more engaging than other enrichments when it is the only option available. However, the interaction time with a single Snail Shell enrichment was not long enough to match the time spent interacting with two enrichments, regardless of whether the Snail Shell was included in the combination or not. Adding a Snail Shell to a dual-enrichment setup increased engagement compared to providing just one Non-Shell item. However, interestingly when comparing the two dual-enrichment setups it emerged that the parrots interacted more with the two Non-Shell enrichments than with the setup that included the Snail Shell. One possible explanation, based on the data, is that the Shell itself may already be highly stimulating. As a result, the addition of another enrichment may not significantly alter the outcomes. It is plausible that the observed preference for items without Snail Shells might be related to the animals' primary frugivorous diet. Given that these animals predominantly consume fruits, it is possible that a Snail Shell does not capture their attention as effectively as other food

items within their diet, such as the Motacu or Coconut, at least when they are provided with both alternatives.

4.4. Troy's Case

The case of Troy, the chestnut-fronted macaw, deserves a separate chapter due to the fact that he was the only subject to consistently display a stereotypical behavior (wings flapping). Since Troy represents a single case, this precludes statistical analysis, but I considered it valuable to present data on the evolution of his behavior. Table 14 illustrates the average time spent performing stereotypical behavior with the different enrichment items present in the cage.

	Average time SB (s)
Motacu	82,40
Pineapple Head	63,66
Liana	37,75
Patuju Flower	122
Snail Shell	55,75
Fresh Coconut	139,5

Tab 14

Regarding the effects of having one versus two enrichment items, it was observed that the average time spent engaging in stereotypical behavior was 12.42 seconds when two items were present, compared to 30.03 seconds when only one item was available. These results suggest that the most effective enrichment for reducing stereotypical behavior in the subject is the Snail Shell. Additionally, the presence of two enrichment items further reduces the occurrence of this behavior.

5. CONCLUSIONS

Many interesting findings regarding the properties and effects of the enrichment items tested have emerged from the study and can be applied by the caretakers of the center: feeding is a significant natural behavior that caretakers aim to stimulate: alongside providing food in an appropriate manner, enrichment items can further enhance feeding behaviors. For example, Fresh Coconut has been demonstrated to prolong feeding duration. Strategic placement of enrichment on feeding platforms, such as Patuju Flowers, Snail Shells, Pineapple Heads, and Fresh Coconut, has been shown to increase the time spent on these platforms. It can be hypothesized that the proximity to food may encourage greater consumption by the parrots. Conversely, certain items, such as Lianas Balls, have been observed to decrease feeding time. Hence, incorporating enrichment items that reduce feeding duration should be avoided if some individuals exhibit insufficient food intake. This understanding facilitates the modification of enrichment strategies to ensure that subjects consume adequate amounts of food, particularly in situations where increased intake is necessary to address underfeeding.

Observations have identified that the preferred enrichment items are Motacu and Snail Shells, characterized by their small size, hard texture, biting stimulation, and manipulability. These features suggest that such items can be strategically used to attract birds into the cage or to engage individuals who show diminished interest in interacting with enrichment. And that new enrichment items should have similar features.

Furthermore, the interaction with permanent enrichment becomes crucial when daily introduced items lose their novelty. This underscores the important role that permanent enrichment plays within the cage environment. While parrots generally prefer new daily items over fixed structures, it is clear that permanent enrichment remains essential for redirecting attention when the novelty of daily items decreases or if they become depleted. Thus, the presence of fixed enrichment structures is fundamental.

When it comes to enrichment combinations, identifying and frequently providing the most effective items is crucial. It is recommended to offer at least two items simultaneously rather than just one to enhance the enrichment experience.

Increasing environmental complexity generally improves engagement with enrichment. For instance, more complex environments can make less preferred items, such as Lianas, more attractive. Environmental complexity can be achieved by combining enrichment items with different properties, hanging and non-hanging items.

Although the results already provide useful information, including observations from the latency study (which was not fully reported and explored here), future research could delve deeper into understanding the individual preferences of each parrot and testing novel types of enrichments and their effectiveness. Additionally, further investigation could focus on identifying the underlying causes that influence the patterns of interaction with the different items: further studies could for example take into consideration other variables that may affect the parrots' behavior alongside the enrichment such as diet, weather conditions, or seasonal influences. This broader approach would provide a more comprehensive understanding of how environmental factors interact with enrichment strategies, ultimately leading to better care and enhanced quality of life for the parrots in different conditions.

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