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A Courting Behavioral Study on a Hyacinth Macaw *(Anodorhynchus hyacinthinus)* Pair

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ABSTRACT: This study observes the courtship behaviors of an *Anodorhynchus hyacinthinus* pair in the Central Florida Zoo and Botanical Gardens in Sanford, Florida. *A. hyacinthinus* reproductive behaviors occur in four steps in the following order: Allopreening, Cloacal allopreening, Back to Back Copulation Position and finally, Copulation (Schneider 2006). Behavioral observations were taken twice a week for an average of 2 to 3 hours each day for ten weeks. The resulting data was analyzed based on the different actions, types of movement, and types of maintenance observed of the *A. hyacinthinus* pair. Percentages and averages were then calculated for actions relevant to courtship behaviors – Destruction, Vocalization, Self-preening, and Mutual Preening. From the observations collected during this study, the pair only fully completed step 1 (Allopreening) of the mating process. This species is known to produce specialized vocalizations when Cloacal Allopreening (step 2) is reached (Schneider 2006). However, the specialized vocalizations were absent during observation sessions. One of the individuals was observed to attempt the beginning positions for step 3, Back-to-Back Copulation Position, but this action was not reciprocated by the other individual, suggesting Step 3 was not completed. Lastly, Copulation was not observed throughout the study. These findings nevertheless demonstrate that the *A. hyacinthinus* pair is well bonded and may be encouraged to copulate if given proper nesting materials and privacy.

KEYWORDS: Hyacinth Macaw; *Anodorhynchus hyacinthinus*, courtship, mating

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INTRODUCTION

Anodorhynchus hyacinthinus, also known as the Hyacinth Macaw or the Blue Macaw, is the largest of the parrots. With an average weight of 1.36 kilograms, these parrots have a wingspan of about 1.22 meters and a length of up to 99.06 centimeters (Hagen 2004). Covered in cobalt blue feathers and possessing distinctive yellow markings around their eyes and at the base of their mandible, *A. hyacinthinus* looks to be always smiling.

This unique species of macaw, native to Central and South America, prefers woodland and savannah habitats and is commonly found in the Pantanal and Cerrados regions of Brazil (Schneider 2006). *A. hyacinthinus* are naturally destructive, and are known for using their beaks to manipulate small stones, thin branches, or bark to sharpen or clean their beaks. These birds may exhibit behaviors such as preening (using their beak and tongue to groom themselves or other macaws), vigilance activity (a pair taking turns patrolling the territorial area), wide ranges of vocalization, and fruit manipulation (holding fruit with one foot while using their beaks or tools to break apart or open mesocarp) (Lafeber Pet Trade; Schneider 2006). They are omnivores, though their diets consist mainly of palm fruit and nuts (De Paula 2017). In some cases, this species uses tools to open and remove the mesocarp of palm fruit (Schneider 2006). This species' protein intake derives from the larvae inside nuts and fruits that have fallen or dropped to the forest floor. This macaw species also feeds on termites found in the decaying wood when building their nests (De Paula 2017).

A. hyacinthinus populations were once abundant in the Pantanal because the area is rich in manduvis trees, which are used for nesting (Pizo 2008). Unfortunately, habitat destruction, illegal bird trading, and the slow process of development and maturation in nestlings has greatly affected the species' numbers. As a result, this species is now considered "Vulnerable," with only an estimated 4,300 mature individuals left in the wild (Kuniy 2006, IUCN 2016). Copulation occurs year-round, but nesting occurs from November to April in South America (Hagen 2004). The female will lay one to two eggs per clutch and incubate them for 25 to 28 days, in which time the male will forage and feed the female. A. hyacinthus eggs hatch asynchronously, therefore, the mother will only bear the first hatchling (keeping the second as insurance), which will fledge in 13 weeks and stay with her for about 18 months (Kuniy 2006, Schneider 2006).

Figure 1. Zack (left) and Stitch (right)

Once they are able to care for themselves, juvenile *A. hyacinthinus* may join another flock of un-mated young adults. However, it is not uncommon to find bigger flocks of 12 to 20 individuals consisting of pairs and family trios (Schneider 2006, Animalia.bio). These birds reach sexual maturity between 6 and 10 years old. While *A. hyacinthinus* prefer to stay in flocks, they are socially and sexually monogamous, staying and reproducing with the same partner throughout their lifetime (Caparroz 2011).

The subjects of this study include a pair: Zack and Stitch. Zack and Stitch were both born in 1996 in different areas of the United States. Zack was transferred to the Central Florida Zoo and Botanical Gardens from a private sector in Dallas, Texas when he was six months old. Sometime later, Zack was paired with another Hyacinth Macaw as a breeding companion. The second subject, Stitch, and her mate at the time, were transferred from a private sector (also in Dallas) to Disney's Animal Kingdom and then to the Central Florida Zoo and Botanical Gardens in 2009. Stitch and her mate were kept off-exhibit for breeding purposes. Stitch's and Zack's mates were later transferred to Palm Beach due to new breeding recommendations, and Stitch was subsequently paired with Zack. Originally,

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Figure 2. A. hyacinthinus *display enclosure.*

zookeepers had believed the pair consisted of two males from information provided by the prior owners of the *A. hyacinthinus*. However, recent genetic tests revealed that one of the macaws, Stitch, appears to be female. Zack and Stitch were kept in an enclosed perching area similar to their current "Night Enclosure" until August of 2018, when the zoo built the Hyacinth Macaw "Display Enclosure". Stitch is distinguished from Zack by a band on his left foot. Moreover, they display a noticeable physical difference; Zack is more distinctively yellow around his mandible and eyes than Stitch (Figure 1).

Zack and Stitch are brought out to their "Display Enclosure" around 9:30 AM. This enclosure consists of eight posts connected by various branches of differing levels, lengths and extending branches (Figure 2). The post directly in front of the zookeeper's entrance to the enclosure was labeled as Post 1, while the rest of the posts were numbered in a clockwise manner from the view of the boardwalk. There is no connecting branch between Post 3 and Post 4 to allow the zookeepers to place a Scarlet Macaw in the enclosure with the Hyacinth Macaws without risk of altercations. Three pieces of mesh fabric have been placed over the enclosure to provide shade, and two fans on the left and right corners on the outside of the habitat provide cool air. Additionally, three sprinklers placed around the enclosure hose down posts 1, 2, 3 and 6 (and all the branches in between) so the pair may cool off and find solace from the extreme heat. Two water bowls have been placed on Post 1 and Post 4. At times, zookeepers attached palm leaves or enrichment toys to the branches and posts of the enclosure.

In response to the loss of their original mating partners, this study aims to determine if the new pair is performing courting and mating behaviors. According to Larissa Schneider (Schneider 2006), copulation of *A. hyacinthinus* occurs in four steps. The first of these steps, allopreening, is characterized by a pair perching side by side, ruffling their feathers and grooming each other's feathers using their beak and tongue. The next step is cloacal allopreening, in which a pair perches side by side and the head of one individual is directed to the other's cloaca, and vise versa; this position is followed by allopreening. Following this step is the back-to-back copulation position, in which, perched back-to-back, a pair leans their heads forward and raise their tails; specialized vocalization may begin as cloacas touch. The final step, copulation, is characterized by a pair with their heads down, tails up, tongues moving up and down, and cloacas connected. At this point, vocalization reaches a high intensity. This final step is the consummation of copulation.

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METHODS

This study began on the 21st of May 2019 at the Central Florida Zoo and Botanical Gardens in Sanford, Florida. Observations were taken twice a week for an average of 2 to 3 hours each day for ten weeks. As previously stated, the observations for this study mainly occurred in the *A. hyacinthinus* "Display Enclosure" from the boardwalk. When storms were predicted, the zookeepers moved *A. hyacinthinus* to their "Night Enclosure." Due to the location of this study, 70% of the observations were taken in the mornings to avoid adverse weather conditions during Florida's wet season. For simplicity of data recording, Zack was labeled as "A" and Stitch was labeled as "B". Observations were taken when an individual or the pair moved in the enclosure, performed an action, vocalized, preened, or destroyed a branch, post or bark. Observations were collected every 10 minutes, as well as when mutual preening occurred to determine the duration of each allo-preening session. Additional data such as temperature, humidity levels, weather conditions were collected every hour from a weather application operated by The Weather Channel. It was also noted if another parrot was in the enclosure. Interactions with visitors, long-term volunteers or other animals that disrupted the current activity of the pair were also described. The observations were later converted into a table separating the "Time and Comments," "Birds and Action," and "Descriptions," as shown below in Figure 3.

6/20/19

Climate: 9:58 AM, 83°F, mostly sunny, Humidity: 79%

Environment: Main display enclosure, Scarlet Macaw on post 5, no more palm leaves

TIME & COMMENTS	BIRDS & ACTION	DESCRIPTION
9:58 AM	A & B: Maintenance	Mutual preening wings A preening B's bottom of wings B preening A's top of wings End 10 AM
10 AM	B: Still	Perched upright, alert, surveying environment
	A: Destruction	Biting at branch between feet
***BRANCH BROKE WHEN B FLIPPED UPSIDE DOWN**		
	A: Action	Grabbing on to broken part of branch while B attempts to climb back up
	A & B: Destruction	Trying to rip off broken piece of branch
	A & B: Still & Destruction	Switch between being perched upright, surveying environment and biting branch
10:09 AM	A & B: Maintenance & Destruction	Self-preening side by side Still destroying branch each holding it with one foot Almost ripped off branch
10:14 AM	A & B: Maintenance	A initiated slight mutual preening B with foot on A Locking jaws End 10:16 am when ZK walked by
	A: Action	Balance/stretch for < 1 minute
	B: Destruction	Biting at broken branch Broke it off successfully
	A: Maintenance	Self-preening

Figure 3. Sample Observation Data

RESULTS

Results have been organized into three tables describing the different actions, types of movement, and types of maintenance observed by the *A. hyacinthinus* pair. Percentages and averages were calculated for actions and types of maintenance relevant to reproductive behaviors: the destruction of branches and bark for nesting, allopreening, and specialized vocalization.

Table 1 describes the different actions observed by the *A. hyacinthinus* pair. "Destruction" was calculated to be 27.24% of all the actions performed by the *A. hyacinthinus* pair. When zookeepers added palm leaves to the enclosure in Week 3, the pair's destructive activity increased to 30%, compared to the average of 23.5% throughout the other weeks. The pair picked at, maneuvered, and stripped the leaves apart. Zack specifically was observed stripping bark from the posts in the enclosure as well. The pair were not observed collecting the branches or bark into a specific area of the enclosure, meaning that the pair was not nesting. The pair mainly used the branches and bark to clean or sharpen their beaks. "Vocalization" was calculated to be 9.15% of all the actions performed. Vocalization did not last more than 3 minutes at a time, and the pair was not observed to be vocal during allopreening. The pair was also observed to be vocal when zookeepers entered the vicinity of the enclosure, when the pair acknowledged an (unknown) threat, or when other macaws began vocalizing as well.

Table 2 describes the different forms of maintenance performed by the *A. hyacinthinus* pair. Of the total maintenance activities observed, the *A. hyacinthinus* spent an average of 59.6% of the time "Self-Preening." The pair performed "Mutual Preening" an average of 36.3% of the total maintenance time. "Self-preening" sessions and "Destruction" sessions both include cleaning and/or sharpening of beaks, and so calculations for "Cleaning/ Sharpening Beak" cannot be accurately analyzed.

Table 3 describes the different types of movement observed by the *A. hyacinthinus* pair. The pair was always observed to be within a few feet from each other. When the pair was perched on opposite sides of the enclosure, one individual would move towards the other within 5 minutes. Additionally, Zack was occasionally observed walking in a pattern, visiting the same posts for a couple of seconds in Week 4, leading us to assume he was making "rounds" and performing vigilance activity. Percentages and averages were not calculated for any

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TYPE OF ACTION	DESCRIPTION
BITING AT LEG TAG	Specific to Stitch. Will bring left leg up to beak and bite at the leg tag.
DESTRUCTION	Occurs when one of the macaws uses their beaks to break off pieces of bark from branches or posts. Usually, they will use their bottom mandible to "dig" into the bark and the top mandible to finish ripping it off from the branch/post
DRINKING WATER	Lowers head into bowl, collects water, raises head and swallows water
EATING	Observed to crack nuts with beak and holding it with foot, using tongue to drop shells to the floor
FLIPPING UPSIDE DOWN	Will thrust their body forward holding on to the branch with their feet. May hang suspended for a few seconds or minutes. May keep their body upright and bite at the branch they are perched on or stretch their bodies toward the ground to reach at leaves from bushes.
PANTING	Occur as part of heat-loss behavior during the afternoon when temperatures and humidity levels are high. Beaks are open, and tongue moves up and down. Usually occurs when macaws are perched upright and alert.
PERCHED	Macaws are still, with bodies upright. May be alert and surveying environment or may be resting with eyes closed. Sometimes may perch with their body parallel to the ground.
VOCALIZATION	Common vocalization includes loud, single squawks when zookeepers come into the enclosure, low chirps in response to one another and "alarm" calls. Alarm calls are much louder and disruptive than regular calls. Reasons for alarm calls have not been observed.

Table 1. Types of Actions Observed of the A. hyacinthinus *Pair*

TYPE OF MAINTENANCE	DESCRIPTION
CLEANING/SHARPENING BEAK	Macaws will clean the inside of their beaks by rubbing pieces of bark through the inside of their top mandible using their tongue. They will sharpen or clean the outside of their beaks by rubbing their beaks against branches.
MUTUAL (ALLO) PREENING	Pair may mutually preen side by side or back to back. When preening side by side, pair usually preens each other's heads, necks, chests, area around beaks and the underside of their wings. When preening back to back, the pair will usually preen their wings, tails and underside of tails near cloaca. When preening contour feathers, the pair will take an individual feather in between their top and bottom mandible and use their tongue to clean and rub against their uropygial gland. When preening down feathers, the pair nibbles against the feathers and the individual getting preened may ruffle their feathers to allow better access to them.
SELF-PREENING	Macaws will contort their bodies and turn their heads around to preen their feathers. Have been observed to self-preen wings, tails and chest. Preen their contour and down feathers the same way when allo-preening

Table 2. Types of Maintenance Observed of the A. hyacinthinus *Pair*

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TYPE OF MOVEMENT	DESCRIPTION
BOUNCING AND DANCING	Usually occurs when interacting with a visitor or zookeeper. When bouncing, the pair lifts and raises the body and when dancing, they step side-to-side while swaying their body. The pair may also bob their heads when bouncing.
CLIMBING	When climbing, the pair will stretch their upper bodies and use their beak to grab a branch above or below them. They will then move their feet towards their beak and then again use their beak to continue climbing up or down a branch.
STRETCHING	When stretching one macaw will extend a wing and leg as far as possible and lean the upper body forward. Most times, they will place their beak on the branch to balance.
WALKING	With zygodactyl feet, the pair will walk placing one foot in front of the other, grabbing on to the post or branch. Their bodies will be slightly leaned forward and sway the opposite direction of the leg they are placing forward. When walking on the ground, their tails drag behind them.

Table 3. Types of Movement Observed of the A. hyacinthinus *Pair*

of these actions because the actions observed are not considered significant to mating or copulating behaviors.

Figure 4 demonstrates the average time spent on activities observed and recorded during observation sessions. Tallies were recorded per observation entry throughout the ten weeks and then averaged. The category "Self-Preening" includes self-preening sessions performed by either Zack or Stitch. "Perched Still" describes moments when Zack or Stitch or both were perched on a branch, surveying their environment or resting. The "Other Actions" category includes entries of Stitch biting her leg band and either macaw flipping around the branches, dancing, bouncing, stretching, climbing, and walking. As previously stated, averages for "Cleaning/Sharpening of Beak" cannot be accurately analyzed since it is observed to occur in preening sessions (both self and mutual) and in destructive behaviors. Figure 4 illustrates that Zack and Stitch spent most of their time (35%) participating in "Other Actions."while "Vocalization" was recorded to occur 3% of the time for the Hyacinth pair, though no vocalizations were recorded during any allopreening sessions.

Additionally, "Destruction," at 11% of observed behavior, did not indicate nesting behaviors. The *A. hyacinthinus* pair simply broke or gnawed at branches and posts to sharpen or clean their beaks or as mental stimulation. Figure 5 compares the averages between Zack's and Stitch's individual self-preening sessions and their mutual (allo) preening sessions. Figures 4 and 5 reveal that Zack and Stitch participated in "Self-Preening" and "Mutual Preening" sessions about an equal amount of time.

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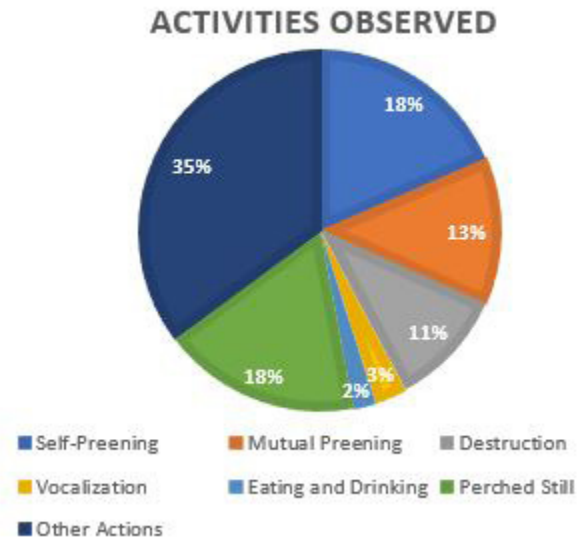

Figure 4. Averages of Activities Observed

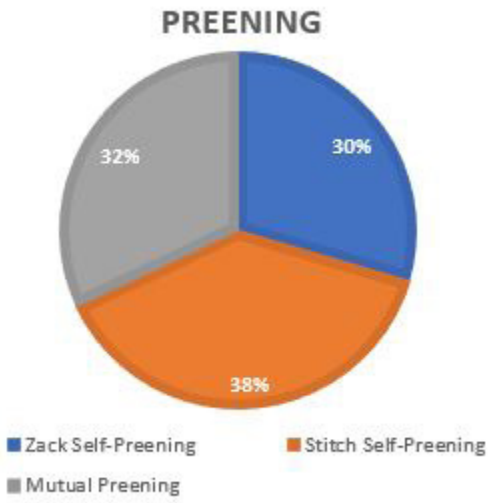

Figure 5. Averages Comparing Preening Sessions

DISCUSSION

This study consists of careful observations of the *A. hyacinthinus* pair at the Central Florida Zoo and Botanical Gardens in Sanford, Florida. Zookeepers had seen the pair increase their destructive behaviors, especially Zack, who has been observed to break and gnaw at bark from the posts in their "Display Enclosure." However, the frequency, duration and force observed during those destructive sessions, and the pair's focus on more than one post, are not definitive enough to identify as nesting behaviors. Additionally, neither enclosure contained a confined area with thin branches or bark ripped from the posts, confirming that the pair has not attempted to build a nest. This destructive behavior of the *A. hyacinthinus* pair is normal for their species, since they instinctually use bark to clean and sharpen their beaks and break open palm fruit (Lafeber Pet Trade). Conversely, wild *A. hyacinthinus* have been recorded using nest boxes provided by farmers due to the massive deforestation of the manduvis trees (Wildlife Conservation Society). If the zoo provided a nest box and additional palm leaves, it might entice the pair to begin nesting.

As previously detailed, *A. hyacinthinus* reproductive behaviors occur in four distinct steps: Allopreening, Cloacal allopreening, Back to Back Copulation Position, and finally, Copulation (Schneider 2006). From the observations collected during this study, we can conclude that the pair only fully completed step 1 (Allopreening) of the mating process. Although mutual preening behaviors (grooming each other's face and neck) were observed, the pair spent most of their time participating in non-reproductive behaviors, as seen above in Figure 1. Typically, allopreening for this species lasts 10 minutes or less, while the pair in this study was observed engaging in this behavior for 30 minutes. This figure is most likely a direct effect of the low temperatures and humidity levels recorded on that day, similar to the climates at dawn and dusk, which is when *A. hyacinthinus* is most likely to preen (Schneider 2006). Conversely, from observations collected during the afternoon in Week 9, Zack and Stich spent the majority of the session exhibiting heat loss behaviors (perched with their wings away from their body and panting) due to the high temperatures (Schneider 2006). During the last three weeks of observations (Weeks 8, 9, 10), little to no movement was recorded until the zookeepers turned on sprinklers designed explicitly to aid the birds in cooling down.

Moreover, the pair was observed performing back to back preening of the tail near the cloaca. However, the species is known to produce specialized vocalizations when Cloacal Allopreening is reached (Schneider 2006). These vocalizations were absent during the above described behaviors, indicating that the pair only reached the beginning stages of step 2 (Cloacal Allopreening). Stitch

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was observed positioning herself so her rear body was over Zack's, possibly signifying that she was attempting the Back-to-Back Copulation Position. This behavior was only observed twice, and Zack did not reciprocate, indicating that step 3 (Back-to-Back Copulation Position) was not completed. Step 4 (Copulation) was not observed and overall, "Destruction," "Allopreening," and "Vocalization" all declined in duration and frequency throughout the last three weeks of the study. From the above analysis, it is clear that the *A. hyacinthinus* pair is not performing any copulating behaviors.

There is a significant factor that could have impacted the lack of copulating or mating behaviors in this *A. hyacinthinus* pair: Zack and Stitch both had long-term mates prior to being paired together. Stitch and her previous mate, Henry, produced one egg while they resided at Disney's Animal Kingdom. Unfortunately, it was unknown which of the pair produced the egg, and the egg turned out to be infertile. *A. hyacinthinus* is a socially and sexually monogamous species (Caparroz 2011). In fact, *A. hyacinthinus* is one of the two known species of macaw that are unable to recognize hatchlings from extra-pair copulations, suggesting that extra-pair copulations are rare or nonexistent (Caparroz 2011). If such is the case, Zack and Stitch would not be inclined to mate since they have each had their own mates for many years. Not recognizing extra-pair copulations or attempting to mate again after the loss of a mate can affect current and future conservation efforts to improve the *A. hyacinthinus* natural population since this species of macaw has limited options to widen the gene pool and increase genetic success of multiple fledglings. Additionally, *A. hyacinthinus* is a phylopatric species, meaning that individuals keep to their own feeding and reproductive sites (Caparroz 2011). If the *A. hyacinthinus* pair were to begin copulating behaviors, they should be transferred to their "Night Enclosure" to allow them privacy from the visitors. Although the *A. hyacinthinus* pair is not performing any reproductive behaviors, this study indicates that they are very well bonded. Like Blue-and-Yellow Macaws (*Ara ararauna*), *A. hyacinthinus* need social interactions to live a healthy lifestyle. A study conducted by Plair et al (2008), established that reintroduced A. ararauna populations had a higher success rates when there was an established pioneer group with sufficient social interactions and feeding. This finding suggests that Zack and Stitch bonded together after the loss of their mates for social contact.

While the observations of this study led to the conclusion that the *A. hyacinthinus* pair at the Central Florida Zoo and Botanical Gardens are not currently mating, there were significant limitations that could have affected the results. Being constricted by the Zoo's hours of operation, observations were not conducted during the *A. hyacinthinus* hours of high activity, dawn and dusk (Schneider 2006). Additionally, having the pair out in the "Main Display Enclosure" could have affected the behavior of the *A. hyacinthinus* pair in regard to their willingness to mate. Future studies could be conducted to observe *A. hyacinthinus* during dawn and dusk in an isolated enclosure with a variety of proper nesting materials and privacy to expand on the behavior of this macaw species with minimal impediments. An expansion of this study could be focused on *A. hyacinthinus* that have had long-term mates previously and look at how mating behavior (or social behavior) changes when paired a second time in one lifetime. Looking at if the Hyacinth Macaw is able to have multiple pairings can aid in conservation efforts such as SSPs (species survival plans) that can help potentially increase the population number in this endangered species.

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