UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento di Biomedicina Comparata e Alimentazione
Department of Comparative Biomedicine and Food Science

Corso di Laurea / First Cycle Degree (B.sc)
in Animal Care – Tutela del Benessere Animale

Animal's social introduction in captivity: Scarlet Macaw (Ara Macao) case study

Relatore/Supervisor
Prof. Giorgio Marchesini

Laureanda/o /Submitted by
Rachele Bosco
Matricola n./Student n.
2045423

ANNO ACCADEMICO/ACADEMIC YEAR
2023/2024

ABSTRACT

The main subject of the proposed thesis is the procedure to be followed for the social introduction of a new individual within a group. Focusing initially on some theories of behavioral biology will talk about social behaviors and how captivity can negatively affect social hierarchies. To address the problem of social isolation in captivity, general social introduction theories and models will be introduced, specifying enclosure and individual management and monitoring methods.

Later, the introduction applied to the Scarlet Macaw as a case study, respecting their biology, their behavior, and the social structure of the species, will be analyzed.

INDEX

INTRODUCTION

The process of social introduction is a fundamental aspect of managing animal welfare in captivity, particularly for species that naturally live in complex social groups. When animals are placed in captive environments, their natural social structures are often disrupted, leading to challenges such as stress, aggression, and behavioral disorders. Successful social integration of new individuals into established groups is crucial for maintaining both the psychological well-being of the animals and the stability of the group dynamics.

This thesis explores the general principles and practices involved in the social introduction of animals in captivity. Key theories in behavioral biology, focusing on the importance of social bonds and the negative impact of isolation on social animals, will be examined.

Effective management of social introductions requires a deep understanding of species-specific behaviors, as well as careful planning of enclosures, monitoring strategies, and the introduction process itself.

To provide a practical context, this thesis uses the Scarlet Macaw (*Ara macao*) as a case study. While the focus remains on general social introduction models, the Scarlet Macaw offers valuable insights into the challenges and strategies involved in integrating highly social, intelligent animals into new groups. By analyzing this species, the knowledge acquired is applicable to broader practices in captivity, enhancing the welfare of various social species.

Through the study of behavioral patterns, social organization, and introduction techniques, this research aims to contribute to improving the methods used to manage social introductions across a wide range of captive animals collecting various theories and research.

CHAPTER 1

BEHAVIORAL BIOLOGY OF ANIMALS AND IMPACT OF SOCIAL ISOLATION IN CAPTIVITY

1.1 Principles of behavioral biology of animals

Behavioral biology is a branch of biology that focuses on the study of behavior of animals in their natural environment. It aims to explore the several ways animals interact with one another, their environment, and other living organisms. One of the approaches to understand how behaviors evolve to increase the fitness of animals is the behavioral ecology.

Behavioral ecology is based on three concepts, first there is the gene-centered approach, then optimality and lastly the recognition of the diverse ways in which behaviors can be performed.

Behavior can be seen as adaptive features that contribute to the survival and/or reproduction of animals known together as the fitness of the adaptive trait. These two elements are seen as the main driving forces behind evolution by natural selection. Behaviors have evolved through adaptive selection, and they must be linked to genes to be heritable; by consequence, the genetic variation inherent to population may lead to differences in the adaptive value of those behaviors when performed. The adaptive value is the contribution of a behavior to animals' fitness whether positive or negative and will be subjected to natural selection also determining animals' genes outcome.

The term "adaptive" is not related to "good" or "desirable" changes. Adaptive means only that a certain behavior will be advantageous for individuals just under a reproductive point of view or beneficial for positive for the genes that underlie the development of the trait (Alcock, 2005).

Social behavior is a fundamental element of animal behavior, encompassing a wide range of either positive or negative interactions among individuals within a species determining social organization. The main behavior of a group is the synchronized movement of individuals that follows basic rules of interaction (Alcock, 2005). The suite of interaction between individuals has the main aim of forming aggregations,

cooperating in sexual or parental behavior, competing over territories, or simply communicate (Dickinson & Koenig, 2024).

Division of labor, cooperation, altruism, and reproduction are the main elements composing a complex society. In nature, sociality is divided into two main routes, one follows the parasocial sequence and the other one the sub social sequence. Following the first sequence the adults of the same generation aid each other, an example are females of communal species, but also in semi social species we can recognize the practice of cooperative brood care. On the other hand, the sub social sequence involves a closer association between females that provide parental care to their offsprings until the adult stage.

Both routes culminate in "eusociality," a system in which different hierarchical levels are present to provide different services and the young are cared for in a cooperative way (Dickinson & Koenig, 2024). According to the definition of eusociality, the presence of castes can be described as groups of individuals that become irreversibly behaviorally distinct at a certain point before reproductive maturity. Societies of this type are based on two fundamental concepts: the first concerns the helping behavior exhibited by individuals of the less reproductive caste, and the second concerns either the behavioral totipotency of only the more reproductive caste (facultative eusociality) or the totipotency of neither caste (obligate eusociality) (Crespi & Yanega, 1995).

Social interaction in gregarious species provides both costs and benefits. Aggregation may provide sharing of information, cooperative defense against threats and increased mating opportunities, so in general an increased chance to survive due to increased probability to get access to resources. On the other hand, close contact with members of the same species may increase the probability of cannibalism, parasitism, diseases, and competition. All the costs and benefits of social groups can be summed up under dominance interactions, conflict between sexes, nepotism, and cooperation (Johnston, 2023).

Many animal groups have a distinctive social network structure that is sometimes hierarchical. When animals move collectively, they gather information through their links within this communication network. These social connections can result in preferences for specific individuals, which in turn influence and modify their interactions and behaviors within the group (Bode, Wood, & Franks, 2010). The social network structure can impact communication efficiency, for example taking

into consideration a social group in which the focus is on a small group of dominant individuals, the information will not propagate through all the group homogenously. This kind of situation will lead to negative changes inside the group members such as less efficient foraging, less efficient flying or slower antipredator reactions. Social preferences can have a significant impact on collective motion in situations where there's limited space for group movement due to restrictive local environment (Bode, Wood, & Franks, 2010). However, a leader-follower theory could be an example proving the existence without the need for social preferences. For example, a small group of informed individuals can lead a large group of naïve individuals simply moving towards the target (Couzin, Krause, Franks, & Levin, 2005).

1.2 Negative effects of social isolation on captive animals

Behavior can be described as a response of an animal to a certain stimulus in the environment. Stimuli may be represented by aspects of the physical environment such as temperature, light, and sound, or may come from other animals as signals as chemicals, postures, or calls. All the behavior that an animal can perform could be driven by endogenous or exogenous factors (Hosey, Melfi, & Pankhurst, 2013). Endogenous factors derive from within the organism itself, encompassing genetics, which is tied to an individual's biological and physiological characteristics, and hormones, which lead to the manifestation of a repertoire of behaviors, such as those related to reproductive activities. As for exogenous factors, these can be defined as stimuli originating from the surrounding environment, encompassing sounds, odors, light, and social interactions. Taking an animal living in an environment rich in food resources as an example, this factor will influence its behavior in multiple ways, including its food-seeking strategy, as well as its levels of aggressiveness and social tolerance.

Captive animals are kept in conditions under which many of the behaviors that they use in nature to attain functional goals are limited. When behaviors are internally motivated but prevented or restricted is the situation in which the welfare is more likely to be endangered because the motivation remains high, and the behavior cannot be performed (Appleby, M. C., Hughes, B.O., & Mench, 1999).

This concept is explained by J.C. Petherick and J. Rushen in “Animal Welfare” (1999, p90):

“The implicit philosophy behind such animal management has been that if the animal’s functional requirements are met then the often energetically expensive behavior need not occur. However, for many animal welfare groups, such behavioral deprivation or restriction is one of the main faults of intensive animal husbandry (Dawkins, M. S., 1988) and there is a widespread belief that animals which are restricted or prevented from performing their full repertoire of behavioral patterns will suffer in the same way that they suffer if their physical requirements, such as for food and water, are not met.”

In their natural habitats, animals engage in a variety of behaviors that allow them to exercise control over their environment and meet their physiological and psychological needs. These behaviors include foraging, mating, territory establishment, and social interactions.

In the wild, animals have the autonomy to make decisions about their activities, such as where to find food, when to mate, and how to avoid predators. This autonomy is crucial for their mental stimulation and overall well-being. However, in captivity, the limitation of these choices often results in frustration and can lead to abnormal or stereotypic behaviors. For example, animals might develop repetitive behaviors such as pacing, over-grooming, or self-mutilation as coping mechanisms for the lack of environmental complexity and control (Hosey, Melfi & Pankhurst, 2013).

The concept of control over one’s environment is closely related to the welfare of captive animals. Studies have shown that providing animals with opportunities to make choices, such as varying their diet or choosing different enrichment activities, can improve their psychological well-being and reduce stress. For instance, providing varied enrichment can allow animals to engage in species-specific behaviors that are otherwise restricted in captivity (Mason et al., 2007).

Environmental enrichment is a strategy used to address the limitations placed on captive animals by introducing elements that encourage natural behaviors and decision-making, promoting mental and physical stimulation. Enrichment can take many forms, including physical structures (e.g., climbing trees, hiding spots),

sensory stimulation (e.g., novel scents, sounds), and interactive activities (e.g., foraging tasks, puzzle feeders).

For example, the provision of foraging enrichment has been shown to reduce signs of stress in captive animals by allowing them to engage in natural feeding behaviors. This type of enrichment not only helps to reduce frustration but also improves the overall quality of life for these animals (Bloomsmith et al., 1991). Similarly, giving animals control over their environment, such as allowing them to choose their resting areas or manipulate objects, has been found to enhance their welfare by providing a sense of agency and reducing behavioral problems (Clay et al., 2009).

Social interactions are another critical area where limited choice can affect captive animals. Many species are highly social and rely on complex social structures for their well-being. When animals are isolated or placed in socially restrictive environments, they can experience significant stress and behavioral issues. Prolonged social isolation has been linked to neuroanatomical and neurochemical changes in the brain, which can exacerbate stress and lead to mental health issues (Heng, Zigmond & Smeyne, 2023).

Research has demonstrated that social interactions and the ability to form social bonds are essential for the well-being of many species. For instance, social enrichment, such as introducing compatible social partners or allowing animals to engage in natural social behaviors, can help mitigate the negative effects of captivity and improve overall welfare (Kuhar et al., 2006).

Social companionship in captive animals is one of the most effective ways of enriching captive animals because is the major source of comfort and entertainment, lowering the levels of abnormal behavior and appear to have calming effect on conspecifics a than when isolated. Humphrey (1976) clearly underlines this point:

"[The monkeys] live in social groups of about eight or nine animals in large cages. But these cages are almost empty of objects, there is nothing to manipulate, nothing to explore; once a day the concrete floor is hosed down, food pellets are thrown in and that is about it. So, I looked, and seeing this barren environment, thought of the stultifying effect it must have on the monkey's intellect. And then one day I looked again and saw a half-weaned infant pestering its mother, two adolescents engaged in a mock battle, an old male grooming a female whilst another female tried to sidle up to him, and I suddenly saw the scene with new eyes: forget about the absence of

objects, these monkeys had each other to manipulate and explore (Galindo, F., Newberry, R. C. & Mendl, 2018).”

Keeping individuals of gregarious species in isolated conditions, either permanently or temporarily, clearly limits social behavior. An isolation’s consequence is seen in physiological stress response, ranging from stereotypical behaviors to self-harming behaviors. Speaking of physiological stress responses, it is important to note that animals can exhibit these not only in cases of isolation but also within a social context. For instance, episodes of high stress can be observed in social conflicts and competitions, as social or sub social animals have dominance hierarchies. Repeated struggles for position are common and some involve violence or harassment. In low-ranking animals of some species, responses such as depression and reduced reproductive opportunities have been observed (Galindo, F., Newberry, R. C. & Mendl, 2018).

Sometimes, animals are excluded from their groups due to antisocial behavior, being perceived as a threat to the dominant male or female, leading to a lack of social interaction and consequently additional stress. This indicates that, despite the physical needs of animals being met in captivity, they can still experience physiological stress responses in different situations.

The stress response consists of a series of hormonal and physiological reactions that help the animal face a specific unpleasant stimulus. The adrenomedullary response results in an increased heart rate and muscle tone, as well as an increase in glucocorticoid hormones that assist the individual in coping with a negative situation. These physiological responses are adaptive, but excessive exposure to them could lead to more profound consequences, such as weight loss, changes in the immune system, and even reduced reproductive capacity (Barroso et al., 2019).

Following studies on prolonged social isolation in adult mice, data have been obtained demonstrating that social isolation affects not only the mood of individuals but also their anatomy and physiological responses. Notably, isolation beginning in adulthood imparts significant changes on the homeostasis of brain structure and chemistry. The subjects were raised from birth to four months in an enriched environment; thereafter, one group was moved to isolation, while the other remained in the enriched environment as controls. Subsequent examinations focused on neuronal structure and levels of catecholamine and brain-derived

neurotrophic factor in various brain regions, comparing isolated individuals to those not isolated. Significant changes were observed in neuronal volume, dendritic length, neuronal complexity, and spine density, depending on brain region, sex, and duration of isolation (Heng, Zigmond & Smeyne, 2023).

For many species, there are permanent physiological alterations after a period of captivity, and these characteristics are potentially genetically transmissible. For instance, animals in captivity often exhibit reduced reproductive capacity compared to their free-living counterparts. This diminished reproductive ability can persist even after changes are made to the features of the enclosure or the composition of the social group. These long-term physiological changes can have significant implications for the conservation and management of captive populations, as they may affect the overall health and genetic diversity of the species. Moreover, the potential for these alterations to be passed on to future generations underscores the importance of carefully monitoring and addressing the welfare of animals in captivity to ensure their long-term viability and well-being.

All the behavioral changes between generations are linked to genetic processes that lead to the evolution of new or modified forms of behavior that will increase the fitness of the animal. But behavior changes during animal's lifetime are usually more related to experience and learning than to genetics (Hosey, Melfi & Pankhurst, 2013). For this reason, individuals raised in isolation lack experience in socialization and this may result in problems if later introduced to socially experienced individuals in a group. Problems that may arise may be related to excessive competition or aggression, lack of tolerance towards other conspecifics or even the disruption of maternal behavior in female (Appleby, Hughes & Mench, 1999). Social stimuli are important in guiding behavior of animals because wild animals live in a social context, even if classified under the category of solitary species.

Intraspecific behaviors can be influenced by the way in which the individual has been reared and the developmental history but also through the maintenance of group that differ in composition from the one that usually is found in wild (Hosey, Melfi & Pankhurst, 2013).

Ecological and behavioral factors influence group size in the wild, for example the need to avoid predators and find food that in captivity has less significance.

Nevertheless, maintaining a group with too many individuals or even too few could have a negative impact on animal's health and behavior.

Mixed-species exhibits can aid to create the social context that animals need to resemble a natural condition even for individuals of solitary species. In general, two species that already inhabit the same area in the wild and do not have prey-predator relationships could show various kinds of behaviors.

Aggressive behaviors have been recorded between ungulates of distantly related species, during births, mating behavior and animal introductions (Popp, 1984). While inter-specific affiliative, aggressive, and neutral interactions have been observed in a mixed species enclosure in which capuchins *Cebus appella* and squirrel monkey *Saimiri sciureus* were present (Leonardi et al., 2010).

Considering the characteristics of the species and their various affiliative or aggressive behaviors, the option of creating a mixed-species environment can be considered where it is not possible to form a group of the same species. This approach is particularly relevant for gregarious individuals to address potential problems related to social isolation.

CHAPTER 2

ANIMALS' SOCIAL INTRODUCTION THEORIES AND MODELS

2.1 Theories

All the advancements that contemporary zoos implement in their facilities, both regarding management practices and the design of enclosures, are meticulously aimed at enhancing and ensuring the well-being of the animals in their care. These innovations encompass the introduction of new tools and methodologies for managing captive populations, which assist in making decisions grounded in scientific research. For instance, decisions concerning the mating of captive species are made to ensure the long-term genetic diversity and demographic stability of these populations.

To preserve a diverse gene pool among captive species, it is a widespread practice for zoo animals to be transferred between different facilities for breeding purposes. These relocations, while beneficial for genetic diversity, can introduce significant stress for the animals involved. This stress arises primarily from the potential separation from their original social groups and the necessity to acclimate to new environments and social structures. The transition period following such relocations is particularly challenging for the animals as they lose their familiar reference points related to both territory and social networks. This phase, characterized by significant changes and the need for adaptation, is referred to as "dispersal."

Powell elaborates on this concept, explaining how the disruption of established routines and the introduction of unfamiliar surroundings can profoundly affect the animals' psychological and physiological states. This process underscores the importance of carefully managed transitions and the implementation of strategies to mitigate the stress associated with such relocations, ensuring the animals' continued well-being during these critical periods.

Social isolation can elicit stress responses that enhance vigilance and responsiveness to potential threats, for this reason it is imperative that captive animals are housed with conspecifics or, in some cases, other species, as discussed

in Chapter 1. In addition to social isolation, social instability is another factor that induces stress in social animals. This stress arises when established social relationships are disrupted, either by the introduction of a new individual into the group or by the removal of a familiar partner. Such disruptions often lead to increased aggression within the group, as the previously established hierarchy is altered, necessitating the establishment of new dominance relationships. This reconfiguration of social structures further exacerbates stress among the animals, highlighting the critical importance of stable social environments for their well-being.

2.2 Models

The socialization process is crucial, as it involves how an animal acquires its social skills, which are essential for reproduction, raising offspring, and living harmoniously with other individuals within the group.

A professionally managed socialization process during the developmental stages of an animal is essential for ensuring that the animal can express a range of appropriate social behaviors in adulthood. An inappropriate or poorly managed socialization process during the animal's formative years can have a profound and lasting impact on the animal's ability to interact socially as an adult. This can manifest in various behavioral issues, such as increased aggression, social anxiety, or difficulties in forming and maintaining social bonds.

There are numerous reasons why an individual may need to be introduced into a group, necessitating a well-planned socialization process. For instance, animals may be introduced to each other for mating purposes, which is vital for maintaining genetic diversity and the overall health of the population. Additionally, new individuals may be introduced to form a new group, expand an existing group, or reintegrate after a period of separation from the group. Each of these scenarios requires a carefully tailored approach to ensure the smooth integration of the new individual and minimize stress for all animals involved.

Regardless of the specific reason for the introduction, the social introduction, also known as the socialization process, should follow several stages, each designed to facilitate the gradual acceptance and integration of the new individual into the group. By following a structured and thoughtful socialization process, the

likelihood of successful integration is increased, thereby promoting the overall well-being and harmony of the group.

Upon analyzing the research conducted by David M. Powell (Kleiman, Thompson, & Baer, 2012), it becomes evident that two main categories of goals need to be established. The first category, short-term goals, pertains to the immediate absence of aggression, demonstration of minimal compatibility, and lack of stress indicators and stereotypical behaviors. This category encompasses all data and factors that can be recorded as indicators of a positively progressing introduction process. The second category, long-term goals, includes the maintenance of overall health, such as ensuring that all individuals in the group, including the new member, maintain appropriate weight, display suitable social behaviors, and achieve successful reproduction and rearing of offspring. These goals include all elements that pertain to long-term compatibility. Taking Powell's example as a reference:

"For females with poor maternal skills, while the long-term goal is to rear offspring properly, short-term goals might include showing appropriate maternal behavior toward a surrogate or allowing the infant to receive supplemental food from animal care staff (Kleiman, Thompson, & Baer (2012)."

In accordance with the species' characteristics, it is essential to gain a comprehensive understanding of the fundamentals of inter-individual communication, the social organization of the species, encompassing mating systems, social and dominance hierarchies, as well as prominent indicators of aggression and/or stress and their manifestations.

2.2.1 Infanticide

Temporarily removing juveniles/subadults from the group during the early introduction phase may serve as an initiative-taking measure in species where instances of infanticide or heightened aggression towards young individuals have been documented (Kleiman, Thompson, & Baer, 2012).

Based on the research conducted by Glenn Hausfater and Sarah Blaffer Hrdy (1984), several hypotheses explain why infanticide is common in some species.

According to the first hypothesis, infanticide can be viewed to obtain nutritional resources. In this context, the relationship between the infanticidal individual and the infant is distant. The age of the infant is less significant than its size and vulnerability; in other words, what matters most is that the infant is small and defenseless enough to be subdued. The killer can be of any sex and age if they are physically capable of overpowering the infant. The primary benefit for the killer is the nutritional gain obtained from consuming the infant.

However, the second hypothesis suggests that infanticide may occur due to competition for resources. In this scenario, the relationship between the killer and the infant remains distant. Here, the vulnerability of the infant is more critical than its specific age. Typically, the killer is an adult, although it can be of either sex.

The benefit for the killer lies in the increased availability of resources for themselves and their kin, as the elimination of the infant reduces competition for those resources.

The third hypothesis involves sexual selection, where infanticide is used to enhance reproductive opportunities. The relationship between the killer and the infant is distant in this case as well. The targeted infants are usually unweaned and specifically younger than the age at which the mother's ovulation resumes or her amenorrhea ends. The killer is an adult of the sex that invests the least in offspring, typically a male. The main advantage for the killer is gaining additional breeding opportunities, as the female may become receptive to mating sooner.

Focusing on the fourth hypothesis, social pathology, posits that infanticide is a result of social disturbances and does not necessarily depend on the relationship between the killer and the infant. Factors such as the size, proximity, and vulnerability of the infant are more important than age. The killer is usually an adult, often of the sex most likely to respond to social disturbances with increased aggressiveness.

Infanticide in animal groups can arise from various ecological and social pressures, with significant influences from both population density and hierarchical structures. The relationship between these factors and infanticide is complex, reflecting how competition for resources and social status can drive such behaviors.

Population density is a key factor influencing infanticide as high-density environments often lead to increased competition for resources, which can escalate aggressive behaviors among individuals. In such conditions, infanticide may occur as a strategy to reduce competition and improve access to resources for the

surviving individuals. According to McClintock et al. (2005), social interactions in densely populated environments are intense, and these interactions can regulate behaviors like infanticide. The competition for limited resources in high-density populations can thus increase the likelihood of infanticide, as individuals attempt to eliminate competitors and secure resources for themselves.

Research by Stensland, Angerbjörn, and Berggren (2003) supports this view, demonstrating that mixed-species groups and high population densities can affect social dynamics and increase aggressive interactions, including infanticide. The stress and competition induced by high density can exacerbate aggressive behaviors as individuals struggle to ensure their own survival and reproductive success.

In species with complex social hierarchies, infanticide is often linked to the maintenance or enhancement of social status. For example, in Spotted Hyenas (*Crocuta crocuta*), hierarchical structures significantly influence infanticide. High-ranking individuals may kill the offspring of lower-ranking group members to assert dominance and reduce competition within the group. Kleiman (2013) notes that in hyena societies, infanticide can serve as a means for dominant individuals to weaken rivals and enhance their own social standing.

Mitani et al. (2012) elaborate on this by discussing how hierarchical interactions in primate societies can lead to infanticide. In these social structures, dominant individuals may kill infants to decrease the number of potential competitors and secure their own position within the hierarchy. The combination of social competition and hierarchical dynamics creates a scenario where infanticide becomes a strategic behavior for maintaining or improving social status.

2.2.2 Dominance relationships

Understanding the social organization and dominance relationships can also help determine which sex will be introduced more rapidly and with a more positive outcome compared to the other. The specific histories of the group members may impact the introduction of the new individual. Occasionally, if accompanied by an ally, the new individual might experience a facilitated process of integration into the group. Referring to the example of David M. Powell:

“Since female Old World monkeys tend to be subordinate when they are introduced to new social groups, we typically introduce them to the male first, so they have his support when they are introduced to the larger social group. […]
When introducing a new silverback gorilla to an established group of females, we found that the temperament of the male could provide insight into which females to introduce first. With an aggressive male, it is preferable to introduce him first to the most dominant females, whereas if a new male is easily intimidated or timid, he should be introduced first to the most subordinate females.”

2.2.3 Timing

The timing is another factor that need to be taken into consideration, as for many species the estrus period is a critical period to introduce a new female to individuals of sex because increased aggressive and assertive behaviors has been recorded (Kleiman, Thompson, & Baer, 2012).
The competition between two estrous females primarily occurs in situations where there is a scarcity of resources necessary for successful reproduction, such as food or territory required for pregnancy and/or nursing, or high-quality mates or sperm (Huchard & Cowlishaw, 2011). Therefore, the competition is based on acquiring a higher social rank to gain easy access to resources. Introducing a female in estrus into a group of males can lead to manifestations of aggression among the males, as individual males typically strive to monopolize access to as many females as possible, thereby creating competition among them (Mitani et al., 2012).

2.2.4 Territoriality

Territoriality is defined in the Encyclopedia Britannica as:

"Territorial behavior, in zoology, the methods by which an animal, or group of animals, protects its territory from incursions by others of its species. Territorial boundaries may be marked by sounds such as bird song, or scents such as pheromones secreted by the skin glands of many mammals.”

This type of behavior can be documented in both male and female individuals, depending on the species in question and can be established by both genders within the same enclosure and may consist of resting spots, perches, preferred dens, or even the entire territory. The motivations for such behavior can be intrinsic to the species' behavior, being an adaptive trait that may be linked to the individual's need for easier access to resources, or the necessity to raise offspring in a location perceived as safe from predators.

To avoid competition between the new group members and the others, it is advisable to consider allowing the individual to explore the enclosure without the resident group inside. This will enable the new member to establish his own spaces, thereby avoiding aggression or stress. Additionally, this increases the likelihood of the individual becoming familiar with the other animals through exposure to their sounds and scents within their physical space.

If the initial approach of the new individual to the enclosure cannot occur without the presence of resident group members, a neutral environment such as holding areas could be considered to prevent the territoriality of the group from hindering the introduction of the new individual (Kleiman, Thompson, & Baer, 2012).

2.2.5 Mixed-Species Communities

Interspecific associations vary from closely related species to those in different orders and are observed across a wide spectrum of taxa. While mixed-species groups have historically been noted among avian species and coral reef fishes, they are also prevalent among various mammalian species inhabiting diverse habitats. Mixed-species groups exhibit considerable variation in their duration, frequency, predominant activity, and structure, contingent upon the interacting species (Stensland, Angerbjörn, & Berggren, 2003). The purpose of these associations is not always evident, and their duration may range from mere minutes to several years, influenced by species-specific factors and environmental conditions.

Based on this behavioral pattern observed in free-ranging animals, we can extrapolate and apply the same social organization in captivity. Mixed-species enclosures provide an opportunity for animals to experience a broader range of behavioral opportunities and increase social interaction and complexity. Regarded as a form of enrichment, it can be considered one of the most intricate, as the

predictability and probability of habituation are less likely compared to other types of enrichments. Activity levels are typically higher in mixed-species enclosures, resulting in improved physical and mental well-being.

However, hybridization and mal-imprinting are significant concerns in mixed-species exhibits in zoos and aquariums.

Hybridization could be present when individuals from distinct species mate and produce offspring. This is more likely to happen between closely related species and can lead to several issues related to genetic integrity as hybridization can compromise the genetic integrity of species, particularly endangered ones, making it challenging to maintain pure genetic lines for conservation purposes. Other problems could arise as challenges in management as hybrids may have intermediate traits that are not well-suited for survival in the wild or in captivity, complicating their management and care.

Mal-imprinting may appear when an animal imprints on members of a different species during a critical period of development, leading to potential behavioral issues related to mating behaviors as animals may direct their mating behaviors toward individuals of the other species, which can result in hybridization or unsuccessful mating attempts, affecting population dynamics and breeding programs. Social behavior can also be affected as mal-imprinted animals might exhibit inappropriate social behaviors, which can lead to increased aggression or stress, negatively impacting their welfare.

Mixed-species enclosures offer significant enrichment opportunities for animals, promoting natural behaviors and social interactions. However, to manage potential issues such as hybridization and mal imprinting, it is crucial to select compatible species and monitoring interactions is essential for detecting and addressing any signs of hybridization or mal imprinting early on. Additionally, designing appropriate environments that allow natural interactions while providing spaces for species-specific behaviors and segregation when necessary is important.

2.3 Process of Introduction

Once thorough research on the specific characteristics of the species has been conducted, it is essential to follow several steps before actual physical contact between individuals. The first step is to establish familiarity through non-tactile

sensory contact. This can be done by allowing the individuals visual access to one another or by rotating them through a common enclosure. Additionally, scent can be transferred from one enclosure to another by swapping dung, urine, scent-marked materials, or bedding. This procedure is crucial because, particularly in mammals, scents are used as a means of non-physical communication.
David M. Ferrero and Stephen D. Liberles (2010) explain this as follows:

"The scents of mammals are complex blends of natural products that reveal a wealth of individual information. Many mammals can decipher these scent codes to discern the gender, age, endocrine status, social status, and genotype of conspecifics using dedicated sensory receptors in their olfactory system. Among these social odors are pheromones, chemicals that trigger innate behaviors and physiological responses."

Once visual, olfactory, and auditory contact have been established, limited tactile interaction through a barrier, such as fencing or cage mesh, should be allowed. Access doors between enclosures can be fitted with mesh windows to facilitate this interaction, ensuring the openings are small enough to prevent injuries from fighting. At this stage, positive reinforcement training can be used to encourage individuals to sit near each other safely, which can be beneficial for subsequent full-contact introductions. For some species, the desire for tactile interaction is so strong that introduction windows may not be needed and could even cause additional stress (Craig, 2007). Many small mammal exhibits have glass fronts with solid walls and limited off-exhibit space, necessitating the use of temporary barriers.
Protected tactile interaction can also be achieved using a "cage within a cage" or "howdy cage," where the new individual is placed in a smaller cage within the established animal's enclosure. In some facilities, visual, olfactory, and limited tactile contact may need to occur simultaneously due to design constraints.
Full-contact physical introductions should only proceed once animals have stopped showing aggression or anxiety when housed next to each other with limited tactile contact. Some animal managers recommend observing affiliative or play behavior through the barrier before proceeding. However, even with these signs, serious aggression can still occur once full access is granted, so staff should closely monitor these introductions and be ready to intervene if necessary. The execution of the full-contact stage can vary greatly. Introducing all individuals to an exhibit at once

without prior exposure can prevent any one animal from claiming the entire space as its territory and may reduce aggression as animals explore their surroundings instead of confronting each other. Naïve individuals might seek contact more readily when placed in a novel environment together. If full-contact introduction and first exposure to a new enclosure are expected to cause significant stress, animals can be introduced individually to the new space before meeting each other. For timid or submissive individuals, it is preferable to conduct the introduction in their familiar enclosure. Among felids, males are more likely to be aggressive, so introducing them in the female's territory can provide her with an advantage (Andrews, 1998).

The process should be guided by the animals' responses, with initial short sessions and positive endings. Introductions should occur consistently, and overnight housing should only happen once stable, positive interactions are observed.

The timing of introductions, particularly concerning feeding and staff presence, is crucial to minimize aggression and stress.

2.3.1 Enclosure's management

During the introduction process, the new individual will not only have to confront a new group but also adapt to a new physical space. Therefore, special attention must be given not only to behavioral aspects but also to the management of the enclosure into which the animal will be introduced. It is essential to thoroughly inspect the enclosure and holding facilities, particularly if they were originally built for a distinct species. Ensuring that all barriers are secure and potential escape routes are eliminated is crucial.

Animals unfamiliar with hotwire may benefit from clear markings or prior exposure to a hotwire panel while still in their old enclosure or indoor holding area. Training animals to respect hotwire by luring them with food and ensuring easy escape routes if they encounter it is essential and complex hotwiring should be avoided in enclosure design. Sensitive equipment like lights and surveillance cameras should be adequately protected, and major horticultural or maintenance work should be completed before the introduction or postponed until after acclimation (Kleiman, Thompson, & Baer, 2012). Clearly identified exhibit boundaries are important to prevent animals from running into fences or moats when frightened, so it is

important screening fences with burlap or shade cloth, marking them with plastic flagging, and marking moat edges can help.

Environmental enrichment materials should be placed in the exhibit before the introduction to reduce anxiety and provide opportunities for distraction or displacement of stress-induced aggression. Critical resources like nest boxes, areas of shade, perches, and feeding stations should be available for each animal. Transferring familiar items from holding areas into exhibits can make the unfamiliar environment seem more familiar to the animal.

Animals should have free access to and from the holding facility, if they spend only a few minutes in the new exhibit on the first day, they should not be forced back out but rewarded for returning to the holding, thus ending the session positively. While some food can be provided on exhibit, it is preferable to feed most of the diet off-exhibit to encourage return to the holding facility (Kleiman, Thompson, & Baer, 2012). Enclosures for social introductions should be selected based on available space and the ability to quickly separate individuals if necessary. While exhibit enclosures are usually larger, they are less suitable for introductions due to the challenges of intervening or separating animals. For particularly aggressive species, breeding introductions might be limited to off-exhibit areas for better control. Indoor, off-exhibit enclosures with multiple access doors are preferred for introductions because connecting multiple cages can increase available space. During full-contact introductions, access to areas where animals could become trapped or injured should be restricted. For some species, a nest box can serve as a valuable refuge and the decision to allow access to these areas should depend on the ability to intervene quickly and effectively, especially for small mammals prone to excessive aggression in confined spaces (Kleiman, Thompson, & Baer, 2012).

2.3.2 Monitoring

The introduction process is crucial for determining the future harmony of the group, as it can lead to either positive behaviors or stress-induced aggression. To establish the timing of the steps to be followed, it is essential to closely monitor the animals and their interactions. Recognizing individuals during introduction is fundamental, as all interactions need to be recorded. Identifying individuals prone to aggression, for instance, allows for isolating or closely monitoring them. Natural identifiers

include markings and physical defects, while artificial ones encompass ear tags, leg bands, microchips, tattoos, and ear notches.

Monitoring animals in naturalistic enclosures that replicate their habitats is often challenging due to various structures such as platforms, feeding devices, and enrichment items. It is advisable to introduce animals initially in a neutral environment, such as a simple shelter or controlled holding area, to facilitate accurate observations and monitoring. It is also crucial to remain as inconspicuous as possible during observations, as the presence of an observer can influence the animals' behavior and interactions, potentially leading to curiosity, aggression, or stress. During observations, tools such as binoculars can be helpful, especially in large enclosures. Once initial observations show no signs of aggression, cameras like camera traps, or trail cameras can be placed.

Radio communication between observers is essential and all team members must be familiar with the animals' behavior patterns, including signs of stress or abnormal behavior, and be prepared to assist with interventions such as rescuing animals from water or other exhibit features. Necessary equipment for interventions (e.g., nets, ropes) should be easily accessible.

The plans and processes for social introductions require ongoing monitoring, documentation, evaluation, and adjustment. Failing to allow adequate time for each step can lead to setbacks, prolonged integration, long-term social instability, fighting, injury, and even death.

Understanding the set of behaviors of the species being observed, including courtship, aggressive, and dominance behaviors, is crucial. Species communicate through various methods, including physical, auditory, and visual signals. Therefore, it is essential to deepen one's knowledge in these areas as well.

Wild species often exhibit considerable behavioral plasticity in their social behavior depending on factors such as food availability. Animals in captive environments are clearly not subject to the same selective pressures as those living in the wild, so we might expect them to exhibit less variation in social behavior. Despite this, it remains critical to monitor and understand their communication methods and social interactions in captivity to ensure their well-being and successful integration into social groups.

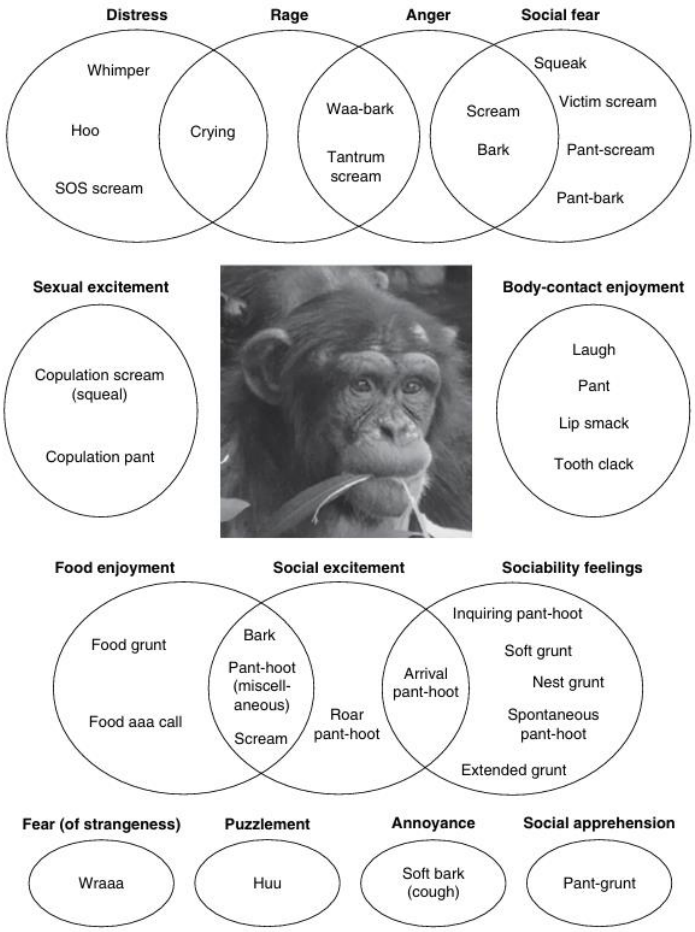

Figure 1. The meanings of chimpanzee (Pan troglodytes) vocalizations (source: Rees, P. A.,2015 adapted from Goodall, 1986).

Monitoring animals throughout the entire process of introduction and continuing to do so afterwards is crucial for understanding their welfare (Figure 1). The size and structure of the social group are aspects that indirectly influence animal welfare, both positively and negatively.

CHAPTER 3

SCARLET MACAO (*ARA MACAO*) SOCIAL INTRODUCTION

3.1 Species specific biology and behavior

3.1.1 Taxonomic classification

Taxonomic suggestions are based on physical characteristics such as plumage coloration, but also on behavioral ecology and biogeography.

Ara are part of the third largest non-passerine avian order, the Psittaciformes one. The evidence that supports the evolution of this order by an arboreal ancestor is related to some physical characteristics. The species included in this order present zygodactyls feed, hooked bill used for tripodal progression, cavity nesting and white eggshells.

The *Ara* genus encompasses the "large macaws," consisting of 15 recognized species including: *Ara ararauna*, *Ara chloropterus*, *Ara militaris*, *Ara ambiguus*, *Ara glaucogularis*, *Ara severus*, and *Ara macao* (W. S., 1921).

The physical characteristics that characterize this genus are the large body size with a moderate bill and graduated tails, there is no sexual dimorphism in color and present exposed epidermis in the facial area.

The *Ara macao*, commonly known as the Scarlet Macaw, is also referred to by other names, including the Red-blue-and-yellow Macaw, Red-and-yellow Macaw, and Red-breasted Macaw.

3.1.2 Morphology

Once reached the adult stage of life the total body length is about 80-96cm (W. S., 1921) (Figure 2) and highlights striking coloration, with its head, neck, nape, and upper mantle covered in bright red feathers, except for the bare lores and cheeks. The lower mantle feathers are red with yellow tips, while the scapulars are yellow with green tips, transitioning to bright blue from the back to the upper tail-coverts. The lesser upper wing-coverts are vivid red, and the median and greater coverts are

primarily yellow with green tips (Juniper & Parr, 1998). The primary coverts and alula are blue, as are the flight feathers, which feature olive-green inner webs and red outer webs. The throat to belly is bright red, with light blue undertail-coverts. The upper tail is centrally red with blue outer feathers, while the undertail is also centrally red. The upper mandible is horn colored with black accents, and the lower mandible is blackish. The bare lores and cheeks are white, turning pinkish when the bird is excited. The iris is yellow, with an olive tint near the pupil, and the legs are charcoal. Overall, the bird is predominantly scarlet to vermillion on the head, neck, back, scapulars, lesser wing coverts, much of the tail, and underparts, with a deeper red on the underside. It also has a large bare white facial patch and blue flight feathers, back, rump, and short outer tail feathers (Iñigo-Elias, 1996).

Body parts	*Male*		*Female*	
	Range mm	Mean mm	Range mm	Mean mm
Body length	742 – 920	841	795 – 950	848
Wing chord	355 – 426	401	368 – 410	391
Tail length	387 – 649	528	480 – 610	529
Tarsus length	33 – 38	36	33 – 36	35
Culmen length	62 – 73	69	59 – 70	67
Samples:	n = 18		n = 13	

Figure 2. Morphometrics of the Scarlet Macaw.
Measurements are range and arithmetic mean in mm following Baldwin et al. (1931) descriptions.
Source Rigdway 1916 and Forshaw 1989

The bills of male and female *Ara macao* differ, with males typically having slightly larger bills than females. This difference is likely an evolutionary adaptation that allows males to be more efficient in gathering food, a task they primarily undertake in the wild (Juniper & Parr, 1998). Additionally, males often have longer tail feathers, which, along with their larger bills, may enhance their flying ability, enabling them to gather food more effectively.

3.1.3 Habitat and diet

This species primarily inhabits lowland tropical forests and savannas across its range, including remote humid forests in Mexico and arid Pacific slopes. In

Honduras, it forages in open areas like cultivated lands and occasionally in pine forests above the rainforest in the Mosquitia region. In Costa Rica, it thrives in deciduous and humid forests, as well as open areas and forest edges with scattered tall trees. In Colombia, it occupies both intact and partially cleared lowland rainforests, along with gallery forests, while in Venezuela, it is found in rainforests, savannas, the Llanos region, and often near rivers (Lamar University, 2023).

Its diet includes fruits from trees like Inga, Micropholis, Sterculia, Bursera, and various palms, as well as seeds from Jacaranda, Dialium, and other species. It also consumes flowers and nectar from plants like Virola and Erythrina. When food is plentiful, it may associate with other parrot species (Juniper & Parr, 1998).

This species is cavity nester and generally a breeding pair produces 2 or 3 eggs per clutch and successful nest may fledge one, two, or rarely three young (Forshaw, 2006). Their population growth can be hindered by the availability of nesting sites, especially in regions like the Neotropics, where they face high rates of poaching by humans or where urbanization is leading to habitat loss.

3.1.4 Communication

Vocalization is characterized by a screeching call, more drawn-out but still difficult to be distinguished from *Ara ararauna*. Sounds are composed of variety of screeches, harsh guttural squawks, and harsh drawn-out growling, while in a situation of relaxation, the sounds are quieter and seem like a creaking door.

The *Ara macao*'s vision and hearing are very well developed compared to other species of birds. Their vision is better than the ones of human because of the presence of 5 different types of cones, that allow them to have an eyesight are higher compared to the one found in humans beings who present just 3 different types of cones, the ones related to red, blue and green wavelengths (Guittar, Dear, & Vaughan, 2010).

One of those cones is a double cone which is believed to help detect motion better than the average eye. This ability is especially useful in birds because allows them to detect predators in a more efficient way.

The other cones are like the human ones with the red, blue, and green wavelengths, but they also have a cone for the violet wavelength, this is probably related to the ability to scatter better food and camouflaged predators.

3.2 Species specific social organization

3.2.1 Social organization in nature

The *Ara macao* is a very social species of bird that can travel in groups of from 8 to 30 individual and those groups are formed to improve the foraging and protection of the individuals from predators (Forshaw, 2010).

It typically occurs in pairs, small groups, or flocks, and sometimes roosts communally in tall trees, including mangroves (Juniper & Parr, 1998).

Individuals often perch atop tall trees and feed primarily in the canopy, usually in silence. During the nighttime, they all sleep close together, however, the *Ara macao* maintains a monogamous relationship for life.

Outside of the breeding season, which typically spans from January to April, mates are rarely seen alone, except to feed when one bird is incubating the eggs (Carpenter, 2019). Both parents in the pair provide parental care to the fledglings for the duration of 11 weeks and in the first 8 weeks visits each fledgling 4-7 times a day. Fledglings become increasingly social after the 3rd week, before interacting exclusively with the parents then siblings start to stay in pair, but interactions start at the 6th week. During the 8th week the interaction and playing behavior between siblings and unrelated macaws starts as chasing each other while climbing among branches, sparring with their feet and beaks, and hanging upside down by the feet while beating each other with their wings.

Parents are fundamental in the development of different behaviors in young individuals as flight and feeding skills, but also learn behavior and movements pattern. In their study on the movement and behavior of *Ara macao* during the post-fledging dependence period, Mark C. Myers and Christopher Vaughan identified 4 primary social states in young individuals: being alone, with siblings, with parents, and with unrelated macaws with the evidence that these social states are not mutually exclusive. Juvenile *Ara macao* progressively honed their flying and feeding abilities, while acquiring behaviors and movement patterns from their parents, and were incorporated into social groups during the post-fledging stage. For this reason, the environmental and social conditions they are exposed to during this period can significantly impact their developmental outcomes.

3.2.2 Social organization in captivity

In captivity, the social structure of *Ara macao* can differ significantly from their natural environment. As already discussed, in the wild, these parrots live in family groups or flocks characterized by stable pair bonds and complex social interactions. However, in controlled environment, social organization is influenced by variables like available space, population density, and management practices (Brereton & Ridgely, 2005). Social hierarchies can emerge in captivity, with certain individuals assuming dominant roles, during feeding interactions or resource possession, where more assertive parrots may monopolize resources (McGraw et al., 2018).

Ara macao can display aggressive behaviors during the initial stages of socialization, particularly when encountering new companions or environments. Brereton and Ridgely (2005) noted that interactions should be managed carefully to minimize conflicts, with sufficient space and opportunities for retreat helping to alleviate social pressure. Environmental enrichment plays a crucial role in fostering positive social interactions and improving the welfare of *Ara macao* in captivity. Meehan and Mench (2002) showed that enrichment influences birds' behavioral responses, promoting exploration and reducing fear of new experiences while stimulating objects and activities encourage social behaviors, facilitating interactions between individuals and decreasing the likelihood of conflicts.

Implementing a targeted enrichment program can thus improve not only individual well-being but also foster more harmonious social relationships.

Pair dynamics among *Ara macao* in captivity often resemble those observed in the wild, in fact, they form stable bonds and collaborate in raising young (Gilardi et al., 2005). However, careful monitoring of pairs is essential to ensure positive interactions, preventing stressful or conflictual situations is crucial, as these can negatively impact breeding success and parental care (Harrison et al., 2016).

3.2.3 Effect of social isolation in captivity

Social isolation can have profound and far-reaching consequences for *Ara macao*, impacting their psychological well-being, behavioral patterns, physical health, and overall quality of life. Given that these birds are inherently social animals, their well-being is intricately linked to their social interactions.

Ara macao in isolation often experience heightened levels of psychological stress. In the wild, these birds thrive in dynamic social environments where they interact with peers, establish bonds, and engage in cooperative behaviors.

Isolation disrupts these interactions, leading to increased anxiety levels and common stress responses include excessive vocalization, which may serve as a call for social interaction, and destructive behaviors such as feather plucking (Meehan & Mench, 2002).

Chronic stress can have long-term implications, leading to conditions such as depression and learned helplessness. According to Dickens and Romero (2013), stressful conditions can cause spikes in corticosterone (the avian equivalent of cortisol), and levels can remain elevated over time, negatively affecting bodily functions and leading to a weakened immune system, making isolated birds more susceptible to infections and disease (Mason et al., 2013).

Monitoring cortisol levels through non-invasive methods, such as feather or droppings analysis, is a common approach to assess stress in captive birds, as highlighted by Bortolotti et al. (2008).

Isolated *Ara macao* may display aggressive behaviors when they do interact with others, stemming from fear or frustration. Studies have shown that these birds can develop a defensive posture when faced with potential social encounters, leading to conflicts (Brereton & Ridgely, 2005). Conversely, some may withdraw entirely, exhibiting signs of apathy or a lack of interest in their surroundings, which can further hinder their ability to reintegrate into social groups.

Behavioral changes can manifest as stereotypes—repetitive, purposeless behaviors such as pacing or rocking and once established, can become ingrained habits that are difficult to modify, leading to further deterioration of the bird's mental state.

Isolation during critical developmental periods can impair social learning, making it difficult for *Ara macao* to develop the necessary skills for effective communication and bonding. Birds that have not had opportunities to socialize may struggle to interpret social cues, leading to misunderstandings and potential conflicts when introduced to other birds (Gonzalez et al., 2019).

The ability to form social bonds is crucial for macaws, not only for emotional support but also for cooperative behaviors that enhance survival in the wild.

Isolated birds may find it challenging to integrate into new social groups, as they lack the familiarity with social dynamics that are typically learned through

interaction with peers. This can result in increased stress during introductions and a heightened risk of aggression from other birds who may perceive the newcomer as a threat (Harrison et al., 2016).

Social isolation can also impact feeding behaviors as, in social settings, macaws often engage in communal foraging, which encourages healthier eating patterns, while an isolated bird may develop poor feeding habits, such as overeating or refusing to eat, leading to malnutrition or obesity (Gonzalez et al., 2019).

Even when breeding occurs, isolated birds may exhibit poor parental care due to their compromised social skills and emotional distress. Insufficient nurturing can lead to low survival rates among chicks, affecting the overall population dynamics of *Ara macao* in captivity.

The consequences of social isolation in *Ara macao* are multifaceted, impacting their psychological well-being, behavior, health, and reproductive success.

3.3 Individual social introduction

To mitigate the risks associated with isolation, it is essential to promote social interaction, provide enriched environments, and implement gradual introductions when integrating new individuals.

The introduction of a new *Ara macao* into an existing group, particularly in captivity, has been the focus of several studies due to the complex social behaviors of these highly social birds. Understanding the intricacies of Ara Macaw social structures, communication, and environmental needs is crucial for ensuring the success of such integrations. Numerous studies have highlighted the importance of factors like social hierarchy, territory, and vocal cues in facilitating smooth introductions while minimizing conflicts.

As highly social animals, macaws exhibit intricate behaviors that are shaped by their environments and social interactions.

Studies such as those by Wilson and Blois-Heulin (2012) and Franklin and Benton (2020) emphasize the necessity of gradual and carefully managed social introductions to avoid disruptions in established hierarchies.

The social structure within captive groups can be delicate, with birds establishing clear dominance and submission roles that are essential to group harmony, so any

disturbance, such as the introduction of a new individual, can challenge these dynamics, leading to potential aggression and stress.

Individual and social environmental enrichment in helping to ease the tension during such introductions are fundamental, including the provision of foraging tools, varied perches, and interactive toys, which allow the new macaw to engage in natural behaviors, reducing its focus on potential social conflicts. Moreover, environmental enrichment fosters positive engagement with the surroundings, which can reduce territorial behaviors typically seen in confined spaces (Abramson, 1995c). Early social exposure is a significant factor in the behavioral development of *Ara macao*, as social learning influences how fledglings interact within a group. Freeberg (2000) and Smith et al. (2002) have shown that early interactions with mixed-age and mixed-sex flocks can affect long-term social behaviors, including mate selection and group integration. When introducing a new macaw, understanding its prior social experiences can help predict how it will adapt to the existing group because, well-socialized macaws tend to integrate more smoothly, while those with limited social exposure may show signs of stress, such as feather plucking or excessive vocalization.

Macaws communicate primarily through vocalizations and body language, making these key areas to monitor during introductions. Vocal exchanges serve as a primary method for establishing social status (Wright et al., 2001) and the new macaw must quickly learn to interpret the established group's calls and postures to avoid misunderstandings that could lead to aggression. Misreading signals such as submissive postures or specific vocalizations can result in prolonged tension or social rejection within the group.

Additionally, social housing arrangements, particularly the use of physical barriers during the initial introduction stages is really important (Franklin and Benton, 2020). This strategy allows for visual and auditory interactions without the risk of physical altercations, giving both the new and resident birds time to adjust to each other's presence. Gradual introductions, where a new macaw is kept in a separate but adjacent enclosure, help reduce aggression and allow for the observation of key behavioral indicators (Vaughan et al., 2005).

Once direct interactions are introduced, aggressive behaviors such as biting, chasing, or feather plucking are common during the initial stages, especially in confined environments where territorial disputes can arise, it is important the

continuous monitoring. In enclosures that are overcrowded or lack sufficient enrichment, macaws are more likely to become territorial and aggressive, so providing ample space, along with resources like toys and perches, allows the birds to engage in natural behaviors and alleviates social tension.

Timing and the pace of the introduction are critical elements in the process and rushing this process can lead to long-term disruptions in the group's social stability (Franklin and Benton, 2020). By allowing the new macaw and the resident group to gradually acclimate to each other's presence, the likelihood of aggressive encounters is reduced. Signs of stress, such as persistent vocalization, feather plucking, or abnormal repetitive behaviors, may indicate the need for intervention, either through temporary re-separation or further environmental enrichment (Wilson & Blois-Heulin, 2012).

Furthermore, the social dynamics of macaws are fluid, and any changes in the group composition can lead to shifts in the established social order, but these shifts can be mitigated through continuous monitoring and intervention, when necessary, ensuring that harmony is maintained within the group (Franklin and Benton, 2020).

Encouraging the new macaw to participate in group foraging or interactive sessions can serve as a form of social bonding, easing its integration into the established hierarchy. These activities allow the new bird to engage with the group in a non-threatening manner, reducing the focus on territorial disputes and fostering a more cooperative social environment.

CONCLUSION

The process of social introduction in captivity presents a multifaceted challenge that requires a thorough understanding of species-specific behaviors, social hierarchies, and environmental needs. Social animals, such as parrots, are deeply impacted by their social surroundings, and the success of introducing new individuals into established groups relies on careful management of these dynamics.

This thesis has explored the general principles of social introduction, emphasizing the importance of minimizing stress and promoting positive interactions through gradual and well-monitored processes.

Key strategies, such as environmental enrichment and controlled introductions, have proven essential in facilitating smooth transitions for new group members. These measures not only help reduce aggression but also foster healthy social bonds, enhancing the overall well-being of the group. The case study of the Scarlet Macaw (*Ara macao*) has provided valuable insights into how these general principles can be applied to specific species, highlighting the importance of considering individual behavioral patterns and prior social experiences when planning introductions.

The findings underscore the importance of ongoing monitoring and flexibility in adjusting introduction plans based on the animals' responses. The integration process is not linear; it requires patience, observation, and adaptation to ensure long-term stability within the group. Future research should continue to explore the nuances of social behavior in captivity, particularly how factors such as early socialization, environmental complexity, and individual temperaments influence the success of introductions. By applying these insights, it is possible to improve the welfare of captive animals, reduce behavioral issues related to social isolation, and promote healthier, more stable group dynamics.

This thesis contributes to the broader understanding of animal welfare in captivity, advocating for evidence-based practices that enhance the social integration of animals across a range of species.

BIBLIOGRAPHY

Abramson, C. I. 1995c. The effects of environmental enrichment on territorial behaviors in captive animals. Journal of Comparative Psychology 109(3): 243-250.

Alcock, J. (2005). Animal Behavior: An Evolutionary Approach (10th ed.). Sinauer Associates Inc.

Andrews, P. 1998. Introducing adult males and females. In Felid Taxon Advisory Group husbandry manual, ed. J. D. Mellen and D. E. Wildt, American Zoo and Aquarium Association.

Appleby, M. C., Hughes, B. O., & Mench, J. A. (1999). Animal Welfare. CABI Publishing.

Baldwin, S. P., Oberholser, H. C., and Worley, L. G. 1931. Measurements of Birds. Cleveland, OH: Scientific Publications of the Cleveland Museum of Natural History.

Barroso, F. T., Esteves, B. B., Dal-Bó, L., Lopes, L. S., de Oliveira, I. M., Machado, F. C., Seabra, B. A. S., Borin, A. L., França, A. C. S., & Vieira, R. V. (2019). Therapeutic potential of cannabidiol (CBD) for skin health and disorders. NCBI.

Bloomsmith, M. A., Lambeth, S. P., & Schapiro, S. J. (1991). The effect of foraging enrichment on the behavior of captive chimpanzees. Applied Animal Behaviour Science, 30(4), 317-326.

Bode, N. W. F., Wood, A. J., & Franks, D. W. (2010). Social networks and models for collective motion in animals. Animal Behaviour, 120-124.

Bortolotti, G. R., Marchant, T. A., Blas, J., & German, T. 2008. Corticosterone in feathers is a long-term, integrated measure of avian stress physiology. Functional Ecology 22(3): 494-500.
Brereton, J. E., & Ridgely, R. S. (2005). "Observations of aggression in captive parrots." Zoo Biology, 24(1), 5-14.

Carpenter, J. A. (2019). Neurobiology and communication in parrots with an emphasis on eye signaling (Doctoral dissertation, uniwien)

Clay, J., & Rottman, S. (2009). Behavioral effects of environmental enrichment on captive primates. International Journal of Primatology, 30(5), 665-678.

Couzin, I. D., Krause, J., Franks, N. R., & Levin, S. A. (2005). Effective leadership and decision-making in animal groups on the move. Nature, 433, 513-516.

Craig, J. 2007. Introducing a male meerkat to an established group. Int. Zoo News 54: 150-54

Crespi, B. J., & Yanega, D. (1995). The definition of eusociality. Behavioral Ecology, 6(1), 109-115.

Dawkins, M. S. (1988). Behavioral deprivation: A central problem in animal welfare. Applied Animal Behavior Science, 20(3-4), 209-225.

Dickinson, J., and W. Koenig. Animal Social Behavior. Encyclopedia Britannica, Encyclopedia Britannica, Inc. Available at: https://www.britannica.com/topic/animal-social-behaviour.

Ferrero, D. M., & Liberles, S. D. (2010). The secret codes of mammalian scents. WIREs Systems Biology and Medicine, 2(1), 23-33

Forshaw, J. M. (2006). Parrots of the World (F. Knight, Illus.). Princeton University Press. (Princeton Field Guides series, p. 463).

Forshaw, J. M. 1989. Parrots of the World, 3rd ed. London, U.K.: Blandford Press

Forshaw, J. M. 2010. Parrots of the World, rev. ed. London, U.K.: HarperCollins Publishers.

Franklin, R. J., & Benton, M. C. 2020. Managing social introductions in captive environments: Best practices for minimizing stress. Zoo Management Journal 28(1): 45-58.

Freeberg, T. M. 2000. Social complexity and mixed-species flocks: Implications for social evolution in birds. Animal Behaviour 59(2): 349-358.

Galindo, F., Newberry, R. C., & Mendl, M. (2018). Social conditions. In A. Olsson, F. Galindo, & M. Appleby (Eds.), Animal Welfare (3rd ed.). CABI Publishing.

Gilardi, J. D., et al. (2005). "Pair Bonding and Social Structure in Scarlet Macaws." Journal of Ornithology, 146(4), 215-223.

Gonzalez, L. M., et al. (2019). "Social Cohesion and Reproductive Success in Scarlet Macaws." Ethology, 125(4), 367-378.

Guittar, J. L., Dear, F., & Vaughan, C. (2010). Scarlet Macaw (Ara macao, Psittaciformes: Psittacidae) Nest Characteristics in the Osa Peninsula Conservation Area (ACOSA), Costa Rica. Ornitología Neotropical, 21(2), 289-299

Harrison, C., et al. (2016). "Communication in Scarlet Macaws: A Study of Social Learning." Ethology, 122(5), 374-382.

Heng, V., Zigmond, M., & Smeyne, R. J. (2023). Neuroanatomical and neurochemical effects of prolonged social isolation in adult mice. Frontiers in Neuroanatomy, 17, 1190291.

Hosey, G., Melfi, V., & Pankhurst, S. (2013). Zoo Animals: Behavior, Management, and Welfare. Oxford University Press.

Hrdy, S. B., & Hausfater, G. (1984). Comparative and evolutionary perspectives on infanticide: An introduction and overview. Pg. XX

Huchard, E., & Cowlishaw, G. (2011). Female–female aggression around mating: an extra cost of sociality in a multimale primate society. Behavioral Ecology, 22(5), 1003–1011.

Humphrey, N. K. 1976. The social function of intellect. In Growing Points in Ethology, eds. P. P. G. Bateson and R. A. Hinde, 303-317. Cambridge, U.K.: Cambridge University Press.

Iñigo-Elias, E. E. (1996). Ecology and breeding biology of the Scarlet Macaw (Ara macao) in the Usumacinta drainage basin of Mexico and Guatemala (Doctoral dissertation, University of Florida). University of Florida.

James W. Popp. "Interspecific aggression in mixed ungulate species exhibits." Zoo Biology, Volume 3, Issue 3, Pg 211-219.

Johnston, T. D. 2023. Animal social behavior. Encyclopedia Britannica. Available at: https://www.britannica.com/topic/animal-social-behaviour.

Juniper, T., & Parr, M. (1998). Parrots: A guide to parrots of the world. Yale University Press.

Kleiman, D. G. (2013). Wild mammals in captivity: Principles and techniques for zoo management (2nd ed.). University of Chicago Press.

Kleiman, D. G., Thompson, K. V., & Baer, C. K. (2012). Wild Mammals in Captivity: Principles and Techniques for Zoo Management (2nd ed.). The University of Chicago Press.

Kuhar, C. W., Maki, T. S., & Tatum, J. M. (2006). Effects of social enrichment on the behavior of captive primates. Journal of Applied Animal Welfare Science, 9(3), 215-223.

Lamar University. (2023). Scarlet Macaw. Retrieved from https://www.lamar.edu/arts-sciences/biology/study-abroad-belize/jungle-critters/jungle-critters-2/scarlet-macaw.html

Leonardi, R., Buchanan-Smith, H. M., Dufour, V., MacDonald, C., & Whiten, A. (2010). Living together: behavior and welfare in single and mixed species groups of capuchins (Cebus apella) and squirrel monkeys (Saimiri sciureus). American Journal of Primatology, 72(1), 33-47. https://doi.org/10.1002/ajp.20748

Mason, G., et al. (2013). "Environmental Enrichment for Captive Parrots: A Review of the Literature." Applied Animal Behaviour Science, 144(1-2), 64-72.

Mason, G., et al. (2013). Environmental enrichment for captive parrots: A review of the literature. Applied Animal Behaviour Science, 144(1-2), 64-72.

McClintock, M. K., Conzen, S. D., Gehlert, S., Masi, C., & Olopade, F. (2005). Mammary cancer and social interactions: Identifying multiple environments that regulate gene expression throughout the lifespan. The Journals of Gerontology: Series B, 60(Special_Issue_1), 32-41.

McGraw, K. J., et al. (2018). "Hierarchy and Social Dynamics in Macaw Flocks." Animal Behaviour, 136, 25-34.

Meehan, C. L., & Mench, J. A. (2002). "Environmental enrichment affects the fear and exploratory responses to novelty of young Amazon parrots." Applied Animal Behaviour Science, 79(1), 75-88.

Mitani, J. C., Call, J., Kappeler, P. M., Palombit, R. A., & Silk, J. B. (Eds.). (2012). The Evolution of Primate Societies. University of Chicago Press. Pg. 195

Myers, M. C., & Vaughan, C. (2004). Movement and behavior of scarlet macaws (Ara macao) during the post-fledging dependence period: Implications for in situ versus ex situ management. Biological Conservation, 118(3), 411-420.

Newberry, R. C. 1995. Environmental enrichment: Increasing the biological relevance of captive environments. Applied Animal Behaviour Science 44(2-4): 229-243.

Petherick, J. C., and J. Rushen. 1999. Animal welfare and behavioral deprivation. In Animal Welfare, p. 90.

Ridgway, R. 1916. The Birds of North and Middle America, Part 7. Washington, DC: Government Printing Office.

Shepherdson, D. J., J. D. Mellen, and M. Hutchins, eds. 1998. Second Nature: Environmental Enrichment for Captive Animals. Washington, D.C.: Smithsonian Institution Press.

Smith, V. A., Evans, C. S., & Mainwaring, M. C. 2002. Social learning in mixed-sex bird flocks: Influences on mate selection and group dynamics. Behavioural Ecology 13(5): 571-578.

Stensland, E., Angerbjörn, A., & Berggren, P. (2003). Mixed species groups in mammals. Mammal Review, 33(3-4), Pg. 205-223.

Vaughan, A. R., Adams, R. P., & Greene, J. M. 2005. Behavioral indicators of aggression in captive macaws during social introductions. Journal of Avian Behavior 46(3): 345-352.

W. S. (1921). Review of Diagnoses of Some New Genera of Birds by Robert Ridgway. The Auk, 38(1).

Wilson, C., & Blois-Heulin, C. 2012. Social dynamics and hierarchical structure in captive animal introductions. Journal of Animal Behavior 84(4): 867-876.

Wright, T. F., Rodriguez, A. M., & Fleischer, R. C. 2001. Vocal communication and social hierarchy in parrots. Journal of Avian Biology 32(2): 189-197.