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# Doing an amazon job with parrots: factors influencing breeding success in three EEP-managed parrot species

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**Abstract**

Studbooks are an important tool used in zoos and aquaria globally as a means of managing important animal populations. While the primary goal of a studbook is to manage genetic diversity, these programmes also have great value in collating information on breeding and husbandry practices across multiple international facilities. The aim of this study was to investigate possible triggers for breeding, enclosure design, husbandry styles, and challenges in the keeping of three amazon species in European Association of Zoos and Aquaria (EAZA)-approved holders. A breeding and husbandry survey was distributed, courtesy of the EAZA Ex situ Programmes (EEP), to holders of the Ecuadorian *Amazona lilacina*, red-tailed *Amazona brasiliensis* and red-crowned amazon *Amazona viridigenalis* in 2024. A total of 23 holders responded to the survey, reporting on the husbandry of 54 amazons. Ten holders (43.48%) had successfully bred these species in the past. The challenges outlined by respondents included individuals too young or too old for breeding, aggression from birds directed at keepers, and hesitancy to breed animals due to challenges with sourcing zoos to take the offspring. The majority of holders (22/23, 95.65%) provide regular enrichment, with nutritional enrichment being the most common form, while cognitive (15/23, 65.22%) and social enrichment (4/23, 17.39%) was used less frequently. These parrots are sometimes kept alongside other species such as small birds and primates. It is hoped that the results of this survey may improve the understanding of the husbandry criteria for amazons, and may aid in developing breeding protocols in the future.

## Introduction

The Earth is currently undergoing through a sixth mass extinction, with anthropomorphic pressures instigating the loss of species at hundreds of times the background rate (Leaky 1996; Barnosky et al. 2011). Whilst species extinction is a natural evolutionary process (Briggs 2017; Cowie et al. 2022), the potential loss of 75% of extant species is a serious concern that conservation organisations including zoos must act upon, as per International Union for Conservation of Nature (IUCN) guidelines. It is important, therefore, that zoos and aquaria prioritise threatened species for their conservation efforts as part of the One Plan Approach, and for some species this conservation strategy involves ex situ breeding (Jara et al. 2016).

It is important that the long-term viability of ex situ populations is considered, so that animal populations remain genetically and demographically healthy for the future (Soulé et al. 1986). In order to support select, high-priority species, zoo organisations globally have set up specialist breeding programmes that make recommendations for pairing animals in order to minimise inbreeding (Pilgrim et al. 2016). The European Association of Zoos and Aquaria (EAZA), for example, have set up EAZA Ex-situ Programmes (EEPs), in order to manage species populations through strategic pairings that reduce inbreeding (Schäfer and Reiners 2017). These programmes are coordinated regionally and are overseen by studbook keepers, who collate information including the population of individuals, parentage, sex, origin and family history (Ballou et al. 2010). Many EEPs aim to maintain at least 90% of an animal population's genetic diversity over a 200-year period (Ballou et al. 2010; Kleiman et al. 2010; EAZA 2025). While EEPs are an excellent way of improving population viability by improving pairing opportunities, there remain challenges in terms of animal reproductive success and movement of animals, and this may hamper long-term genetic goals if left unchecked.

Studbooks are effective in ex-situ management, but not all species are currently managed using studbooks. For example, various species of mammals, especially primates and carnivores, are well represented in studbooks, whereas other taxa such as amphibians tend to be less represented (Brereton 2024). Avian taxa are particularly often managed in studbooks, and the most threatened bird family is the parrots (Psittaciformes), of which 58% of the extant species are threatened (Chan et al. 2021). Of this, the amazons *Amazona* spp. represent a genus in which over half of all species are globally threatened and showing a decreasing population trend (Ribas et al. 2007; Zulian et al. 2021). Amazons are threatened due to native habitat loss through urbanisation, plantations, livestock and illegal logging, with a major threat emerges also from illegal poaching for the pet trade (Mori et al. 2017). Wild populations are still decreasing, and breeding of individuals is therefore important for safety net population development (Aloysius et al. 2020). While the Convention on the International Trade of Endangered Species of fauna and flora (CITES) is beneficial in reducing the collection of amazons from the wild, it also affects the movement of zoo-housed individuals, making pairing of birds between holders difficult (Collar and Butchart 2013).

Understanding the behaviour of amazons maintained under professional care in zoological collections could aid in improving the reproductive success (Lopes et al. 2018; Sans and Grajal 1998). Amazons are long-lived birds, and many individuals that are currently housed in zoos have not yet successfully bred (Pilgrim et al. 2016). Identifying strategies that improve breeding could therefore improve the long-term genetic diversity outcomes for these species (de Souza et al. 2017). A better knowledge of breeding triggers could improve the sustainability of these populations by improving breeding success (Saidenburg et al. 2015; Stagegaard et al. 2018).

Despite the need for ex situ populations, some species have only recently been bred, an example is the imperial parrot *Amazona imperiallis* was first recorded to have been bred in 2010 (Reillo et al. 2011; Marcuk et al. 2021). There are many variables that may halt the reproductive success of these species; Clubb et al. (2015) highlighted some key aspects that may influence Puerto Rican parrots *Amazona vittata.* These included environmental aspects such as climate, perching and enclosure, also nutrition, disease and age. Ramos-Guivas (2013) investigated pairing on reproductive success in this species. Understanding how to increase the reproductive success of these species is important for their ex-situ sustainability, a lack of research into this has been highlighted with recent studies starting to investigate reproductive parameters for ex-situ breeding (Marcuk et al. 2023). This study, therefore, was initiated to better understand the predictors of breeding success for amazons, and to identify any barriers that may hinder breeding success. To do this, the study focused on three species: the Ecuadorian *Amazona lilacina*, red-tailed *Amazona brasiliensis* and red-crowned amazon *Amazona viridigenalis.* These three species are at threat of extinction, and are categorised as Critically Endangered (Ecuadorian), Near Threatened (red-tailed) and Endangered (red-crowned amazon) respectively (Biddle et al. 2020; IUCN 2024). Information gathered from this survey could also help populations of other closely related taxa. The study also aimed to gather knowledge that could be used provide recommendations to EEP participants to enhance breeding.

## Methods

This study was approved by the ethics committee of University Centre Sparsholt prior to the participation of data holders in the study. For this study, a Google Forms™ questionnaire was developed for the purpose of investigating predictors of breeding success in amazons. The questionnaire was developed in collaboration with the studbook keepers for the red-tailed *A. brasiliensis*, Ecuadorian *A. lilacina* and red-crowned *A. viridigenalis*. The questionnaire was distributed in March 2024 to all European holders of these three amazon species, and prompts were sent to holders in April, May and July 2024 to increase the response rate.

The questionnaire contained both multiple-choice questions and long-answer questions, with questions separated into sections for breeding success, nutrition, housing, husbandry, health and breeding preparation. The purpose of the questionnaire was to identify predictors of breeding success, and as a result holders were asked how many eggs, hatchlings and fledglings they had produced in the last five years. The nutrition section asked for respondents to document changes in diet in breeding season, and the frequency of feeding. The housing section documented whether birds were kept indoors, outdoors, or both, and the enclosure dimensions and whether supplemental heating was provided. The husbandry section investigated the types of enrichment that were commonly provided, and the frequency they were given, alongside temperature and humidity questions. The health section asked for information as to whether birds had any known health conditions, including viruses, and whether viral screening was regularly conducted. The breeding section investigated the nest box availability and nesting substrates, and the techniques used by keepers to encourage breeding, alongside any behaviours that keepers believed were linked with breeding success.

### *Data analysis*

Data were collated using the Google Forms platform and were then uploaded to a Microsoft Excel™ 2016 spreadsheet for data cleaning and visualisation. Statistical analysis was carried out using Minitab, version 21.1. Data were presented descriptively, in the form of bar charts. Additional data were collected from Species360's Zoological Information Management System (ZIMS) on the number of individuals and number of successfully bred birds in the last 12 months in EAZA and globally. Additionally, a binary logistic regression was run, to determine whether species of amazon, the simulation of rain in the exhibit, or the changing of the diet during the breeding season was a significant predictor of successful breeding (presence or absence of fertile eggs).

## Results

### *Holders involved*

A total of 23 holders responded to the survey, representing a total of 54 individual birds (Table 1). For the purposes of anonymity, the specific holders are not named in the remainder of the results.

### *Housing*

Overall, the majority of holders (17/23, 88.89%) housed their amazons on show to the public. Internal temperatures throughout the year ranged from 5-25$^{o}$C, and perching was generally between

**Table 1.** The three amazon species in EAZA holders and responses to the survey.

| Species | Number in EAZA (male.female.unknown) | total | Birds in the survey (male.female.unknown) | total |
|---|---|---|---|---|
| Ecuadorian *Amazona lilacina* | 30.34.1 | 65 | 18.11 | 19 |
| Red-tailed *Amazona brasiliensis* | 17.10.0 | 27 | 5.3 | 8 |
| Red-crowned *Amazona viridigenalis* | 35.32.2 | 69 | 7.7 | 14 |

151-200cm above the floor (10 responses, 43.48%) or above two metres (8 responses, 34.78%), with only a few holders (3/23, 13.04%) reporting lower perching. The birds were occasionally kept with other species, namely other birds and primates (Table 2). Perches were generally made of wood, though on occasions rope swings were also provided. In terms of supplemental heat, 13 holders (56.52%) provided heat, using several different methods (Figure 1).

***Diet***
Respondents provided information on the diets provided to their birds, and the changes in diets in association with the breeding period. The majority of holders (12/23, 52.17%) responded that the birds were fed twice per day, while fewer holders reported that they fed their birds either once (9/23, 39.13%) or three times (2/23, 09.70%) per day. The majority of holders (17/23, 73.91%) responded that they modified their diets in preparation for the breeding period. Dietary changes included feeding of additional seeds, breeder's pellets, germinated seeds and insect patee (Figure 2).

***Enrichment***
Of all respondents, all but one (22/23, 95.65%) provided enrichment regularly to their birds. The most common type of enrichment provided was nutritional enrichment (defined as food-based tasks), with cognitive (defined as problem-solving tasks that did not involve food) and social (defined as social opportunities such as flocking) enrichment provided less frequently (Figure 3). Enrichment was provided daily (2/23. 8.70%), twice or more per week (10/23, 43.48%), or weekly (8/23. 34.78%), with three holders stating less frequent use of enrichment.

***Breeding success***
Ten holders (43.48%) reported breeding success (fledged offspring) in their amazons in the past (*A. brasiliensis*, 1/6, *A. lilacina*, 6/11, *A. viridigenalis*, 3/7). When asked if the birds had laid eggs in the past five years, 13 holders (56.52%) responded that eggs had been observed (*A. brasiliensis*, 1/6, *A. lilacina*, 6/11, *A. viridigenalis*, 6/7). Of these, fertility was often assessed by candling the eggs: in *A. brasiliensis*, 1 zoo reported fertile eggs, in *A. lilacina*, 4 zoos reported fertile eggs and two reported scenarios where only some

**Table 2.** Range of species used in multi-taxa exhibits, with the number of holders that house the species with amazons.

| Taxon | Common name | Scientific name | Number of holders |
|---|---|---|---|
| Aves | Green-winged macaw | *Ara chloropterus* | 1 |
| | Red-fronted macaw | *Ara rubrogenys* | 1 |
| | Sun parakeet | *Aratinga solstitialis* | 1 |
| | Seriema | *Cariama cristata* | 1 |
| | Palawan peacock pheasant | *Polyplectron napoleonis* | 1 |
| | Bornean peacock-pheasant | *Polyplectron schleiermacheri* | 1 |
| | Toco toucan | *Ramphastos toco* | 1 |
| Mammalia | Goeldi's monkey | *Callimico goeldii* | 1 |
| | Pygmy marmoset | *Cebuella pygmaea* | 1 |
| | Agouti | *Dasyprocta azarae* | 1 |
| | Cotton-headed tamarin | *Saguinus oedipus* | 1 |

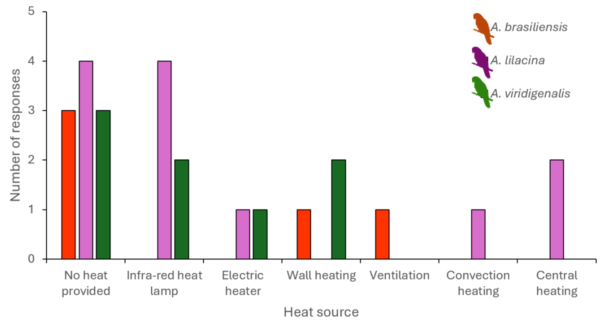


**Figure 1.** Types of supplemental heat strategy for amazons

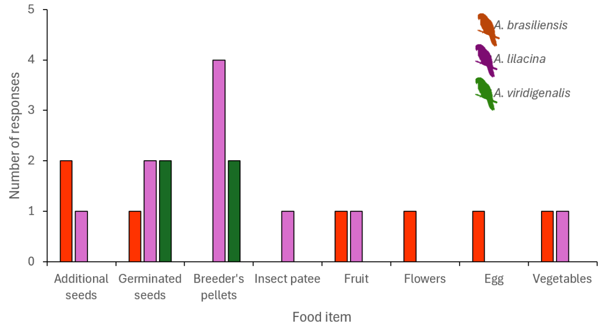


**Figure 2.** Changes to diet in preparation for breeding season.

of the eggs in a clutch were fertile, whereas one reported infertile clutches, and in *A. viridigenalis*, two zoos reported fertile clutches, three reported infertile clutches, and one did not check the eggs. Candling is commonly used for assessing fertility; we note that it is not always reliable in assessing true infertility in birds (Hall et al. 2023). A binary logistic regression was run to investigate potential predictors of previous breeding success (measured as presence of fertile eggs) in holders ($R^2$=0.099, P=0.665). The model identified no significant effect of species (P=0.437), simulation of rain in the exhibit (P=0.288) or changing of the diet in preparation for breeding season (P=0.432).

The breeding success of amazons in EAZA-affiliated and international zoos was identified using ZIMS (Table 3). Across the wider population, breeding is relatively rare, and it appears that successful breeding for each pair occurs sporadically each year. When asked if they had observed any courtship behaviours, respondents noted that they observed allopreening (three responses), and sitting in close proximity (three responses). It should be noted that these behaviours were not always associated with successful breeding. Challenges affecting breeding included birds that were either too old or too young for breeding, were aggressive to keepers, or challenges with placing offspring following breeding.

Holders put forward several strategies to improve the possibility of breeding. All birds, bar one group, had access to a nest box. Several holders allowed the birds to personalise their nest box, by using soft timber that allowed chewing, and blocking the nest box entrance with wood to encourage excavation prior to egg laying. One respondent stated that ‘When we offer the nest box again, we close its entrance with a small piece of soft cardboard, they destroy it within hours to get access to the box afterward”. Eleven (47.83%) respondents reported that they encouraged breeding by providing nesting substrates including twigs, hemp, branches, sawdust and straw. Eleven (47.83%) holders simulated rain conditions during the breeding season.

***Health***

Viral infections are a concern for both wild and zoo amazons (Gough et al. 2006; Díaz Forero 2020; Vaz et al. 2021), and so several questions were dedicated to health and disease surveillance. Nineteen holders (82.61%) responded that their birds did not have any ongoing health concerns, and the majority of holders (20/23, 13.04%) reported that their birds were not virus positive. The majority of holders reported that they regularly screened for viruses (13/23, 65/52%). It should be noted that weight is likely to play a role in fertility for captive birds (Jordan 1995; Chitty 2023). Unfortunately, no questions were asked relating to weighing of birds and weight management more generally.

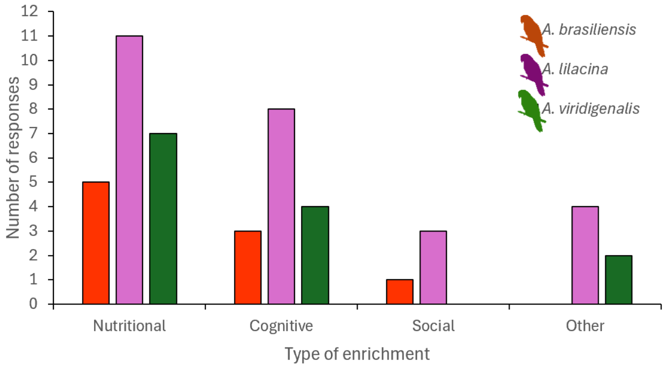


**Figure 3.** Enrichment types provided to amazons.


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**Table 3.** Breeding success in the last 12 months for amazons in EAZA and globally, according to ZIMS. N.b: m means male, f means female, u means unknown.

| Species | EAZA | | | Globally | | |
|---|---|---|---|---|---|---|
| | Number bred | Current population size | % increase in population | Number bred | Number bred (m.f.u = total) | % increase in population |
| Ecuadorian *Amazona lilacina* | 2 | 30.34.1 = 65 | 3.08 | 2 | 45.48.4 = 97 | 2.06 |
| Red-tailed *Amazona brasiliensis* | 0 | 17.10.0 = 27 | 0 | 0 | 25.30.1 = 56 | 0 |
| Red-crowned *Amazona viridigenalis* | 2 | 35.32.2 = 69 | 2.90 | 2 | 57.53.24=136 | 1.47 |

## Discussion

This study identified no significant predictors of breeding success for amazons. However, the number of responses was relatively low from a statistical viewpoint, and so further responses would be needed to investigate further. Overall, a total of ten holders reported successful breeding of their amazons in their collections, and over half of all respondents had reported successful laying of eggs. It is promising to note that the majority of these clutches were determined to be fertile following candling procedures. This suggests that many birds in the ex-situ amazon population are reproductively fertile, so there is considerable scope for developing breeding practices within the EEP holder. Some of the challenges identified by holders of *Amazona* spp. included logistical challenges, such as keeping birds that were either too young or too old to breed. Other temporal challenges included aggression directed at keepers, and some reluctance to breed birds given lack of interest in other zoos housing the offspring. This study also provides initial information on the types of enrichment and husbandry styles for *Amazona* spp. throughout Europe (Gowland 2014).

### *Housing*

In European zoos, amazons were generally housed in exhibits with access to both outdoor and indoor exhibits, and many were provided with a form of supplemental heat in their indoor exhibit. Perching heights varied between holders, but the majority of holders offered perching that was between 150-200 cm, or higher still. The ability to perch, and potentially to nest in high places may be important for amazons. For example, wild Tucuman amazons *A. tucumana* have been noted to normally choose nest sites at a minimum height of 200 cm (Rivera and Politi 2021; Rivera et al. 2012, 2020). This could suggest that there are benefits in terms of providing nest boxes and perches as high as possible in an exhibit, as it may calm the birds. To support this point, studies of nesting in blue-fronted parrots *A. aestiva* identified that lower nesting sites had a lower survival rate as a result of predation (Berkunsky et al. 2016): though this may in part be a result of higher predation risk. The height of the nest box therefore presents great potential as an area for developing breeding in zoo birds (Paulino et al. 2018). Aviaries are not always excessively tall and often nest boxes are placed at a height whereby they can be regularly checked without the use of a ladder, and therefore below 200 cm. Higher nest boxes run the risk of reducing a keeper's ability to regularly check boxes, but may have value in encouraging breeding. Providing nest boxes above 200cm may need to be considered at the stage of enclosure design, given the heigh limitations on existing exhibits.

It is likely that other attributes of nest sites also play a key role in nest site selection and success. For example, selection may also be determined by the nest characteristics and inter-nest distance between neighbour pairings, interior spacing, substrate and also accessibility. Many aspects of selection are likely to be species-specific, so differences in preference may occur between amazon species. Further research is required to identify the specific preferences in order to improve nest box and breeding recommendations.

All species of Amazona require a nest cavity to reproduce (Zulian et al. 2021). The study did not identify the height of the nest cavity, however if kept at a height lower than 200 cm, this could have decreased the chances of reproductive success (Berkunsky et al. 2016), possibly associated with a lower predation risk. Rivera et al. (2022) discovered that Tucuman parrots preferred cavities that were higher and deeper, and they would also steal nesting cavities from other birds. This could pose an issue for populations in mixed species exhibits as they may steal from other birds, thus causing potential conflicts. The territoriality of amazons may also result in unwanted aggression directed towards other species housed in the enclosure during the breeding season. Given that some amazons were kept with other avian and mammalian species, the behaviour and territoriality, and its effects on breeding success in amazons, would be beneficial to investigate (Marini et al. 2010).

The use of artificial nest sites is essential for captive amazons, as it is unlikely that appropriate natural nesting sites will be available in zoos. Fortunately, artificial nesting does not appear to be a problem in amazons. Indeed, studies of wild amazons have demonstrated that birds will use artificial nesting sites if they are available, even when natural nesting sites are accessible (White Jr et al. 2005). This is beneficial to ex-situ breeding as the availability of tree cavities or the resources to create could prove difficult and costly Sanz and Grajal 1998).

Holders regularly reported that they filled in or covered the entrance to nest boxes in preparation for the breeding season, in order to encourage chewing and excavation behaviour (Rivera et al. 2022). In the wild, yellow-naped parrot *A. auropallita* increase their searching for food and cavities during breeding, but they did not show preference for a particular tree species, and over 21 species of tree were used for nesting by birds (Dahlin et al. 2018). While several different strategies were used to allow birds to personalise their nest boxes, including filling the cavity with cardboard or constructing the nest out of soft and chewable wood, it appears that multiple strategies can be effective. Nest box design needs to ensure there is sufficient space for incubation, and air circulation is an important part of the design if birds are to be successful. Experimentation may be required to identify optimal design parameters for each species.

Environment is important for the reproduction of amazons as most species migrate to different environments, Stahala (2008) found that there was a preference for coppice habitats during reproduction. In captivity, coppiced habitat is not a normal aim for a zoo exhibit designer, as coppice is typically associated with anthropogenic activities. However, there may be some potential for select amazon species, if this is reflective of the wild environment. It should be noted, however, that amazons often display nest site fidelity (Waugh and Romero 2000), and so care needs to be taken when making enclosure modifications, especially if birds have previously selected nest sites.

***Diet***

While this study did not focus on the nutritional composition of amazon diets, it did investigate the changes in diet that took place in preparation for breeding. Previous studies have demonstrated that nutrition and food presentation may be linked to courtship and reproductive success in parrots (Brightsmith 2012; James et al. 2021). On average, amazons in this study were fed twice daily, and there was a change in diet during the breeding season for the majority of holders. Changes to diet included the addition of breeder pellet (which is higher in both calcium and protein) and additional fruit, egg and insect patee for the birds. This increase in variety, especially in terms of protein, may be important for the birds. Seasonal change in food availability is likely a proximate trigger for breeding and also is important for breeding these species in captivity. In previous research on wild amazons, the diversity of food items being selected increased considerably (Dahlin et al. 2018). An increased diversity of foods allows the birds to self-select foods which are most appropriate for their stage of reproduction, though it may also allow animals to exclusively select calorie-rich foods (Brightsmith 2012). It is highly likely that low caloric expenditure, in combination with easily available foods, will lead to obesity, which may ultimately impact breeding success. This questionnaire did not investigate weight and weight management of birds, though this area warrants further research in future studies.

***Enrichment***

The majority of the institutions responded that enrichment was embedded well into their husbandry. Nutritional enrichment was carried out by most holders, though some holders supplemented this with cognitive enrichment and social enrichment. This particularly important for members of Psittacidae, Meehan et al. (2004) investigated orange-winged parrots *A. amazonica* that had sub-optimal conditions. The study identified that 96% of the population performed stereotypic behaviours, which likely resulted from a limiting foraging and fewer opportunities to engage in activities. In vinaceous-breasted parrots *A. vinacea*, the provision of foraging through environmental enrichment resulted in parrots spending less time at feeders and choosing to forage instead (Ramos et al. 2021). This demonstrates that amazons require cognitive enrichment and choose to engage in contrafreeloading when given the opportunity to do so. Further exploration into what types of enrichment could be beneficial, Kim et al. (2009) found that orange-winged parrots have preferences for colour, size, hardness, and material of the enrichment. De Azevedo et al. (2017) also found that social learning is a big part of enrichment for *A. aestiva* and how many individuals housed may influence social behaviours.

***Breeding success***

Exhibit population size and density may also affect breeding. Many parrot species are highly social and so access to many conspecifics is often valuable. While amazons are social, they are territorial during breeding, and a high density of parrots could result in competition and aggression between pairs during the incubation and chick rearing periods (Marcuk et al. 2023). The reproductive aggression can be addressed by maintaining pairs separately; a management method selected by many holders. Relatively few holders reported any other social group (i.e. a couple of holders reported keeping of single sex pairs, and occasionally three birds of mixed sex were housed together. The keeping of birds in free mate choice in environments therefore currently appears to be uncommon. There may be considerable benefit in keeping amazons in groups (e.g. four to twelve birds) in terms of mate selection and pair bonding, in addition to social competence and cohesion (Waught and Romero 2000).

The potential impacts of this keeping style need to be considered carefully. For example, multiple pairs in the same exhibit might compete over preferred nest boxes and interfere with each other's breeding and incubation attempts (Berkunsky and Reboreda 2009). If birds fail to breed in a specific nest box in a given year, they are less likely to use the same nest box in future years for subsequent breeding attempts (Pilgrim et al. 2016). Limiting disturbance of nest boxes is therefore important, as is the provision of multiple nest boxes.

***Health***

The risk of viral infection in zoo-housed amazons is important to consider, especially as amazons may become carriers for years following initial exposure to viral infection (Silva et al. 2020). Virus infection is a key concern for the amazon EEPs at current, and given the health concerns associated with this, guidelines are available for holders on how to test for, and act following identification of positive viral tests (Molloy et al. 2020; Saidenberg et al. 2015). This study identified that virus-positive groups of birds exist in EAZA holders, and some of these birds may be genetically important. Care and attention must therefore be given to the movement of birds and the prevention of viral spread within the EEP population (Lacerda et al. 2023). Infection exists in wild amazon populations too: a study of four wild amazon populations revealed that individuals from all areas were seropositive to Chlamydophila sp. (Araujo et al. 2019). Minimum health screening protocols should be conducted to mitigate spread of disease (Saidenburg et al. 2015; Molloy et al. 2020). This is paramount as clinical signs can be minimal or non-existent but still test positive for a viral infection as discovered by Schmitt et al. (2024) and Silva De Souza Matos et al. (2017). Regular screening is becoming more frequent, largely as a greater awareness of viral challenges for these species in zoos (Silva et al. 2020).

***Future directions and recommendations***

Across the three amazon species that were sampled, the questionnaire captured 29.63% (8/27), 29.23% (19/65) and 21.54% (14/69) of the EEP populations for *A. brasiliensis*, *A. lilacina* and *A. viridigenalis*, respectively. While a relatively good response rate for a questionnaire, there is scope to extend this questionnaire. Strategies to enhance response rate could be to run the questionnaire in combination alongside a parrot Taxonomic Advisory Group (TAG) meeting or bird conference. While there is still scope to extend this research, the response rate is reasonable, and this study as a result provides some initial information on strategies for encouraging breeding and normal husbandry practices for *Amazona* spp. in Europe.


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If ex situ reproduction is limited due to the time constraints or small populations, a potential avenue as a temporary strategy may be artificial insemination (AI). Fischer et al. (2020) investigated semen analysis of St. Vincent amazons *A. guildingii* and demonstrated that it is possible to Artificial Insemination (AI) with a successful incubation. However, this does not promote a pair bond or breeding behaviour, so while there is scope to produce offspring using these methods, it is unlikely to increase rearing success. Additionally, this does not necessarily address challenges associated with confirmed infertility, as has been observed in many of the amazon pairings in this study. While sperm fertility assessment may be carried out during AI, sperm quality may not be sufficient for successful AI attempts.

Keepers of amazons are encouraged to provide several nest boxes, and to place the nest boxes high in the enclosure. Regular screening for viruses is advised as per the EAZA viral screening guidelines (Molloy et al. 2020), and holders are encouraged to keep records on breeding success along any strategies that were used prior to egg laying and nesting. Development of these breeding records through platforms such as ZIMS may aid researchers in the future to identify trends that may improve breeding success in these species.

## Conclusion

There remain challenges ahead in the successful breeding and maintenance of European populations of amazons. While some birds have been successfully bred in the past, few birds are breeding on a regular basis, and so further research into courtship and simulation of wild-type nest styles may have value in better understanding breeding triggers for this species. It is important that these studies are conducted in the near future while genetic diversity remains comparatively high and founder birds are still available for breeding. Future investigations surrounding social grouping and mate choice may also have benefit in ensuring that birds are allowed to reach their reproductive potential.

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