Seventeen-fold increase in breeding success and intensified plumage pigmentation of the Scarlet Ibis (*Eudocimus ruber)* at the Jurong Bird Park

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ABSTRACT

In the wild, scarlet ibises *(Eudocimus ruber)* have a distinct bright red plumage that is hard to maintain under human care, due to their highly specific diet that is not readily available. Scarlet ibises are easily maintained in zoos, but pose a challenge in terms of optimum husbandry diet and welfare to recreate the conditions in the wild. The bright red plumage of scarlet ibises often fades into pink when in captivity, which was the case for Jurong Bird Park (JBP). Not only did the scarlet ibises in JBP have a faint pink plumage, they were also experiencing an extremely low breeding season for the past two years with only two hatchings recorded from 2015 to 2017. Even though they were being fed a standard diet of ibis pellets, fish and krill, they were not receiving an optimal balance of nutrients to give them their bright red plumage and in turn induce a breeding season. Thus, in this project we aimed to (1) correct the pigmentation of their plumage, and (2) increase breeding success by simulating a breeding season. The intensity of the scarlet ibises' bright red plumage is vital during breeding season as it helps to attract possible mates. The lack of specific nutrients within the diet could have caused the plumage to be faint which in turn affected the breeding season, as the birds were not at their "best". By altering their diet and husbandry into one that was optimal, rather than simply meeting requirements, the pigmentation of their plumage should improve and ultimately simulate a breeding season. At the JBP, there are 162 scarlet ibises housed together with other water birds such as the straw-necked ibis *(Threskiornis spinicollis),* white ibis *(Eudocimus albus),* Waldrapp ibis *(Geronticus eremita)* and roseate spoonbills *(Platalea ajaja).* To achieve the results we hoped for, we made changes to the diet and husbandry of the scarlet ibises within three aviaries. This included testing out a range of nesting materials to identify what they preferred. Given various options such as nest baskets, platforms and trees, the majority of scarlet ibises chose to nest in tree forks. The amount and type of nesting material given seemed to be associated with a successful breeding season, as it encouraged them to build bigger and more stable nests. Nesting materials such as ferns, twigs, Chinese bamboo, lalang, baphia, tembusu, hibiscus and fir twigs were given. The nesting material preference and diet intake of the scarlet ibises changed throughout the various stages of a breeding season, with them preferring larger branchy twigs at the start and softer leafy material later on in the breeding season. This suggested the need to change the husbandry as the season progressed. With the changes made, the scarlet ibises showcased a drastic change in plumage pigmentation from faint pink to bright red and a seventeen-fold increase in breeding success with thirty-four hatchings recorded from January to May 2018.

INTRODUCTION

Ibises are medium-sized wetlands birds that wade in shallow marshes and lakes. They possess a narrow, curved bill that allows them to probe the mud for food such as crustaceans, soft mollusks, small fishes and worms. They breed in colonies, usually nesting in trees or bushes, with nests made of sticks and twigs. There are about 26 different ibis species.

The scarlet ibis *(Eudocimus ruber)* is distinguishable by its bright red plumage. Their wild plumage is highly pigmented due to the vast amounts of carotenoid present in their diet from crustaceans (ANTAS, 1979). Scarlet ibises are easily maintained in zoos, but pose a challenge in terms of optimum husbandry diet and welfare to recreate the conditions in the wild. The bright red plumage of scarlet ibises often fades into pink when in captivity, which was the case for Jurong Bird Park (JBP). Not only did the Scarlet ibises in JBP have a faint pink plumage, they were also experiencing an extremely low breeding season for the past two years with only 2 hatchings recorded from 2015 to 2017. Even though they were being fed a standard diet of ibis pellets, fish and krill, we suspect they were not receiving an optimal balance of nutrients due to their pale pink plumage. An optimal diet should lead to a scarlet plumage and yearly breeding seasons.

In this project we aimed to (1) correct the pigmentation of their plumage and (2) increase breeding success by simulating a breeding season. The intensity of the scarlet ibises' bright red plumage is vital during breeding season as it helps to attract possible mates through honest signaling (Keyser, 2000). The lack of specific nutrients within the diet could have caused the plumage to be faint which in turn affected the breeding season, as the birds were not at their peak (Minias et al., 2017).

METHODS

We identified three key components that could have influenced their pigmentation and breeding success. These components can be largely categorized as **(1) enclosure, (2) diet and (3) husbandry**.

(1) Enclosure

At JBP, there are 162 Scarlet ibises housed together with other water birds such as the straw-necked ibis *(Threskiornis spinicollis)*, white ibis *(Eudocimus albus)*, Waldrapp ibis *(Geronticus eremita)* and roseate spoonbills *(Platalea ajaja).* They are housed in 2 separate aviaries, eighty-one in each. Both aviaries are 9.5 m wide and 30 m long. The roof is triangular with a maximum height of 6.1 m and a minimum height of 3.5 m (figure 1). Both aviaries have meshing, with glass panels covering the length of the aviary for guest viewing.

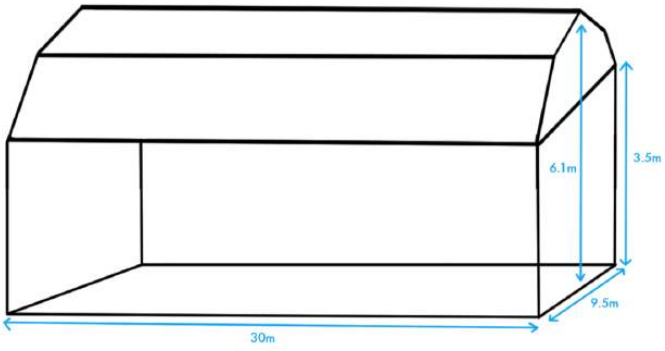

Figure 1: Diagram showing the Scarlet ibis aviary dimensions

The substrate in both aviaries comprise of coarse white sand, with planter areas at the back and sides that are filled with mud. The planter areas have various types of plants. There are three to four trees in each exhibit, which are the preferred perching sites by the birds. Large logs and branches are placed both on the ground and in elevated positions to provide more roosting spots. Stable nesting areas composed of two artificial poles with nesting platforms are provided in each aviary to facilitate breeding. Each aviary is also fitted with multiple ponds. One of the aviaries has a 3 m by 2 m shallow feeding pond with a depth of 0.3 m, as well as a 1 m deep pond coupled with a wave-generating machine that helps to simulate a more naturalistic environment. The other aviary has two shallow feeding ponds with a depth of 0.3 m. It also has a larger pond approximately 13.5 m by 5 m, with a depth of 0.3 m.
With the fixed enclosure design, changes were made to the diet and husbandry of the scarlet ibises.

Diet

The ibises were initially given a standard diet of Verselle-Laga, Belgium ibis pellets, silver striped herring and krill.
The ibis pellets were presented dry, in a food bowl while the fish and krill were presented in the shallow feeding pond. They were fed 8 kg of silver striped herring split into morning and afternoon feeding, 2 kg of krill in the morning, as well as 3 kg ibis pellets for the whole day. The brand of ibis pellet used was then changed to Wisbroek Ibis and Flamingo Pellet). Changes were also made to the proportions of food components of the scarlet ibis (figure 2).
The amount of ibis pellets was increased to 6 kg for the whole day, while the silver striped herring was decreased to 6 kg split into morning and afternoon feeding. Krill remained the same with the occasional replacement of yellow shrimp. The ibis pellets were presented in two bowls; one soaked and one dry. Additionally, crickets and mealworms were also provided randomly throughout the day. Soldier fly larvae, live frogs and fish were also provided once every week.

Changes in proportion of food components

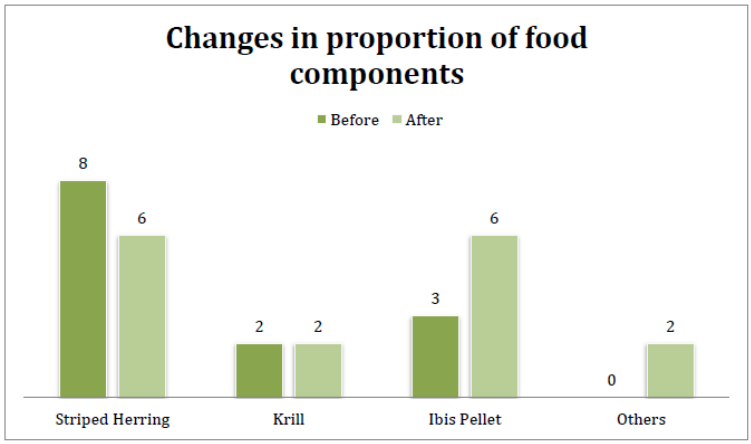

Figure 2: Bar graph showing the proportion of food components in the scarlet ibis diet before and after the changes were made

Husbandry

Pre-existing poles with nesting platforms were used. Additionally, metal nest baskets were placed more than 3 m from the ground (figure 3). A bag of twigs was provided as nesting substrate every two days.

Figure 3: Diagram showing the dimensions of the metal nest basket used.

Once the ibises appeared to be in a breeding mode, two bags of nesting material were provided daily. These included items such as ferns, twigs, Chinese bamboo *(Dracaena braunii)*, lalang *(Imperata cylindrical)*, baphia *(Baphia nitida)*, tembusu *(Fagraea fragrans)*, hibiscus and fir *(Abies spp.)* twigs were given. They were cut into approximately 50 cm in length.

Figure 4: From top to bottom, hibiscus twigs, fir twigs, ferns and lalang.

RESULTS AND DISCUSSION

The changes made in terms of husbandry and diet resulted in a seventeen-fold increase in breeding success **and** intensified plumage pigmentation.

Pigmentation

The pigmentation of the scarlet ibis increased significantly (figure 5) following our diet change. The new diet provided a much more varied array of carotenoids. Canthaxanthin has been identified as being particularly important within the diets of flamingos, which has been assumed to extend to ibises, as well (Fox 1962 a, b, c). Wisbroek's pellets had of various carotenoids from different sources including corn, shrimps, beets and spirulina. It is difficult to ascertain the exact amount of canthaxanthin within the pellets, as manufacturers only reported additives. Flamingo/ibis pellets are very common and many of them have similar nutrient compositions, 19.0 % crude protein and 5.0 % crude fat. The higher crude fat content of the Wisbroek pellets (9.0 %) may help to stabilize the carotenoids; as such compounds are particularly prone to oxidation (Boon et al. 2010). Although no conclusions can be made, possibilities include increasing the diversity of minor carotenoids from a variety of sources, and increasing the fat content of the pellets so carotenoids are more stable.

Figure 5: From top to bottom, scarlet Ibis coloration before the diet change followed by their coloration after the diet change.

Breeding

The intensified plumage pigmentation is believed to play a large role in inducing a breeding season by facilitating mate attraction, compared to when they were pale pink (Keyser, 2000). According to Keyser, the bright plumage is suggested to be a signal of good health (including reproductive health), thereby increasing mate attraction. Once the ibises were paired up and ready to breed, a constant supply of nesting material was supplied throughout the breeding season to encourage the birds to build better nests. This, coupled with an increase in variety of nesting material may have allowed the birds to choose their preferred nesting material, as opposed to only being given one option. The plumage pigmentation and provision of nesting materials were believed to be essential in inducing a breeding season, but the amount of nest sites and nesting materials provided was paramount in ensuring chick survival. This increase in breeding success was evident from the thirty-four hatchings recorded from January- May 2018 as opposed to the 2 hatchings from 2015 to 2017.

It is also important to note that birds in the different exhibits preferred nesting at different locations, as well as nesting materials. For instance, the ibises in one aviary preferred nesting in tree forks and selected for the harder thicker nesting material such as the baphia *(Baphia nitida)* and tembusu *(Fagraea fragrans)* twigs. On the other hand, the other ibises preferred to nest on the metal nesting platforms, and displayed a preference for softer material such as ferns, Chinese bamboo *(Dracaena braunii)* and lalang *(Imperata cylindrical)*. The two aviaries also differed in bird species composition. The different enclosure mates may have also played a part in the choice of nesting materials and nest sites. The ibises that nested on the platforms had to compete with the straw-necked ibis and white ibis for nesting materials and nest sites, and may have chosen the softer nesting material since the platforms already provided stable nests. Whereas, the ibises that nested in the tree forks preferred sturdy twigs to create a stable nest as a base.

There was also a change in preference of nesting materials as the breeding season progressed, with harder twigs being preferred earlier in the season and softer leafy material preferred later on in the season. This may imply that the nests are built first with thicker twigs in order to create a stable base and leafy material later on to create a soft place to lay their eggs.

CONCLUSION

In conclusion, plumage pigmentation appears to be dependent on the optimal balance of nutrients within the diet of a species. In this case, the ideal ratio of silver-striped herring, krill, ibis pellets and other nutrient abundant food's components was essential in intensifying the plumage of the scarlet ibises. Furthermore, providing a greater variety of nesting materials gave the scarlet ibises the ability to choose their preferred nesting material rather than limiting their options. Further studies around preference for nesting material types could be done, so as to optimize chick survivability.

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