Flamingo
Journal of the IUCN SSC WI Flamingo Specialist Group

Does flock size affect greater flamingo sociality and vigilance in captive collections?

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Abstract

With at least 7000 individuals held in zoos, the greater flamingo *(Phoenicopterus roseus)* is a popular zoo bird. In captivity, flock size varies from three to 300 birds, yet wild flocks may exceed 1,000 birds. To investigate the effect of flock size, we investigated a small flock of 35 birds at ZSL London Zoo, and a large flock of 274 birds at WWT Slimbridge from March to July 2015. To measure welfare, we analysed the enclosure use, social network structure, and proportion of vigilance expressed by both flamingo flocks. Both flocks at London Zoo and Slimbridge showed a similar pattern of enclosure use, with uneven enclosure use shown during the day. A comparison of vigilance behaviours revealed while there was no significant difference in levels of vigilance between the large and small flock, however, individual birds were more vigilant in the small rather than large flocks. However, vigilance levels were considerably lower than those of wild flocks. Larger flocks may provide greater opportunities for social interactions between birds, allowing some individuals to reduce their time spent engaged in vigilance.

Introduction

The greater flamingo (*Phoenicopterus roseus)* is found throughout Africa, Europe, and some regions of Asia, and is described as Least Concern by the International Union for the Conservation of Nature (IUCN) (Knox *et al.* 2002). With a current zoo population of at least 7,050 greater flamingos, these birds are well represented in captivity (Species360, 2018). Despite this large captive population, the greater flamingo population may not be sustainable. Flamingo breeding is often unpredictable, and entire flocks may have unsuccessful breeding years during which no chicks are reared (King 2000).

Flamingo breeding success and welfare, therefore, remain key areas for further study (Rose *et al*. 2014). In the wild, greater flamingos may be found in groups exceeding thousands (Rendón *et al*. 2011). In captivity, many researchers suggest that larger flamingo flocks experience better welfare (Brown and King 2008; King 2008; Studer-Thiersch 2000). On the other hand, maintenance of a large flamingo flock may be expensive in terms of food and space (Pickering 1992), which may make some animal managers reluctant to increase their flock size without evidence of welfare improvements.

To evaluate the benefits of large group sizes for the greater flamingo, a small and large flamingo flock were compared. To assess welfare, three observational assessment methods were used; these were enclosure usage, social networks and vigilance behaviours. Enclosure usage helped to identify how flamingos interacted with their enclosure; even use of an enclosure indicates that all aspects of the environment are relevant and therefore usable to the animal (Plowman 2003). Social network analysis was used to identify differences in flock structure and the number of associations that each bird shows (Rose and Croft 2018). The strength of an individual bird's associations may be used as an indicator of welfare; for a flock bird, a lack of associations with other birds may be an indicator of compromised welfare. Vigilance was used as a final welfare indicator; for many species including the flamingo, high vigilance levels are indicative of stress (Beauchamp and McNeil 2003; Beauchamp and McNeil 2004).

Methods

Observations took place from March to July 2015 on a small flock (35 birds, ZSL London Zoo) and large flock (WWT Slimbridge, 274 birds). Observations took place during four daily observation blocks, from 9:00-9:30, 11:00-11:30, 13:00-13:30 and 15:00-15:30, at one-minute intervals.

Enclosure use

The ZSL flamingo enclosure was divided into five different zones according to different biological qualities, and the WWT enclosure was divides into 8 zones (see Table 1 and Figures 1 and 2). The area of each zone was measured using Google Earth Pro™. T. At the start of each time period, photographs were taken to determine which zone each flamingo was occupying. Modified Spread of Participation Index (SPI), an index often used to measure enclosure use, was used to assess usage for both enclosures.

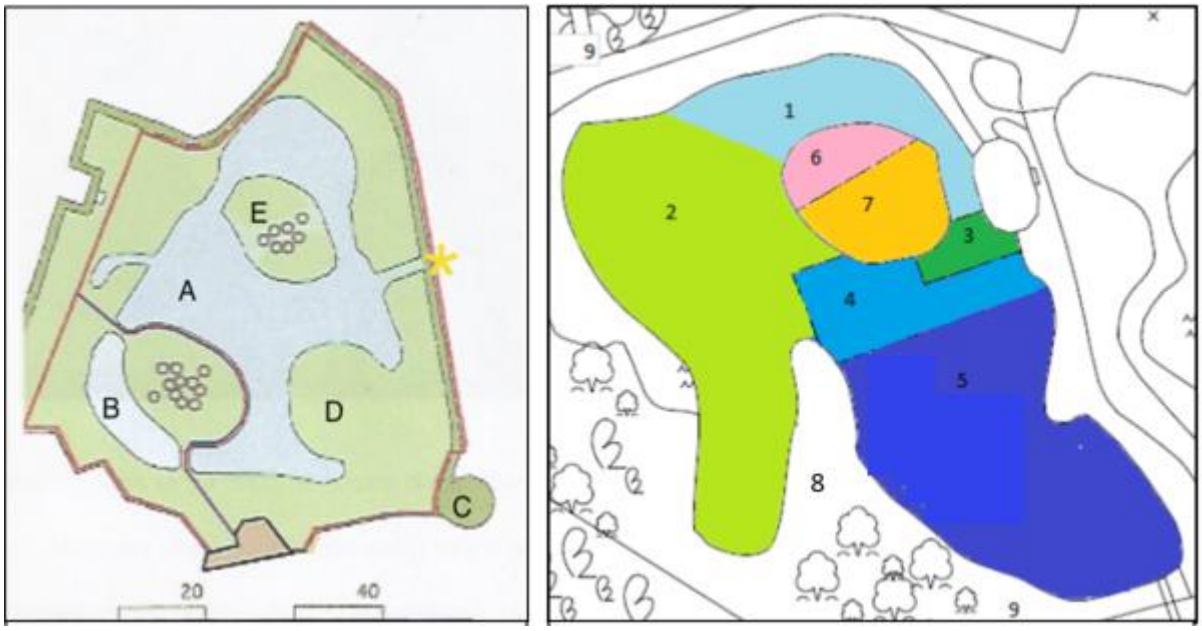

Figure 1: ZSL London Zoo flamingo enclosure map and WWT Slimbridge flamingo enclosure map. Zone sizes are available in Table 1.

Table 1: *ZSL & WWT enclosure zone measurements*

ZSL zones	**ZSL Areas (m^2)**	**WWT Zones**	**WWT areas (m^2)**
A: main pond	394	**1.** right pool	722.5
B: feeding pond	67.3	**2.** back pool	1062
C: grass	76.2	**3.** feeding site	125
D: grass and mud	948.8	**4.** middle pool	236.7
E: Nesting island	127	**5.** left pool	670.5
		6. crèche	157.1
		7. nest area	157.1
		8. accessible bank	224.8

The modified SPI formula, created by Plowman (2003) was used to assess enclosure use for both flamingo flocks. SPI = Σ | fo - fe | / 2(N - fe min)

$\mathbf{f^e}$ is the expected frequency that flamingos will be found in a given zone, $\mathbf{f^o}$ is the observed number of flamingos in a zone, and $\mathbf{f^{emin}}$ is the expected frequency of flamingos in the smallest zone. **N** is the flock size. The formula provides values between 0 (even use of all zones) and 1 (use of only one zone).

Social network analysis

At the start of each study period, associations were recorded. Pictures were taken using a Nikon COOLPIX S3400 camera for analysis of social networks. Birds standing closer than one neck length from each other were described as associating together, as per Rose and Croft's (2018) study. Flamingos were identified using darvic ring codes. Social network analysis involved calculating the strength of pair bonds between birds, and the degree (also known as centrality, or number and strength of associations a flamingo has with all other flock members) for each bird (Ross *et al*. 2014).

To understand flamingo social networks and individual bird personality, continuous focal sampling took place for individual birds. During these focal sample observations, the number of bouts of aggression, head flagging and copulation were recorded. These

data were used to identify whether more aggressive or breeding-oriented birds occupied more central positions in the social network.

Data was analysed initially through Socprog, then through UCINet and Netdraw for creation of network maps. Spring embedding was used and filtered by the average association value in order to remove associations that may have arisen by chance. The half-weight association index used in the course of all association analyses, as a half weight index accounts for periods when individual birds may not be identifiable.

Vigilance behaviours

An instantaneous scan sample was conducted at one-minute intervals for half hour periods for both flocks. Each minute, camera pictures were taken for behaviour analysis. Behaviours were separated into broad, generic categories in order to give an overall flock-wide behaviour score. The ethogram was modified and shortened from Rose's (2017) full ethogram of flamingo behaviours. An activity budget was calculated for both groups for comparison. Vigilance behaviours were compared against wild vigilance levels, as recorded by (Beauchamp and McNeil, 2004). These authors recorded an average level of vigilance of 17% in their wild flocks when foraging, and this can be compared to the flock-wide percentages produced by the current study.

Results

Enclosure use

The modified SPI was conducted for both flocks. The SPI for the ZSL flock was 0.75 (+/-0.09), and 0.79 (+/-0.12) for the WWT flock, indicating relatively uneven enclosure use for both collections. After inferential analysis, there was no significant difference in enclosure use between the two collections.

Social network analysis

Social network maps were produced for both collections. Strong associations were identified in the small ZSL flock, with individual birds showing clear preferences for particular partners (see Figure 2). Older birds tended to take on more central positions

in the social network, whereas the young birds showed fewer, and weaker associations with flock members.

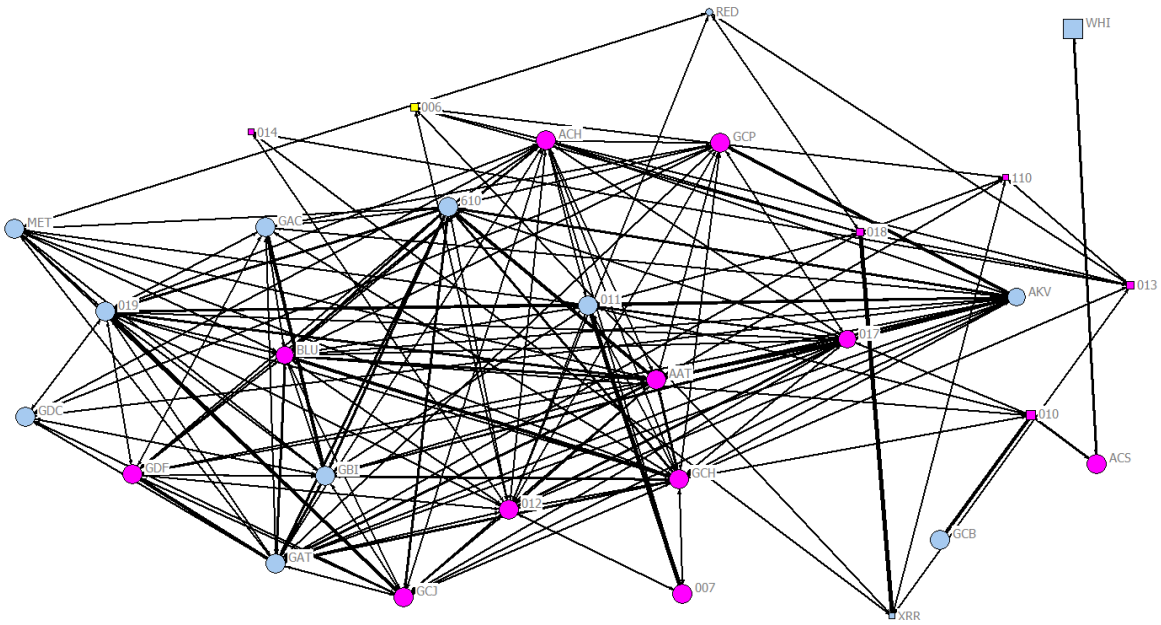

Figure 2: Social network map of the ZSL flock. Blue nodes indicate a male, females are pink, and unsexed individuals are yellow. The social network was filtered to remove weak, coincidental associations between individuals.

By contrast, weaker associations were identified in the larger WWT flock (Figure 3). Individual birds appeared to associate with a much greater number of individuals, but these associations appeared weaker overall: i.e. individual birds were not seen associating with the same individuals as often.

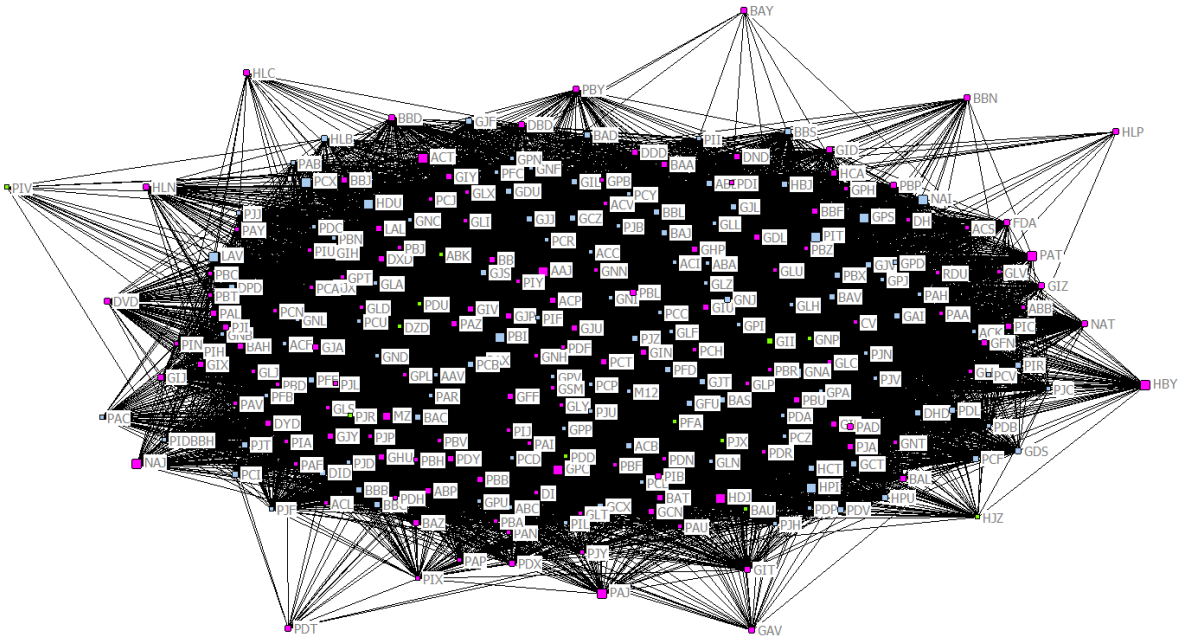

Figure 3: The social network map for the WWT flock, filtered to remove weak associations. Blue nodes indicate male birds, pink are females, and yellow are unsexed birds.

To better compare the ZSL and WWT flocks, the average association index was used to filter the associations of the WWT flock (see Figure 4). The resulting network revealed relatively few remaining associations.

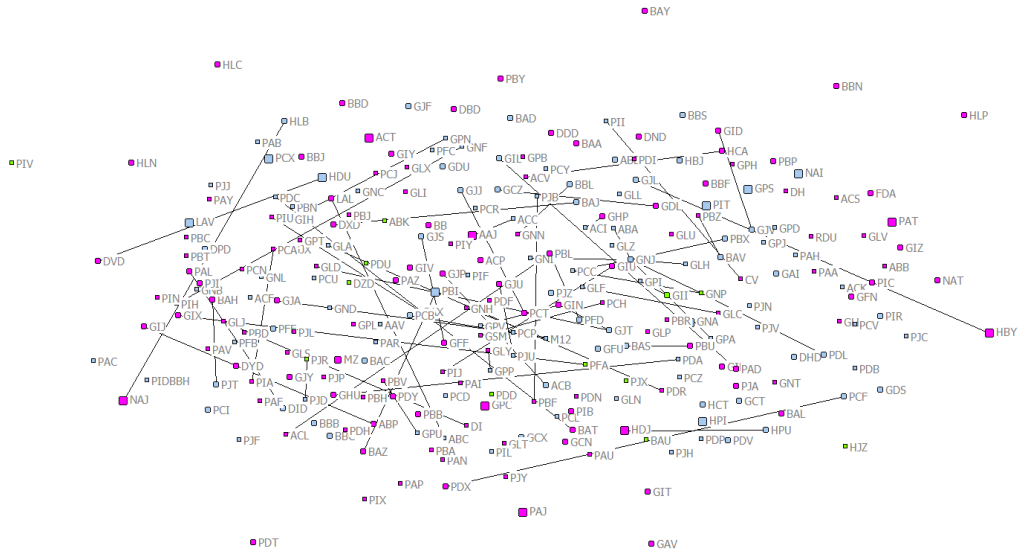

Figure 4: The WWT social network map, filtered using the average association index from the ZSL birds. This shows associations that are only of comparative strength to ZSL bird associations.

Vigilance behaviours

Beauchamp and McNeil's (2003) study in the Camargue indicated that wild flamingos spent on average 17% of their activity budget, while foraging, on vigilance behaviours. By contrast, the ZSL flock spent on average 0.98% of their time engaged in vigilance, and the WWT flock spent 0.12% of their time being vigilant. There was no significant difference between the levels of vigilance between the small and large flocks, but there was a considerable difference between captive flocks and the Beauchamp and McNeil's (2003) data.

Discussion

Enclosure use

The high values of 0.75 and 0.79 for the two flamingo flocks indicate that the birds are not using their enclosures evenly. The flamingos used island nesting areas more than any other zone during the observations. By contrast, water regions and land were underutilised. Enclosure use studies have become prominent in zoo literature (Pastorino *et al*. 2017) and Plowman's (2003) is a valuable tool to identify whether an enclosure is biologically relevant to its inhabitants, and whether particular zones or resources are being avoided.

Whilst these high SPI values might intuitively indicate that the enclosures provided are not relevant, some considerations must be taken into account. As a social bird that naturally congregates in flocks, greater flamingos are more likely to spend time in groups, rather than scattered across their enclosure (Brown and King 2005). Furthermore, the study took place over the breeding season for both flocks, when the flamingos were congregating around their breeding islands (Stevens 1991). Furthermore, flamingos may actually spend more time foraging at dawn, dusk and at night (Beauchamp 2006; Kear 1986). Observations during zoo open hours may therefore not reflect the enclosure use for these birds.

The larger flamingo flock demonstrated less even enclosure use. This might suggest that large flocks are highly invested in breeding, and many individuals spend long

periods of the spring and summer incubating eggs and rearing chicks, and therefore using relatively little space in their enclosures during daytime when breeding.

Social network analysis

Strong pair bonds were identified in the ZSL flock, in which pairs of flamingos were often observed standing closely together. Each bird only appeared to associate strongly with a few other individuals. By contrast, the WWT social network displayed many weak associations between birds. Each individual bird was seen associating with a range of other individuals, rarely with the same partners. Having a wide range of associations may be important for the long-term health of a social bird species (Studer-Thiersch 2000).

Overall, many birds had the opportunity to associate more widely when kept in a large flock scenario. This greater diversity of associations may bring opportunities in terms of breeding partners, social security, and also avoidance of particular birds which have been aggressive in the past.

Vigilance behaviours

For both flocks, vigilance behaviour levels lower than those calculated for foraging wild greater flamingos (Beauchamp and McNeil 2003). There was no significant difference in vigilance levels between large and small flocks. However, focal sample data suggested that on average, the individual flamingo in a large group spends less time being vigilant. This may suggest benefits to individual animals, as a flamingo spending less time being vigilant may have more time to engage in feeding, social and breeding behaviours (Pickering 1992).

Consideration should be given, however, to the fact that Beauchamp and McNeil's (2003) data was from foraging flamingos, whereas the current study addressed flamingo activity budgets during the normal zoo day. To provide a more accurate comparison, studies of zoo and captive birds would be undertaken during the same time periods.

However, these data do suggest that zoo birds may be spending less time engaged in vigilance than their wild counterparts. Wild birds need to scan regularly for predators,

whereas a captive bird is unlikely to be at risk (Stephens and Pickett 1994). It should be noted, however, that flamingos engaged in greater levels of vigilance when keepers walked past their enclosures.

Given that vigilance is often used as a measure of welfare in a range of animal species, these data are promising for captive birds. Additionally, these data suggest that there are benefits in terms of providing a larger flock size for individual perceived safety in flamingo flocks. However, further research would be beneficial for medium sized flocks of 40 to 120 birds, to identify whether these trends are consistent.

Conclusions

Overall, it appears that a large flock scenario may be beneficial for flamingos, as measured by vigilance levels and social networks, but not SPI. Vigilance are useful measures of flamingo welfare for future work. Further research into captive greater flamingo flocks of all sizes would be valuable to identify whether the trends observed remain consistent. Finally, further investigation of flamingo behaviour outside the normal 'zoo day' would be beneficial, to identify whether behaviour and enclosure use is different during dawn, dusk and night.

Acknowledgements

The authors would like to thank the keepers at ZSL London Zoo and WWT Slimbridge Wetlands Centre for facilitating the project.

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Citation

Brereton, J.E., Gardner, L. & Rose, P.E. (2018). Does flock size affect greater flamingo sociality and vigilance in captive collections? *Flamingo e1,* early view.