



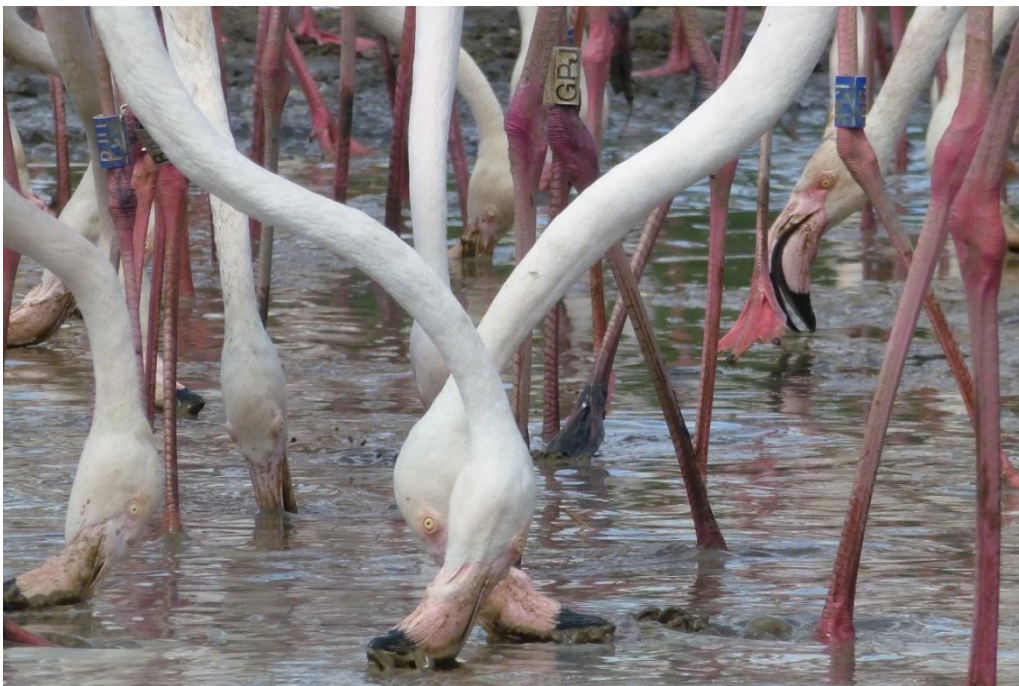
Flamingo

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About the Flamingo Specialist Group

Co-Chairs: Dr Paul Rose (WWT & University of Exeter) / Cathy King (Weltvogelpark Walsrode).

Steering Committee: Dr Felicity Arengo (American Museum of Natural History), Dr Arnaud Bechét (Tour du Valat) and Laurie Conrad.

The Flamingo Specialist Group (FSG) is a global network of flamingo specialists (both scientists and non-scientists) concerned with the study, monitoring, management and conservation of the world's six flamingo species. Its role is to actively promote flamingo research, conservation and education worldwide by encouraging information exchange and cooperation among these specialists, and with other relevant organisations, particularly the IUCN SSC, Wetlands International, the Ramsar Convention on Wetlands, the Convention on the Conservation of Migratory Species (CMS), the African-Eurasian Waterbird Agreement (AEWA) and BirdLife International. The group is coordinated from the Wildfowl & Wetlands Trust, Slimbridge, UK, as part of the IUCN-SSC/Wetlands International Waterbird Network.

Aims and objectives

- Developing and maintaining an active and comprehensive international network of *in situ* and *ex situ* flamingo conservation specialists (both scientists and non-scientists)
- Stimulating and supporting information exchange among flamingo conservation specialists
- Encouraging development and implementation of conservation action plans for the three species of greatest conservation concern: *Phoenicoparrus andinus*, *P. jamesi* and *Phoeniconaias minor*
- Promoting innovative conservation approaches and reconciliation of water conservation for people and for flamingos in the context of climate change and predicted water shortage
- Providing information and advice in support of the programmes of Wetlands International, IUCN-SSC and others that promote the conservation of flamingos and their habitats

FSG members include experts in both *in situ* (wild) and *ex situ* (captive) flamingo conservation and a wide-range of related fields, including breeding biology, infectious disease, toxicology, movement tracking and data management. Members currently represent over 100 organisations in 46 countries around the world.

Further information about the FSG, its membership, the members' email list server and this publication can be obtained from Paul Rose (paul.rose@wwt.org.uk).

Website: www.flamingo-sg.org

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Editorial

Welcome to the relaunched “Flamingo”, the first e-version of the FSG’s popular annual journal. This is the first publication by the FSG since 2011 and we are very proud to have been able to start up the journal a-fresh.

We would like to thank the former chairs of the FSG for their efforts in making the Group what it is today. Alan Johnson, instrumental to the creation of the FSG, worked hard to produce the first newsletter of the FSG- which was then developed further by Brooks Childress. Rebecca Lee created the FSG’s (now thriving) social media platforms and helped with the design and creation of our website. We hope and plan, in time, to grow the new FSG webpage to be a useful and a valuable resource for all those working with flamingos, both wild and captive populations.

Adapting to profound changes in the way researchers and interested parties access information nowadays we have opted for an electronic re-launch of the FSG’s journal. We hope that this will facilitate the diffusion of its contents across a wider audience. Hence Flamingo e1 will succeed Flamingo 18 (2011), the last flamingo newsletter published in paper form.

The breadth of articles providing for Flamingo e1 is heartening. It is great to see so much enthusiasm for flamingo-based research. And that there is a clear need for a platform for its dissemination. The range of *in-* and *ex-situ* papers showcases the extent of flamingo projects running globally, on many populations of flamingos wherever they live. This volume also covers all six flamingo species. A comprehensive set of articles with something to interest all those involved with the lives of these remarkable birds. We are grateful to all authors for sharing their work and we thank them for their efforts and enthusiasm in writing for the re-launched journal.

We are accepting articles for Flamingo e2, due out in December 2019. Given that flamingo habitats worldwide are threatened, it is critical that we compile and disseminate research and studies on flamingos to the widest audience. Long or short reports, original research or descriptive pieces are welcome. Guidelines for publishing can be found on the FSG’s website (<http://www.flamingo-sg.org/journal/>) and at the back of this volume.

With very best wishes for this holiday season.

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Laterality and temperature effects in flamingo resting behaviour

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Abstract

A webcam and online weather data were employed to study laterality and temperature effects in resting Caribbean flamingos (*Phoenicopterus ruber*) on display at Chester Zoo (Chester, UK). Consistent with previous research, a significant population-level preference for rightward neck-resting was observed, no evidence for lateral support leg preferences during unipedal resting was obtained, and a relationship between temperature and unipedal resting was found, such that on cooler days more birds were seen resting on one leg. These results offer support for the generality of the lateral preference toward rightward neck-resting in Caribbean flamingos, as well as the role of unipedal resting in thermoregulation.

Resumen

Se utilizaron una cámara web y datos meteorológicos disponibles en internet para estudiar la lateralidad y los efectos de la temperatura en flamencos caribeños (*Phoenicopterus ruber*) en exhibición en el Zoológico de Chester (Chester, Reino Unido). Consistente con investigaciones anteriores, se observó una preferencia significativa a nivel poblacional para el reposo del cuello hacia la derecha, no se obtuvo evidencia de preferencias de apoyo lateral en las patas durante el reposo unipédico, y se encontró una relación entre la temperatura y el reposo unipédico, por lo que en los días más fríos más individuos fueron observados descansando sobre una pata. Estos resultados dan apoyo a la generalidad de la preferencia lateral del descanso con el cuello hacia la derecha en los flamencos del Caribe, así como el rol del reposo unipédico en la termorregulación.

Résumé

Une webcam et des données météorologiques en ligne ont été utilisées pour étudier la latéralité et les effets de la température sur des flamants des Caraïbes (*Phoenicopterus ruber*) en posture de repos au zoo de Chester (Chester, Royaume-Uni). Conformément aux précédentes études, nous avons observé une préférence significative au niveau de la population pour le repos du cou à droite, une absence de préférence pour la patte utilisée pour le repos unipodal, et une relation entre la température et le repos unipodal, de sorte que lors des journées plus fraîches, davantage d'oiseaux ont été observés se reposant sur une patte. Ces résultats confirment la généralité de la préférence latérale en faveur du repos du cou vers la droite chez les flamants des Caraïbes, ainsi que le rôle de repos unipodal dans la thermorégulation.

Introduction

Side preferences in brain and behaviour (i.e., laterality) have been observed in a wide variety of animals (Rogers, Vallortigara, & Andrew, 2013) including Caribbean flamingos

(*Phoenicopterus ruber*) (e.g., Anderson et al., 2009) and lesser flamingos (*Phoeniconaias minor*) (Anderson, 2009) (but not Chilean flamingos [Anderson & Laughlin, 2014]). Indeed, research has suggested that individual resting flamingos can possess consistent

lateral preferences for curving their neck to either their right or their left when laying their heads on their back (i.e., an individual-level lateral preference), and that when groups are tracked over time one may possibly note a greater preference for rightward neck-resting among most flamingos (i.e., a population-level lateral preference) (e.g., Anderson et al., 2009; but see Hughes et al. [2014] who failed to obtain such a result). As the majority of evidence for flamingo lateral neck-resting preferences has come from Caribbean flamingos held at the Philadelphia Zoo (for review see Anderson, 2017), the present study sought to examine such preferences in a different captive population via an online webcam in order to examine the generalizability of this behavioural phenomenon.

In addition to lateral neck-resting preferences, efforts have been made to obtain evidence of lateral support leg preferences during unipedal resting in Caribbean flamingos (e.g., Anderson & Williams, 2010), but convincing evidence of such preferences has not been as readily obtained (for review see Anderson, 2017). Overexposure of one leg to the harsh conditions characteristic of their wading lifestyles and a need for thermoregulation have been cited as potential reasons for the observed lack of lateral preferences in preferred support leg during unipedal resting (Anderson & Williams, 2010). Indeed, studies have suggested a relationship between flamingo unipedal resting and temperature, with a greater percentage of resting flamingos being seen on one leg in cooler temperatures (e.g., Anderson & Williams, 2010), and flamingos resting on one leg for longer periods of time when it is cooler (Bouchard & Anderson, 2011).

The present study sought to examine the lateral neck-resting and unipedal resting support leg preferences of the Caribbean flamingos on display at Chester Zoo (Chester, UK) via an online webcam. Moreover, local temperature measures were obtained via an

internet resource in hopes of examining the relationship between unipedal resting and temperature. This was done in an effort to replicate these previous effects and further establish their generalisability.

Methodology

Immediately prior to beginning each flamingo observation, observers directed their internet browsers to www.weather.com. On this website observers searched for and recorded the current temperature (°C) from Chester, UK. Twenty once-daily observations of the Caribbean flamingos at the Chester Zoo (Chester, UK) were made between 10 September and 24 October 2012, between the hours of 7:06 a.m. EDT and 10:19 a.m. EDT (aka 12:06 p.m. BST and 3:19 p.m. BST). Observations were gathered by one of four investigators employing a scan sampling technique (Altmann, 1974) that involved simply logging on to Chester Zoo's flamingo webcam (<https://www.chesterzoo.org/must-sees/web-cams/flamingo-cam>), pausing the live feed, and tallying the number of birds displaying various behaviours. Observers recorded the number of flamingos visible, as well as the number of resting flamingos. To be counted as resting, a flamingo had to be clearly seen standing and having its head resting on its back with its neck curved to either the right or left of its centre of gravity. Birds that were clearly seen as resting in the following manners were tallied: bipedal stance w/neck to the left, bipedal stance w/neck to the right, unipedal stance on left leg w/neck to the left, unipedal stance on right leg w/neck to the left, unipedal stance on left leg w/neck to the right, unipedal stance on right leg w/neck to the right, unipedal stance on unclear leg w/neck to the left, unipedal stance on unclear leg w/neck to the right. In all behaviours above, only those birds that were clearly seen as displaying the various behaviours were tallied. If there was any ambiguity, those flamingos simply were not counted.

From the obtained tallies we computed the total number of birds clearly engaging in unipedal resting on each day, the total number of birds clearly engaging in bipedal resting on each day, and the daily percent preference for unipedal resting among resting flamingos (Note that this measure was not generated for days when no birds were observed resting). These particular variables would later be correlated with daily temperature measures in order to examine a potential thermoregulatory function of unipedal resting. Moreover, the total numbers of birds seen resting their necks to the right and left (irrespective of leg stance) were summed across all twenty observations. Similar sums were generated for left and right support leg during unipedal resting (irrespective of neck-resting direction), and for those instances of rightward and leftward neck-resting that had occurred during unipedal resting when leg stance data was also available. This second neck-resting tally (specific to unipedal resting and when leg stance was known) was calculated in order to allow for an informal comparison of the relative strengths of neck-resting and unipedal support leg preferences. All correlational analyses were performed via SPSS PASW Statistics (Release 18.0.3) for Mac, and all one-tailed binomial analyses (normal approximation w/continuity correction) were conducted according Siegel (1956).

Results

A one-tailed binomial analysis (normal approximation w/continuity correction) (Siegel, 1956) examining the proportion of total numbers of flamingos seen resting their necks to the right vs. the left (irrespective of leg stance) across all observations yielded statistically significant results (Right=47, Left=29; $z=-1.95$, one-tailed $p=0.026$), suggesting a greater probability of rightward neck-resting. A similar analysis was performed to examining the proportion of flamingos

clearly seen resting on their right vs. left legs during unipedal resting failed to obtain evidence of a population-level lateral preference in support leg during unipedal resting (Right=8, Left=7; $z=0$, one-tailed $p=0.500$). A final binomial analysis examined the proportion of right vs. left neck-resting preferences for those birds for which unipedal leg stance data were also available. This analysis yielded marginally significant results with a greater proportion of rightward neck-resting (Right=11, Left=4; $z=-1.55$, one-tailed $p=0.061$).

Pearson (r) correlation analyses were employed to examine the relationships between daily temperature and the total number of birds clearly engaging in unipedal resting on each day, the total number of birds clearly engaging in bipedal resting on each day, and the daily percent preference for unipedal resting among resting flamingos. Temperature was significantly negatively correlated with the number of flamingos seen resting on one leg on a given day ($r(18)=-0.589$, two-tailed $p=0.006$) (see Figure 1), and while the relationship between temperature and percentage of resting birds engaging in unipedal resting did not achieve statistical significance, it was generally trending in the same direction ($r(15)=-0.406$, two-tailed $p=0.106$), both of which suggest that more birds engaged in unipedal resting on cooler days. The total number of birds clearly engaging in bipedal resting on each day was not significantly related to daily temperature; ($r(18)=0.153$, two-tailed $p=0.518$). While the number of total flamingos visible on the cam was for some reason marginally negatively related to temperature ($r(18)=-0.439$, two-tailed $p=0.053$), no relationship was observed between temperature and the total number of resting flamingos (irrespective of leg stance) observed on a given day ($r(18)=-0.377$, two-tailed $p=0.101$), and thus this seems unlikely to have influenced the results described above.

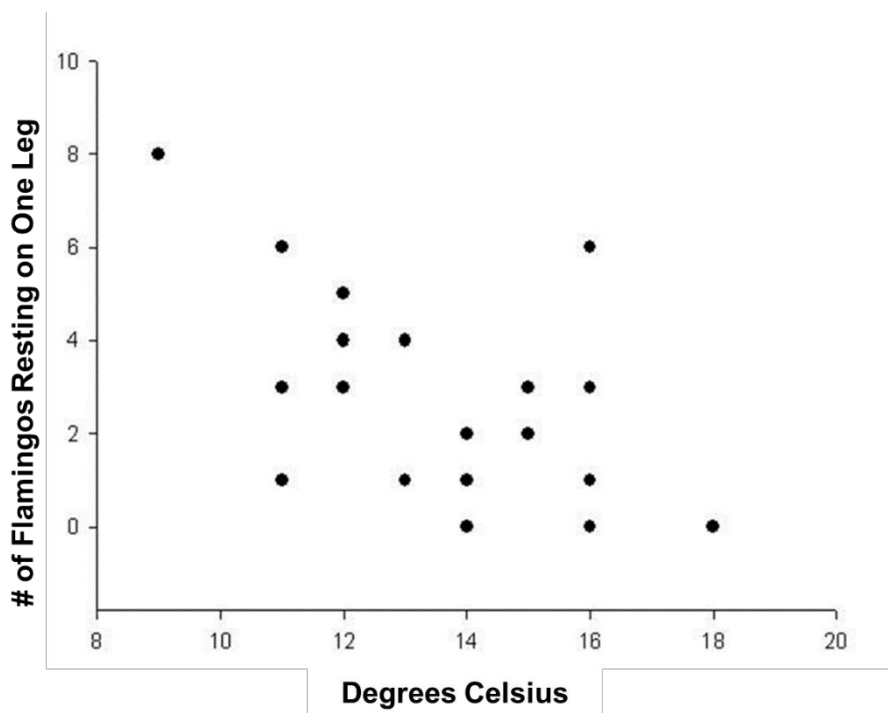


Figure 1: The relationship between temperature and the number of flamingos observed resting on one leg.

Discussion

Results evidenced a population-level lateral preference for rightward neck-resting in the Caribbean flamingos on display via the Chester Zoo flamingo webcam (cf., Anderson et al., 2009). Moreover, no evidence was found for a population-level support leg preference during unipedal resting, which is also consistent with previous findings (e.g., Anderson & Williams, 2010). Indeed, it is noteworthy that even when restricting our analysis of neck-resting to those resting birds for which unipedal leg stance data were also available, we still obtained some evidence (albeit, marginal) of a tendency towards rightward neck-resting. Given this, it seems that the tendency towards lateral neck-resting preferences is stronger than that of leg preferences during unipedal resting. It seems likely that the wading lifestyle of flamingos has discouraged such leg preferences, as a leg preference could result in chronic exposure of one limb to the often harsh aquatic environments which are typical of flamingo haunts, could conceivably lead to excessive

heat loss from one limb (cf., Anderson & Williams, 2010), and could conceivably lead to undue stress and wear on the preferred limb (but see Chang & Ting, 2017).

The present results also provide evidence for a thermoregulatory function of unipedal resting. In previous reports we obtained evidence of a greater percentage of resting flamingos engaging in unipedal resting on cooler days (e.g., Anderson & Williams, 2010), as well as a tendency towards engaging in unipedal resting for longer periods on cooler days (Bouchard & Anderson, 2011). While the correlation between temperature and percentage of resting flamingos engaging in unipedal resting did not achieve statistical significance in the present report, the relationship was in a direction consistent with previous research (e.g., Anderson & Williams, 2010). More impressively, we did obtain evidence of a significant negative correlation between daily temperature and the total number of flamingos seen engaging in unipedal resting on a given day. Thus, our results suggest that on cooler days more

flamingos will be seen engaging in unipedal resting, providing further evidence for a thermoregulatory function of this behaviour.

Conclusions

The present results offer further evidence of a lateral preference for rightward neck-resting in Caribbean flamingos and suggest that this effect may generalize to flocks beyond the Philadelphia Zoo. Lateral support leg preferences during unipedal resting were not found, and a thermoregulatory explanation of unipedal resting was supported as flamingos were more likely to engage in unipedal resting on cooler days, thus evidencing the generalizability of the phenomena.

Acknowledgements

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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, individual birds were more vigilant in the small rather than large flock. 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.

Resumen

Con al menos 7000 individuos albergados en zoológicos, el flamenco rosado (*Phoenicopterus roseus*) es un ave popular de zoológico. En cautiverio, el tamaño de la bandada varía de tres a 300 individuos, pero las bandadas silvestres pueden exceder los 1,000 individuos. Para investigar el efecto del tamaño de la bandada, estudiamos una pequeña bandada de 35 individuos en el ZSL London Zoo y una bandada grande de 274 aves en WWT Slimbridge de marzo a julio de 2015. Para medir el bienestar, analizamos el uso del recinto, la estructura de la red social y la proporción de comportamiento de vigilancia expresada por ambas bandadas de flamencos. Ambas bandadas, tanto la del London Zoo y la de Slimbridge mostraron un patrón similar de uso del recinto, con un uso desigual durante el día. La comparación de los comportamientos de vigilancia reveló que no había una diferencia significativa en los niveles de vigilancia entre el grupo más grande y el más pequeño, sin embargo, los individuos en los grupos pequeños estaban más atentos que los de grupos grandes. Los niveles de vigilancia fueron considerablemente más bajos que los de los grupos silvestres. Las bandadas más grandes pueden proporcionar mayores oportunidades para las interacciones sociales entre las aves, lo que permite a algunos individuos reducir su tiempo dedicado a la vigilancia.

Résumé

Avec plus de 7 000 individus détenus dans des zoos, le flamant rose (*Phoenicopterus roseus*) est un oiseau de zoo populaire. En captivité, le nombre d'oiseaux varie de trois à 300 oiseaux, alors que dans la nature les flamants peuvent évoluer dans des groupes pouvant dépasser 1 000 oiseaux. Pour évaluer les effets de la taille du groupe, nous avons

étudié un petit groupe de 35 oiseaux au ZSL London Zoo et un grand groupe de 274 oiseaux au WWT Slimbridge de mars à juillet 2015. Pour mesurer le bien-être, nous avons analysé l'utilisation de l'enclos, la structure du réseau social et la proportion de vigilance exprimée par les deux groupes de flamants roses. Les flamants des zoo de Londres et de Slimbridge ont montré un schéma similaire d'utilisation des enclos, avec une utilisation inégale des enclos pendant la journée. Une comparaison des comportements de vigilance n'a révélé aucune différence significative de vigilance entre les grands et les petits groupes. Toutefois, les oiseaux isolés étaient plus vigilants dans les petits groupes que dans les grands. Cependant, les niveaux de vigilance étaient considérablement inférieurs à ceux des groupes sauvages. Des groupes de taille plus importante peuvent offrir de plus grandes possibilités d'interactions sociales entre les oiseaux, permettant à certains individus de réduire leur temps passé en 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 divided 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. The modified SPI formula, created by Plowman (2003) was used to assess enclosure use for both flamingo flocks.

$$SPI = \sum | f_o - f_e | / 2(N - f_{emin})$$

f_e is the expected frequency that flamingos will be found in a given zone.

f_o is the observed number of flamingos in a zone.

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).

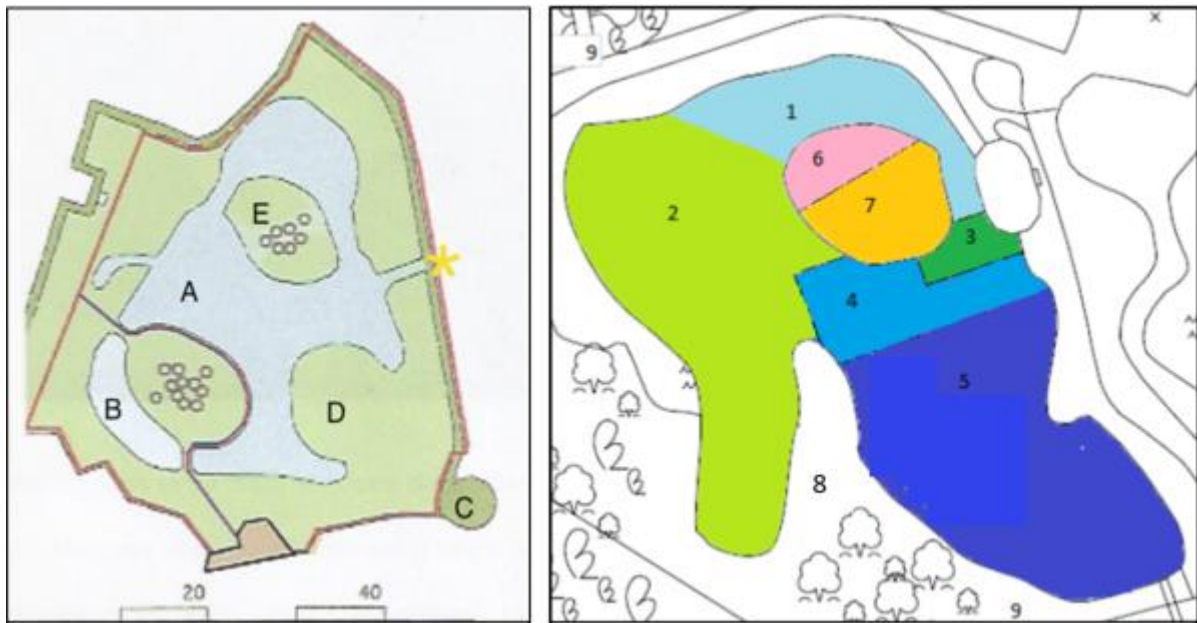


Figure 1: ZSL London Zoo flamingo enclosure map and WWT Slimbridge flamingo enclosure map. Zone sizes are available in Table 1.

Table 1: ZSL London Zoo & WWT Slimbridge 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

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.

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 for 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.

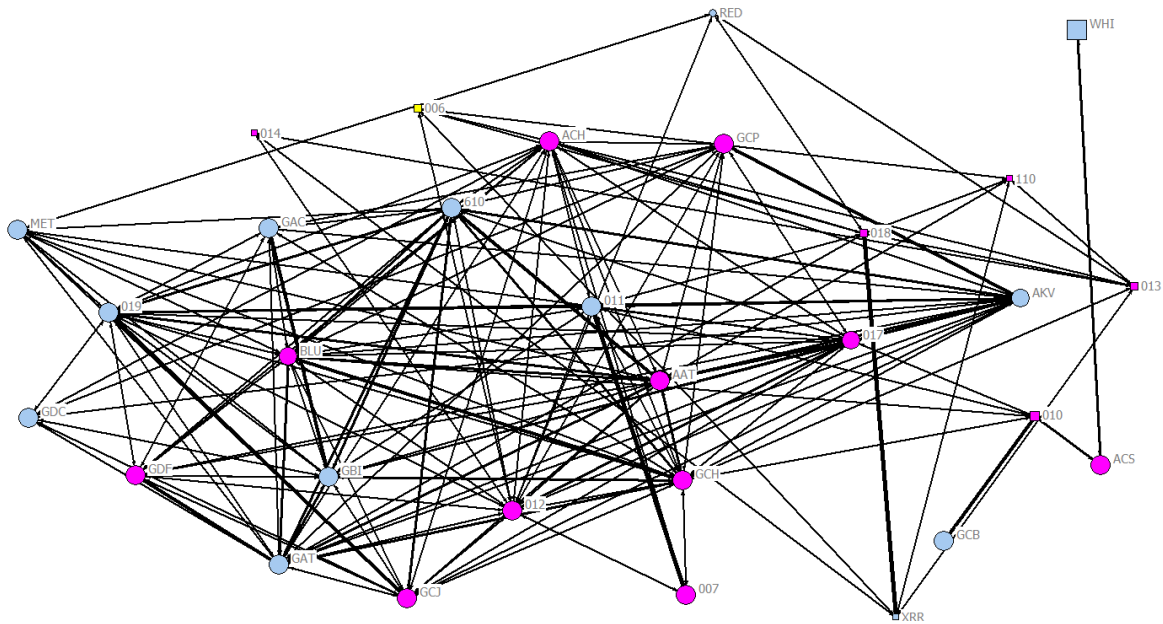


Figure 2: Social network map of the ZSL flock. Blue nodes indicate a male, females are pink, and unsexed individuals are yellow. The social network was filtered to remove weak, coincidental associations between individuals.

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.

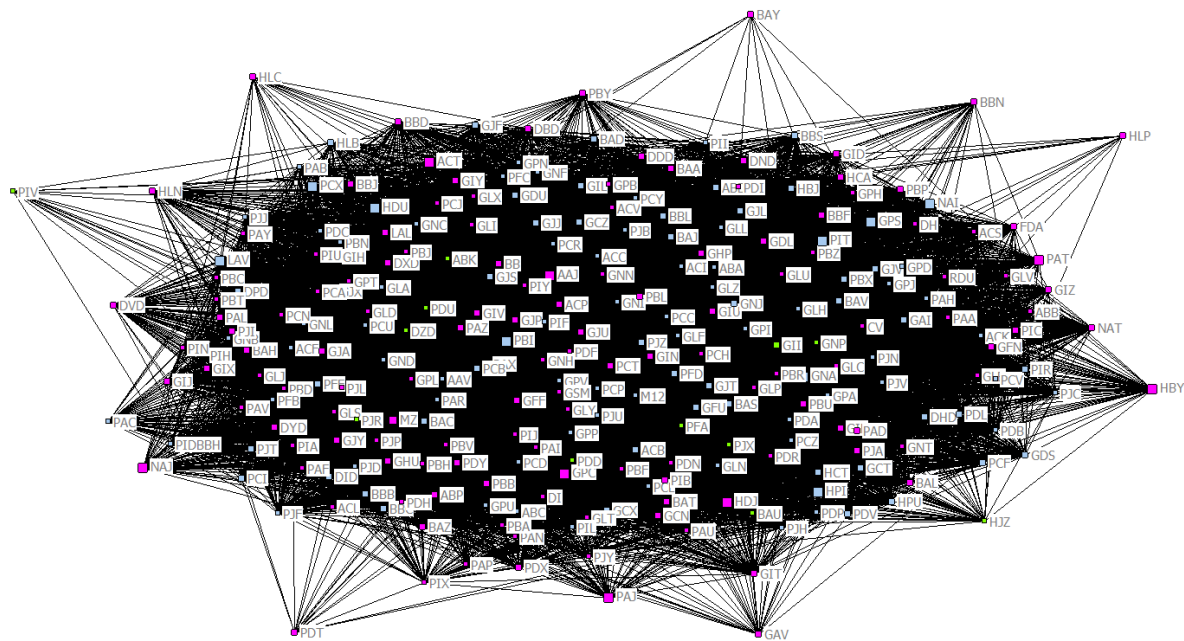


Figure 3: The social network map for the WWT flock, filtered to remove weak associations. Blue nodes indicate male birds, pink are females, and yellow are unsexed birds.

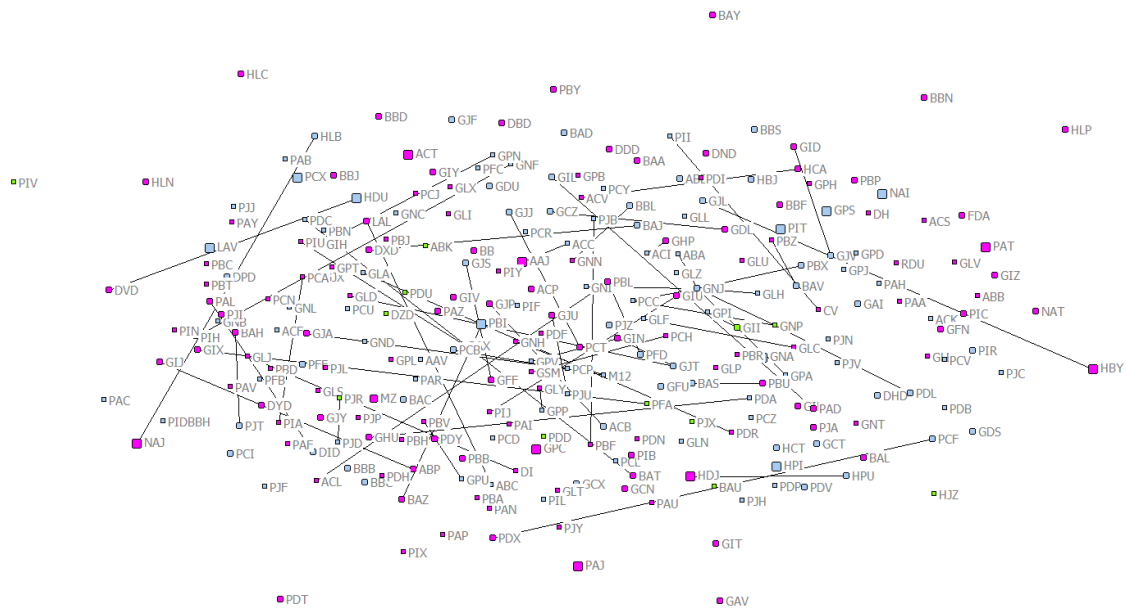


Figure 4: The WWT social network map, filtered using the average association index from the ZSL birds. This shows associations that are only of comparative strength to ZSL bird associations.

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.

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.

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Population status and trend of lesser flamingos at Lakes Natron and Manyara, Tanzania

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Abstract

The wild lesser flamingo population count at Lake Natron and Lake Manyara was carried out in January 2012, 2016 and 2017. The population of lesser flamingos was estimated using a ground count technique with the aid of a pair of binoculars and telescope to identify and count flamingos at each side of the two lakes. A total of 20,378 flamingos were observed and recorded at both sides of Lake Natron while at Lake Manyara a total number of 25,262 flamingos were counted at both sides of the Lake. The results revealed that the average count of lesser flamingos for the ten years from 1992 to 2012 at Lakes Natron and Manyara were $193,756 \pm 63083.9$ and $404,854 \pm 223404.2$ birds respectively. The general trend of the lesser flamingo population for these ten years for these two lakes indicates that the population is declining. A larger decline was observed at Lake Manyara from 1995 to 2017 in contrast to at Lake Natron. From this study, recommendations are given for more counts to be conducted to further improve our understanding of the temporal and spatial distribution and abundance of lesser flamingos in Tanzania, and across Africa as a whole.

Resumen

Conteos de la población silvestre de flamenco enano en el Lago Natron y el Lago Manyara se llevaron a cabo en enero de 2012, 2016 y 2017. La población de flamenco enano se estimó utilizando una técnica de conteo terrestre usando binoculares y un telescopio para identificar y contar los flamencos en cada lado de los dos lagos. Se observaron y registraron un total de 20.378 flamencos en ambos lados del Lago Natron, mientras que en el Lago Manyara se contaron un total de 25.262 flamencos en ambos lados del lago. Los resultados revelaron que el conteo promedio de flamencos enanos durante los diez años, de 1992 a 2012, en los lagos Natron y Manyara fue de $193.756 \pm 63.083,9$ y $404.854 \pm 223.404,2$ individuos respectivamente. La tendencia general de la población de flamenco enano durante estos diez años para estos dos lagos indica que la población está disminuyendo. Se observó una disminución mayor en el Lago Manyara desde 1995 hasta 2017 en comparación con el Lago Natron. A partir de este estudio, se dan recomendaciones para que se realicen más conteos para mejorar aún más nuestra comprensión de la distribución temporal y espacial y la abundancia de flamencos menores en Tanzania y en toda África.

Résumé

Le dénombrement des flamants nains sur les lacs Natron et Manyara a été effectué en janvier 2012, 2016 et 2017. La population de flamants nains a été estimée à l'aide d'une

technique de dénombrement au sol à l'aide d'une paire de jumelles et d'un télescope pour identifier et compter les flamants de chaque côté des deux lacs. Un total de 20 378 flamants roses a été observé des deux côtés du lac Natron, tandis qu'au lac Manyara, ce sont 25 262 flamants roses qui ont été dénombrés des deux côtés du lac. Les résultats ont révélé que le nombre moyen de flamants nains pour les dix années allant de 1992 à 2012 sur les lacs Natron et Manyara était respectivement de $193\,756 \pm 63\,083.9$ et $404\,854 \pm 223\,404.2$ oiseaux. La tendance générale de la population de flamants nains pendant ces dix années pour ces deux lacs indique que la population est en déclin. Le déclin était plus marqué au lac Manyara de 1995 à 2017, contrairement au lac Natron. À partir de cette étude, il est recommandé d'effectuer davantage de dénombrements afin d'améliorer notre compréhension de la répartition temporelle et spatiale et de l'abondance des flamants nains en Tanzanie et dans l'ensemble de l'Afrique.

Introduction

The lesser flamingo (*Phoeniconaias minor*) occurs in eastern, southern and western Africa, as well as in Pakistan and northwestern India. In East Africa, the lesser flamingo is a characteristic bird of soda lakes in the Rift Valley, where it is highly gregarious and nomadic (Britton, 1980; Zimmerman, Turner, Pearson, Willis, & Pratt, 1996). The lesser flamingo breeds mainly in the Rift Valley lakes of East Africa including Lakes Natron, Eyasi and Magadi in Kenya. Three other smaller breeding populations occur in West Africa, in southern Africa, in India and Pakistan (BirdLife International, 2016). The lesser flamingo has been categorized as "Near Threatened" due to a declining population, which might be caused by reduced number of breeding sites, anthropogenic activities and infrequent breeding (BirdLife International, 2016). Other factors are considered to be a threat to the lesser flamingos specifically at Lake Natron- the hydroelectric power scheme proposed by the Government of Kenya at Ewaso Ngiro River (Anonymous, 1993; Johnson, 1994), which pours its water into Lake Natron might alter the inflow of water into the lake. A reduced or abrupt change of inflow into the lake could lead to the alteration of the hydroecology of the lake and pose danger to the breeding site and survival of flamingos.

Despite Lake Natron being considered as the main and only regular breeding site for lesser flamingos (Brown & Britton, 1980; BirdLife

International, 2013), the population of lesser flamingos at Lakes Natron and Manyara have been declining subsequently from 1994 to date- however multiple factors may contribute the decline of the species (Baker, 1996; Pennycuik, Fuller, Oar, & Kirkpatrick, 1994; TWCM, 1995). Based on these past predictions and published information on population trends, the purpose of the present survey was to assess the current population and distribution of the lesser flamingos at Lakes Natron and Manyara via a ground counting method.

Study area

Lake Natron (02°25S 36°00E/2.417°S 36°E; 02°25S 36°00E / 2.417°S 36°E /) is a shallow endorheic lake on the floor of the Eastern Rift Valley. The Lake is elongated in shape, extending 58km south of the Kenya border with a mean width of 15km and 3.3m depth, with a total surface area of about 950km² (Figure 1). The water is highly caustic with chloride concentrations reaching 65,000mg/litre and is unsuitable for direct human and livestock use (Collar, Crosby, & Stattersfield, 1994). The surrounding land is dry bush dominated by *Acacia* thorn-trees and inhabited by pastoral Maasai. There is some seasonal cultivation along the riverbanks and a small settlement in the south associated with a minor soda-extraction plant and a few small tourist camps (Njaga & Githaiga, 1999).

Lake Manyara (03°30'S; 35°60'E is also located in the Rift Valley, about 120km southwest of Arusha (Figure 1). It is a shallow alkaline lake (pH ~9.5) and covers approximately 231km². Lake Manyara is within the Manyara National Park that is also designated as Biosphere

Reserve by the IUCN. The Lake is home to over 300 migratory bird species, including flamingos. The Lake is used as a wintering water body for flamingo after breeding at Lake Natron.

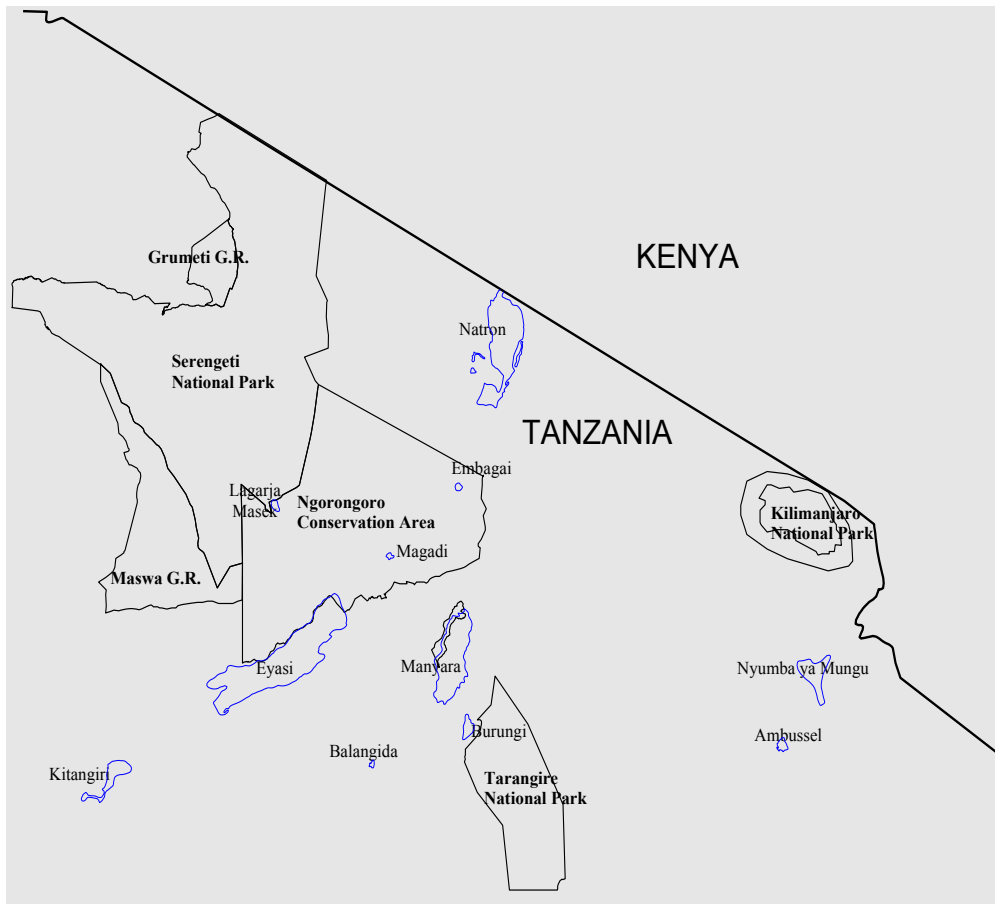


Figure 1: A map of Tanzania showing the study areas (Lakes Natron and Manyara) and the other soda lakes in this region.

Methods

Flamingo counts were conducted in January 2012, 2016 and 2017 at Lake Natron and Lake Manyara National Park with the aim of knowing abundance and distribution. Each lake was divided into two sides namely the western and the eastern side. In each surveyed lake, a point with high elevation was selected for ease of observing and counting the flamingos. The lesser flamingo population was estimated using a ground count technique with the aid of binoculars and telescopes to identify and count flamingos at each side of the two lakes. The participants

stood at the highest point of the lake so that they could see the scenery of the lake from a far for easy counting of the flamingos. Flamingo flocks were divided into equal group sizes and individuals in each group were then counted. The total individuals in a counted group were multiplied by the number of obtained groups of flamingos. Each participant estimated the number of each flock of flamingos and then each participant's counts were summed and divided by the number of participants to get the total flamingo population estimate in each lake. Where flocks were small, direct counts of individuals were made.

Results

A total of 20,378 flamingos were recorded at both sides of Lake Natron in 2012. The highest number of flamingos were counted from the western side of the Lake- 13,617 individuals compared to from eastern side where flamingo count was 6,761 individuals. At Lake Manyara a total of 25,262 flamingos were counted from both sides of the Lake; 20,830 flamingos were counted on the eastern side and 4,432 were counted from the north-west of the Lake. The flamingo survey was again conducted in 2016 and 8,403 flamingos were counted at Lake Natron and 34,000 at Lake Manyara.

In 2017 1,500,000 flamingos were counted at Lake Natron and 100,000 at Lake Manyara. However, during 2016/2017 counts were performed over the entire Lake regardless of sides. The result revealed that the average count of lesser flamingos for the period 1992 to 2012 was $193,756 \pm 6.3$ (Lake Natron) and $404,854 \pm 2.2$ (Lake Manyara). The general trend of the lesser flamingo population over these ten years, for these two Lakes, may indicate an overall population decline. A larger decline was observed from Lake Manyara from 1995 to date in contrast to that from Lake Natron.

Discussion

The lesser flamingo is a highly nomadic species that is dependent on a range of soda lakes to complete its annual cycle (Zaccara et al., 2011). The nomadic behaviour of Lesser flamingo is demonstrated by annual fluctuations in the total number of birds counted in two lakes, ranging from less than 100,000 birds in 1969 to nearly two million in 1991. This situation is further demonstrated by annual changes in numbers at individual lakes. Based on census data currently available, the distribution of lesser flamingos in Tanzania is restricted to soda lakes within the Rift Valley and volcanic highlands in the northern part of the country. It has been noted that the distribution and abundance of

flamingos are related to food supply (Burgis & Symoens, 1987; Tuite, 1981). Thus, changes in the numbers of flamingos at a particular soda lake both during the year and between years may reflect fluctuations in the availability of their food supply. The lesser flamingo is specialized for feeding on *Spirulina*, a species of blue-green algae that is found in alkaline water (Middlemiss, 1958; Pennycuik & Bartholomew, 1973). Increased siltation and chemical pollution from agricultural activities pose a major threat to most of the lakes which are not well protected (Mlingwa & Baker, 2006). The chemical pollutants produced from agricultural activities may affect the availability of the *Spirulina* food supply for lesser flamingos that, in turn, affects the distribution of flamingos. Such human activities can greatly affect the abundance and distribution of lesser flamingos in these two soda lakes under study.

Conclusions

The soda lakes of Kenya and Tanzania are the most important habitat for the lesser flamingo in Africa. However, most of the important lakes in Tanzania are outside of the network of highly protected national parks and game reserves. Only a portion of Lake Manyara is within the Lake Manyara National Park, while Lake Eyasi is completely unprotected as it falls within community land. Lakes Empakai, Lagarja, Masek and the Momella are the only soda lakes located within highly-protected areas. A similar situation is also found for the soda lakes in Kenya. The two countries should therefore take responsibility for conserving all of their existing soda lakes, regardless of size, in order to ensure the continued survival of this near-threatened flamingo (and other waterbird species too). Any human activities that can be detrimental to the Rift Valley drainage system should be discouraged. There are no synchronised counts of lesser flamingos across all African countries where soda lakes could be an important habitat for this flamingo species. Thus, estimates of the lesser flamingo population for Africa overall

remain incomplete. We therefore suggest that continent-wide co-ordinated counts of lesser flamingos are important to improve our understanding of the spatial-temporal distribution and abundance of this flamingo species, and to assist in the planning of effective conservation action.

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The relevance of captive flamingos to meeting the four aims of the modern zoo

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Abstract

Flamingos are popular inhabitants of zoological collections around the world and are one of the most commonly-seen zoo species. The modern zoo has four aims: Conservation, education, research and recreation. Meeting each of these aims adds value to the animal collection and allows zoos to explain their wider work to their visitors and guests. As many zoos are reliant on gate entry and return visitation as their main source of income, the animal collection must maintain visitor interest and be engaging. The income from visitors is used by zoos to uphold their education, conservation and research programmes, and the way in which animals are displayed to the visitor helps to define educational strategies and impart relevant information on a species, its ecosystem, ecology and conservation value. As zoos move towards encouraging behaviour change in their visitors, stories on climate change and human impacts can be emphasised by using particular species within the animal collection to tell such stories. Iconic or eye-catching species can have a particular role in encouraging visitors to remember stories on human impacts and their effects on the planet. This paper outlines the ways in which zoo-housed flamingos can be utilised to emphasis the main roles of the modern zoo and provides a discussion of the relevance of zoo-housed birds to meeting the wider aims of the zoo (both in terms of its work with other zoos and that with the wild world).

Resumen

Los flamencos son habitantes populares de colecciones zoológicas de todo el mundo y son una de las especies de zoológicos más vistas. El zoológico moderno tiene cuatro objetivos: conservación, educación, investigación y recreación. Cumplir con cada uno de estos objetivos agrega valor a la colección de animales y permite a los zoológicos explicar su trabajo más amplio a sus visitantes e invitados. Como muchos zoológicos dependen de la recaudación de las entradas y de las visitas repetidas como su principal fuente de ingresos, la colección de animales debe mantener el interés del visitante y ser atractiva. Los zoológicos utilizan los ingresos de los visitantes para justificar sus programas de educación, conservación e investigación, y la forma en que se muestran los animales al visitante ayuda a definir estrategias educativas e imparte información relevante sobre una especie, su ecosistema, ecología y valor de conservación. A medida que los zoológicos fomentan el cambio de comportamiento en sus visitantes, la información sobre cambio climático y los impactos humanos se pueden enfatizar utilizando especies particulares dentro de la colección de animales para contar cuentos. Las especies icónicas o llamativas pueden tener un papel particular en recordar a los visitantes las historias sobre los impactos humanos y sus efectos en el planeta. Este trabajo describe las formas en que los flamencos albergados en zoológicos pueden utilizarse para enfatizar las funciones principales del zoológico moderno y proporciona una discusión sobre la relevancia de las aves alojadas en zoológicos para cumplir con los objetivos más amplios del zoológico (tanto en términos de su trabajo con otros zoológicos y con el mundo silvestre).

Résumé

Les flamants roses sont des oiseaux populaires dans les collections zoologiques du monde entier et font partie des espèces de zoo les plus fréquemment observées. Le zoo moderne a quatre objectifs : la conservation, l'éducation, la recherche et les loisirs. La réalisation de chacun de ces objectifs ajoute de la valeur à la collection zoologique et permet aux zoos d'expliquer les objectifs plus larges de leur travail aux visiteurs et invités. Étant donné que de nombreux zoos dépendent principalement des entrées et des visites répétées, la collection zoologique doit susciter l'intérêt du visiteur et être attrayante. Les revenus des visiteurs sont utilisés par les zoos pour soutenir leurs programmes d'éducation, de conservation et de recherche. La manière dont les animaux sont présentés au visiteur aide à définir des stratégies éducatives et à communiquer des informations pertinentes sur une espèce, son écosystème, son écologie et sa valeur de conservation. Au fur et à mesure que les zoos encouragent le changement de comportement de leurs visiteurs, les effets du changement climatique et les impacts de l'homme peuvent être soulignés en mettant certaines espèces au cœur d'histoires sensibilisant à ces enjeux. Les espèces emblématiques ou attractives peuvent jouer un rôle particulier en encourageant les visiteurs à se souvenir d'histoires marquantes sur les impacts de l'homme et leurs effets sur la planète. Cet article décrit les différentes manières d'utiliser les flamants roses hébergés dans les zoos pour souligner les rôles du zoo moderne et fournit une discussion sur la pertinence des oiseaux hébergés dans les zoos pour atteindre les objectifs plus larges du zoo (tant pour son travail avec d'autres zoos qu'avec le monde sauvage).

Introduction

The modern zoo's four aims of conservation, education, research and recreation (Fernandez et al., 2009) are seemingly well-understood by zoo professionals, and the successful fulfilment of these roles depends on the exhibition, display and interpretation of the zoo's animal collection. Flamingos are incredibly population captive subjects, with species360 currently stating nearly 20,500 birds residing in Zoological Information Management System (ZIMS)-registered zoos globally (species360, 2018). This ubiquitous presence in captivity explains, in part, why they are such a familiar and easy-to-identify species with the general public. As such, zoo flamingos can have a large role to play in explaining key conservation messages and be used for story telling of a zoo's educational or scientific goals.

Of the six extant flamingo species, four are of conservation concern (BirdLife International, 2016a, 2016b, 2016c, 2016d); whilst only one of these four (the Chilean flamingo, *Phoenicopterus chilensis*) is commonly seen in

zoos, as flamingos (as a whole) live in similar habitats, feed on similar food items, breed in the same way, and are affected by the same anthropogenic environmental changes those more familiar captive-held species can highlight the struggles faced by all flamingos species out in the wild.

The life history strategy of flamingos means that (for most of their range) they breed in huge flocks, producing large numbers of chicks at irregular intervals (Johnson & Cézilly, 2009). Changes to favoured environments, such as disturbance at a specific breeding lake (Johnson, 1997; Tebbs et al., 2013) or pollution (Hill et al., 2013) can have dramatic, negative impacts on the future growth or stability of a flamingo population. Adult flamingos can live for a long time (Rose, Croft, et al., 2014), therefore the impact of past negative events (such as disturbance, egg harvesting or hunting pressures) can manifest as future population fluctuations many years after the threat has been mitigated (BirdLife International, 2016b, 2016c, 2016d). A decline due to past poorer breeding events will only become apparent as adult flamingos die

without the same number of young birds around to replace them. Zoos flamingos are perfectly placed to bring to life the unique ecology of these species, and why they may need more of our attention in the wild.

Based on current species360 (2018) data, global zoo populations consist of c7400 greater flamingos (*P. roseus*), Least Concern, c6200 Caribbean flamingos (*P. ruber*) and c5600 Chilean flamingos. Both greater and Caribbean flamingos are deemed “Least Concern” (BirdLife International, 2016e, 2017) but this does not mean they are of lower value than the rarer species when it comes to their role in the zoo. These species could still be at risk from the same threats that have caused declines to Andean (*Phoenicoparrus andinus*), James’/puna (*P. jamesi*) and lesser (*Phoeniconaias minor*) flamingo populations, and so they can help focus attention on the

wider plight of flamingos globally whilst being managed in a sustainable fashion within zoological collections. This principle is well explained by the World Association of Zoos and Aquariums (WAZA) on the “Virtual zoo” section of its website: (WAZA, 2018b):

“The Andean flamingo is only rarely kept by zoos and if so, either for educational purposes, e.g. for demonstrating speciation within the flamingo family, or for scientific interest. As a matter of principle, flamingos are also excellent ambassador species for wetland conservation but this role could as well be taken on by the more common Chilean flamingo” (WAZA, 2018a).

The aim of this article is to provide examples of exactly how zoo flamingos are these excellent ambassadors for their wild cousins and for the wetlands they live in.

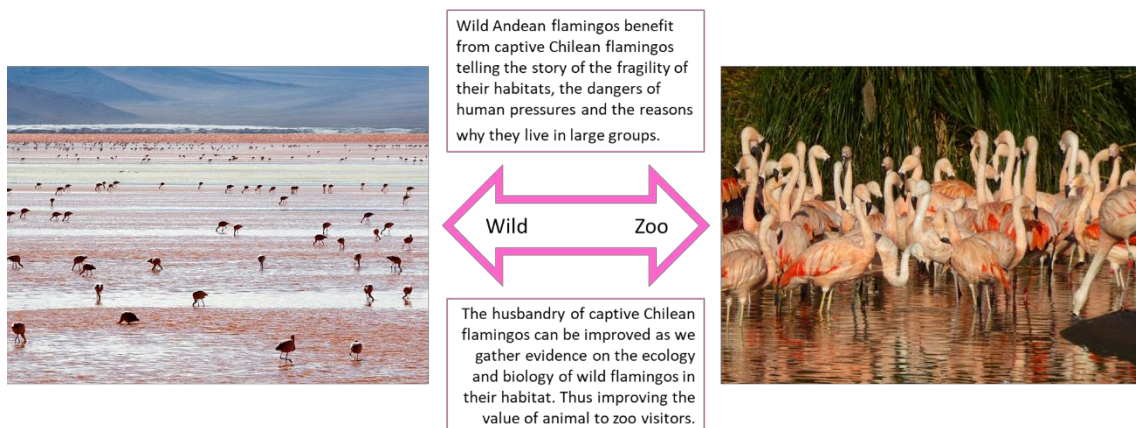


Figure 1: Some flamingo species are best managed and conserved out in their natural habitat (left) but zoo-housed birds (right) can play a part in promoting key aspects of flamingo ecology and natural history to make the wider public more aware of the unique ecosystem that flamingos inhabit and the threats it faces. Photo credits: Wikimedia Commons and P. Rose / WWF.

Conservation

Captive flamingos can play a relevant role in promoting wild world conservation initiatives or being directly involved in metapopulation management ideas related to the IUCN’s One Plan Approach to conservation (CBSG, 2015). Such ideas were broached at the 2014 International Flamingo Symposium, hosted by SeaWorld San Diego, for the lesser flamingo. With delegates discussing how an integrated

approach to the conservation of this species could benefit by including work on free-living and captive birds assimilated into an overall future strategy for the protection of this flamingo species. Lesser flamingos are less common in captivity than the three *Phoenicopterus* species, with 1183 individuals listed on ZIMS as of October 2018, but promotion of this bird’s biology and behaviour, and its specific ecosystem can be undertaken with other species, especially the

greater flamingo, which occurs alongside of the lesser flamingo in some parts of its range (Bartholomew & Pennyquick, 1973; Kumssa & Bekele, 2014; Woodworth et al., 1997).

Managed breeding of captive flamingos also has a role to play in the conservation of wild populations. Harvesting of wild birds for the ornamental bird trade, or to increase the size of captive populations is detrimental to the health and productivity of free-living flocks (Kear, 1987). By working together, and moving individuals between institutions, zoos can establish larger flocks and assist with each zoological collection achieving the minimum number of birds (40) that best increases the chance of flamingos nesting in captivity (Pickering et al., 1992).

Translocation of flamingos between zoos helps to keep captive populations sustainable. And interventions with a breeding flock to hand-rear chicks as part of a specific population management plan have been successful; for example the hand-rearing of greater flamingos at the Wildfowl & Wetlands Trust (WWT) Slimbridge centre for export to Auckland Zoo, New Zealand as the nucleus for a new breeding flock (Batty et al., 2006) has resulted in a colony of these birds now breeding and rearing their own chicks

(Auckland Zoo, 2018), and is the only breeding flamingo flock in Australasia.

Education

The flamingo's appearance has a great deal to lend to zoo education programmes (Figure 2). Eye-catching plumage, highly-obvious courtship displays, loud vocalisations and a unique way of feeding all fit into stories that explain evolution, animal behaviour, ecology and biodiversity conservation. The familiar one-legged posture of flamingos is an example of thermoregulation, weight-bearing and anatomical structures. Commonly observed in captive birds, this way of standing can be explained to human audiences via active participation ("how long can you stand on one leg for?") as well as by interpretation of the flamingo's skeletal system.

And the many human elements to their behaviour patterns, such as feeding their young on (crop) milk and using a crèche to keep their chicks safe whilst parents go and feed all add relatability to animal behaviour when explained to a human audience. The unique mud nest mounds of a flamingo, evolved to protect eggs and chicks from flooding and high ground temperatures can be scaled up to human-size as an interactive way of describing parental care and environmental pressures on behavioural evolution.



Figure 2: Flamingo biology and natural history explained in interactive signage at the Copenhagen Zoo. Photo credit: P. Rose.

Using flamingos to highlight the wider effects of climate change is something that can have benefits to all biodiversity and to

humans too. Flooding of coastal areas is an oft cited symptom of climate change that will affect where humans will be able to live in

future (McGranahan et al., 2007). Hydrological changes to the wetlands favoured by flamingos are known to influence their distribution and abundance (Ndetei & Muhandiki, 2005; Schagerl & Oduor, 2008). Further changes to water chemistry caused by climate change-inducing flooding could reduce suitable available habitat further. Therefore, explaining the global influence of climate change, using the flamingo as familiar and easy-to-comprehend example species is a way of zoos activity promoting pro-conservation behaviours and sustainable activities in their visitors. As an example, flamingos featured heavily in an exhibition at Chester Zoo (Figure 3), originally conceived by the Monterey Bay Aquarium, on the effects of climate change and how small changes can

make a big difference to reduce negative human pressures on the natural world (Harrison, 2014). Flamingos were the “poster boys” for this event, not the main feature. Stories about recycling, re-using and reducing your impact on the planet were centred around what can happen to the world around us if we live in an unsustainable manner. The flamingo’s colour, their eye-catching appearance and the play on words of hot pink (colour and temperature) help to emphasise the birds’ role in grabbing zoo visitors’ attentions, encouraging them to look around the exhibition and hopefully to engage with pro-sustainability behaviours by having a better take-home message on the long-term effects of climate change.



Figure 3: Examples of directional signage at Chester Zoo, UK, where visitors could engage with a “Hot Pink Flamingos” exhibition about the wider effects of climate change on people and on wildlife. As well as information signage about the benefits of recycling with the same “Hot Pink Flamingos” theme. Photo credit: A. Moss / Chester Zoo.

Research

Zoo flamingos can tell us a great deal about their wild counterparts (King, 2000) by allowing scientists to answer behavioural, ecological and evolutionary questions that may be tricky in wild flocks in inhospitable wetland habitats. Large flock sizes in zoos, with individual birds ringed for identification, means captive flamingos make excellent sample populations for behavioural research. Collaborations between academic institutions and zoological collections can bring many benefits, such as the sharing of resources and the development of projects that dissertation/thesis students can help collect data for (Fernandez & Timberlake, 2008; Hosey, 1997; Rose, Evans, et al., 2014). Such

projects then provide evidence for best practice captive care. Captive flamingos enable good quality science to be conducted in zoos that can be lacking when other species are studied; large sample sizes improve statistical validity and replication across zoos is easy as the same species of flamingo are commonly housed in similar conditions.

Several zoo organisations, such as the Association of British & Irish Wild Animal Keepers (ABWAK) actively runs workshops to engage flamingo keepers with the latest developments in flamingo science (Rose, Walls, et al., 2016) and zoo accrediting bodies like the British & Irish Association of Zoos and Aquariums (BIAZA) within whose organisational structure are various taxon

working groups (such as the Bird Working Group) that encourage the dissemination of evidence-based practice between keepers (BIAZA, 2018). The output of such meetings can be collated and presented as ways of changing how flamingos are cared for to promote good welfare, or to enhance husbandry so that birds experience similar beneficial conditions to those within a wild habitat, or for developing ways of providing environmental enrichment for flamingos to enhance natural activity patterns (Rose, Brereton, et al., 2016).

Recreation

Recent research has documented that out of the twenty most charismatic species as categorised by the general public, all except two are mammals (Albert et al., 2018) and zoo visitors do not always consider birds to be amongst the most exciting thing to see on their visit (Carr, 2016a). However, in spite of the small number of respondents that chose flamingo as their favourite animal at the zoo, Carr (2016a)'s survey shows that flamingos are the most popular of all birds with visitors

to this specific animal collection. And of a wider survey of zoo visitors on their "most wanted to see zoo animal" flamingos score third out of all birds after penguins and parrots (Carr, 2016b). Flamingos clearly have a lot to offer zoos in a way of capturing visitors' attention and increasing dwell time at an enclosure to allow for a wider or deeper educational message to be conveyed and taken away.

Recent research from Skibins et al. (2017) shows that whilst zoos have often tried to connect their visitors to conservation work via charismatic, mammalian megafauna as flagships, pro-conservation outcomes can be achieved by using other species too. Figure 4 clearly illustrates the attention-grabbing nature of flamingos with visitors to WWT centres that are nearly as popular as a highly charismatic mammal, the otter. Therefore, zoos should give more consideration to how they display and use their birds to increase dwell time and provide a biologically-relevant message to their visitors based on this evident popularity.



Figure 4: "Word cloud" produced from responses to the question "what was your favourite area of the centre?" for visitors across all nine WWT centres. Size of each word is an indication of number of responses (and hence popularity). This survey ran in August 2016 and shows that flamingo/flamingos/flamingoes were second only in popularity to otter exhibits. Reproduced with permission from WWT. Whilst the number of overall responses used to create the figure is unknown, the relative scale of the words against each other, coupled with the large number of descriptions that appear in the figure suggests a large number of responses that gives a true reflection of the frequency that flamingos were mentioned by WWT visitors.

Discussion and conclusions

This article has shown that flamingos are an excellent asset to the modern zoological collection and can uphold the key aims of the zoo in a variety of ways. Captive flamingos are highly-relevant ambassadors for wild birds and can tell the story of fragile wetland habitats. The public’s familiarity with them and their eye-catching appearance makes

flamingos easy to notice and their “crowd-pulling” potential can be used to facilitate engagement with topics such as climate change, sustainability and ecosystem health. Table 1 summarises some key points that define what value a zoo flamingo has to the aims of the modern zoo and suggests areas that zoos could consider when displaying and exhibiting their birds.

Table 1: Summary of how flamingos can promote the aims of the modern zoo.

<p>Conservation</p> <ul style="list-style-type: none"> - Promote the threats to wild birds. - Support wild-world conservation initiatives with fund raising events. - Ambassador birds: common flamingo species tell the story of rarer, more specialised wild cousins. 	<p>Education</p> <ul style="list-style-type: none"> - A good flagship for climate change and global biodiversity issues. - Excellent examples of selection, speciation, ecological niches and evolutionary biology. - Nesting behaviour, parenting actions and unipedal resting are easy to demonstrate to zoo visitors.
<p>Research</p> <ul style="list-style-type: none"> - Large study populations that can provide quality scientific data. - Easy replication across zoos. - Application of captive bird data to wild bird management and vice versa. 	<p>Recreation</p> <ul style="list-style-type: none"> - Evident popularity with zoo-going public. - Extend visitor dwell time by encouraging “participation” in flamingo behaviours. - A long-lifespan means adoption schemes can follow the same bird for many years.

Flamingos are intrinsically linked to their wider environment; their colour comes from their diet and they only breed successfully when habitats can support large flocks. There are clear messages here that can resound in the human world- diet is important to health and wellbeing and all of our actions combined can affect the planet and therefore influence where we, and other species can live. All zoos that house flamingos can promote the objectives of the Flamingo Specialist Group (FSG) on their signage and can direct their visitors to the FSG’s webpage and social media outlets.

Finally, we should remember that flamingos can be sensitive to disturbance around them;

whilst captive birds have been shown to not negatively change behaviour based on increases to visitor number (Rose et al., 2018), wild flamingos can be easily disturbed by the activities of people (Galicia & Baldassarre, 1997). Care should therefore be taken to display flamingos in a manner that allows them to move away from disturbance if needed. Wild flamingos however can generate income from ecotourism revenues (Galicia et al., 2018), illustrating the benefits of correctly managed flamingo watching. Here is further scope for zoos to link to *in situ* populations to help raise awareness of the world of the wild flamingo- watching flamingos in the zoo generates conservation

funding in a similar way that wild flamingo ecotourism can help protect wetlands and their wildlife too.

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Description of Caribbean flamingo nests in the Wildlife Refuge and Fishing Reserve Ciénaga Los Olivitos

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Abstract

The abundance and distribution of flamingos in Venezuela have been the main parameters chosen to measure their populations throughout the country, however some aspects of their reproductive biology are still unknown. To cover these aspects, more information is required, which can be obtained by taking into account the most important nesting site of flamingos in the country. In this study the nests were counted directly. Then to an estimation of 100 nests, measurements of the internal diameter, external diameter and height were taken. As a result, 8335 active and 1724 inactive nests were recorded, distributed over an area of 29700 m², with a density of 0.3 n/m². In addition, it was calculated that the average internal diameter of the nests was 23.62 cm, the external diameter was 31.96 cm, with an average height of 39.5 cm. From these data it can be expressed that one of the possible causes of decrease in the number of nests compared to these data reported previously, is that the refuge has been affected in recent years by periods of drought.

Resumen

La abundancia y distribución de flamencos en Venezuela han sido los principales parámetros elegidos para medir sus poblaciones en todo el país, sin embargo, todavía se desconocen algunos aspectos de su biología reproductiva. Para cubrir estos aspectos, se requiere más información, la cual puede obtenerse teniendo en cuenta el sitio de nidificación más importante de flamencos en el país. En este estudio los nidos fueron contados directamente. Luego, se tomaron medidas del diámetro interno, el diámetro externo y la altura a alrededor de 100 nidos. Como resultado, se registraron 8.335 nidos activos y 1.724 inactivos, distribuidos en un área de 29.700 m², con una densidad de 0,3 nidos / m². Además, se calculó que el diámetro interno promedio de los nidos era de 23,62 cm, el diámetro externo era de 31,96 cm, con una altura promedio de 39,5 cm. De estos datos se puede expresar que una de las posibles causas de la disminución en el número de nidos en comparación con datos informados anteriormente es que el refugio se ha visto afectado en los últimos años por períodos de sequía.

Résumé

L'abondance et la répartition des flamants des Caraïbes au Venezuela ont été les principaux paramètres choisis pour évaluer le statut de leurs populations dans tout le pays. Cependant, certains aspects de leur biologie de la reproduction restent méconnus. Pour couvrir ces aspects, des informations supplémentaires sont nécessaires. Elles ont pu être obtenues en étudiant le site de nidification le plus important du flamant des Caraïbes dans le pays. Dans cette étude, les nids ont été comptés directement. Ensuite, pour un échantillon de 100 nids, des mesures du diamètre interne, du diamètre externe et de la hauteur ont été prises. En conséquence, 8335 nids actifs et 1724 nids inactifs ont été mesurés, répartis sur une superficie de 29 700 m², avec une densité de 0,3 nid / m². Le

diamètre interne moyen des nids était de 23,62 cm et le diamètre externe de 31,96 cm, avec une hauteur moyenne de 39,5 cm. À partir de ces données, on peut dire que l'une des causes possibles de la diminution du nombre de nids par rapport aux données précédemment rapportées est que le refuge a été affecté ces dernières années par des périodes de sécheresse.

Introduction

In Venezuela, the Caribbean flamingo (*Phoenicopterus ruber*) reproduces annually in the Wildlife Refuge and Ciénaga de los Olivitos Fishing Reserve (R.F.S.R.P.C.L.O.), RAMSAR site of Venezuela. The first reproduction attempt of Caribbean flamenco was recorded between February and July 1987 (Casler et al., 1994) and for a decade (1987-1997) they did not successfully nest until 1998-1999. For this population, some aspects related to the reproductive event are unknown, such as the characteristics of the nest, the size of the nest, among others. The research conducted on the population of this flamingo species have been classified only in population censuses.

Aims and objectives

The objective of this work was to describe the characteristics of Caribbean flamingo nests in R.F.S.R.P.C.L.O in the post-reproductive period 2012.

Study area

R.F.S.R.P.C.L.O is located in the northeast of Zulia state, in the north-eastern end of Lake Maracaibo, Miranda municipality, 50 km from the city of Maracaibo (Pirela, 2000). The nesting area includes Los Corianos sector of the refuge, between the geographic coordinates of 10°52'12.6 "N and 71°23'48.5" W (Figure 1).

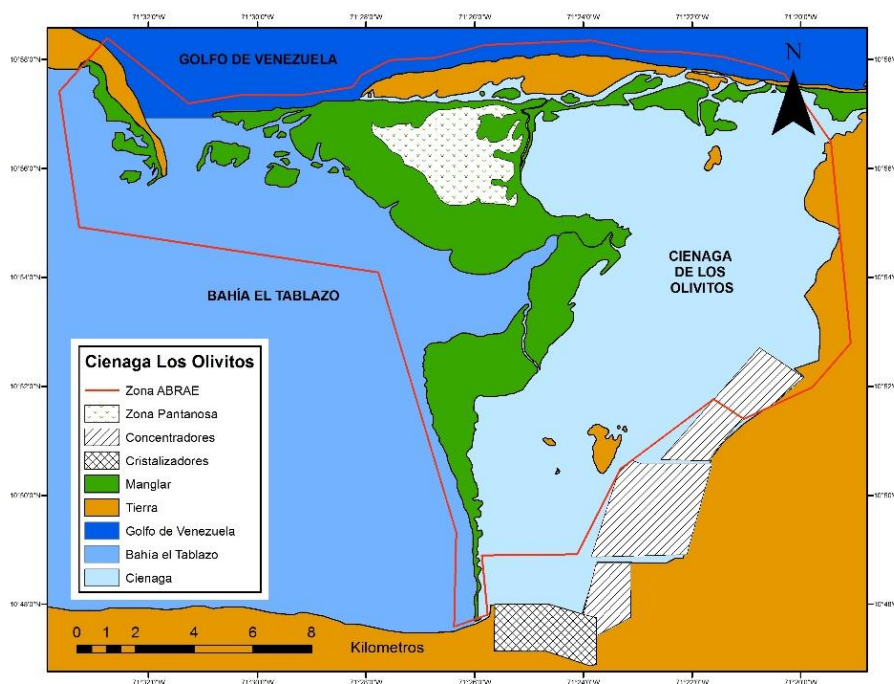


Figure 1: Map of Wildlife Refuge and Fishing Reserve Ciénaga Los Olivitos.

Methodology

During the months of reproductive inactivity (June, July and October 2013) direct counting of nests was carried out with the help of a

manual counter, following the methodology proposed by Sosa (1999), which consisted in the demarcation of the area in sections cordoned with nylon in order to subdivide it,

without specific measurements between the divisions, and each nest were punctured superficially with a wooden stake to prevent them from being counted more than once. Likewise, a sample of 100 nests was randomly selected to which the following morphological variables were measured with the help of a flexible tape measure (Figure 2):

Di: Internal diameter of the nest: from the opposite inner edges of the upper part of the nest.

De: External diameter of the nest: from the periphery of the upper part of the nest.

H: Nest height: includes the measurement of the existing depression between the nests, by the extraction of the material for its construction, up to the top of the nest.

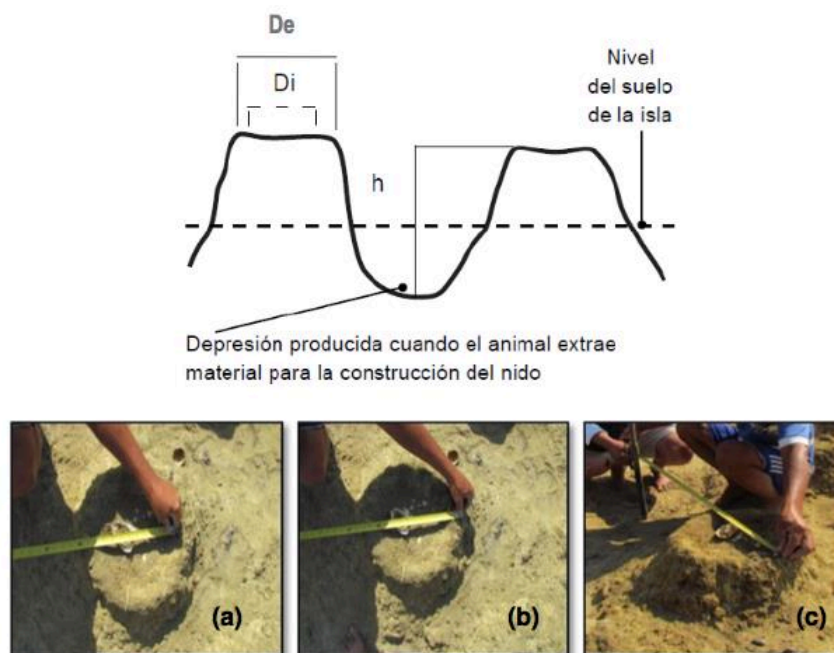


Figure 2: Measurements of the diameters: internal (a), external (b) and height (c) of the nests in the colony of Caribbean flamingos in Los Olivitos.

The density of the nests was calculated considering the area occupied by them, using the formula used by Sosa 2011: $D = \text{Number of nests} / \text{Area of nesting area}$

Results

The nesting area of the Caribbean flamingo in the refuge represents a well-defined area of 29,700 m² (2.9 ha). Usually the water partially floods the nesting area, having a height that

slightly exceeds the water level; however, in dry season this area remains completely dry. A total of 8335 active nests and a total of 1724 inactive nests were recorded (Figure 3), with a density of 0.3 n/m², (in an area of 29,700 m²). Remains of shells, feathers and eggs were observed without hatching in the upper part of some nests and in others as inclusions within the clay material, which probably would indicate that they were reconstructed (Figure 4).

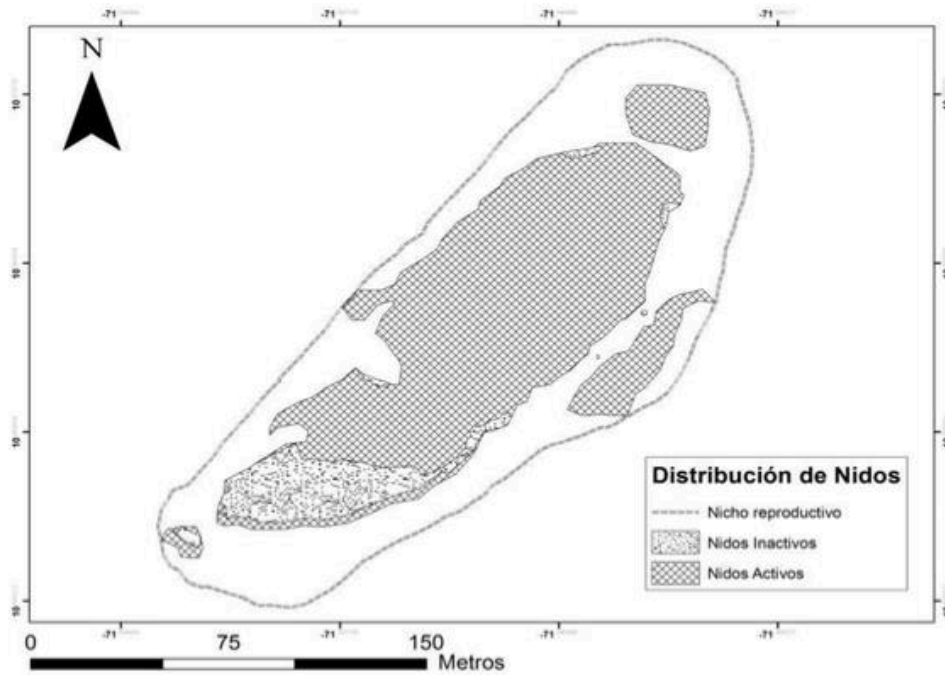


Figure 3: Nests and nesting area of the Caribbean flamingo colony in the Wildlife Refuge and Fishing Reserve Ciénaga Los Olivitos.



Figure 4: Principal component materials of nests and reconstructed nests of Caribbean flamingos in Los Olivitos.

The average height of the nests was 39.5 ± 7.52 cm with maximum values of 54 cm and with minimum values of 25.5 cm, the sample was classified into 5 intervals with length of 5 cm each, nests with height intervals between 37 and 42 cm accounted for 28% (28 nests), followed by intervals between 25.5 and 30.5 cm, as well as 31-36 cm with a percentage of

20% for each, for nests with a height interval between 43 and 48 cm they represented 19% and for nests between 49 and 54 cm the percentage was 11% (Figure 5). The category of height that concentrated the greatest number of nests was that of the intervals of 37 to 42 cm in height and that of least quantity was that of the intervals of 49 to 54 cm.

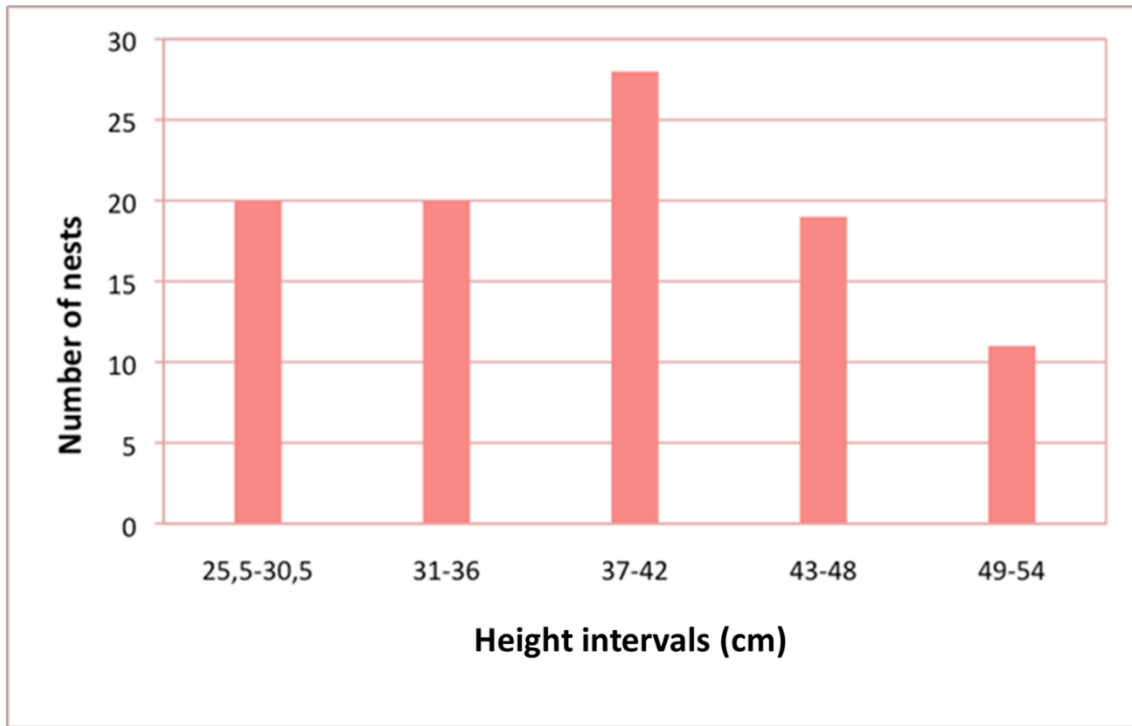


Figure 5: Intervals of height of the Caribbean flamingo nests in Los Olivitos.

The average diameter (cm) internal of the nests was 23.63 ± 2.47 , with maximum values of 34 cm and minimum values of 17 cm, of which 68% of the nests had an internal diameter between 23 and 28, followed by 29% nests with an interval between 17 and 22.5 and finally with only 3% nests with intervals

between 29 and 34 (Figure 6). The category of internal diameter that concentrated the greatest number of nests was that of the intervals of 23 to 28 cm, and the smallest quantity was that of the intervals of 29 to 34 cm.

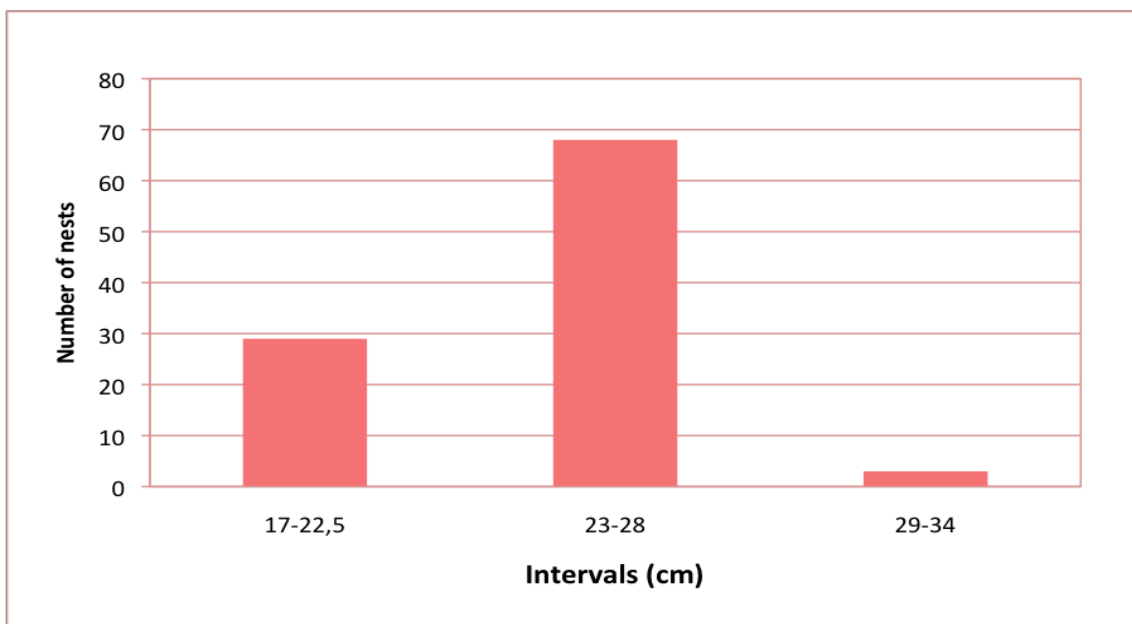


Figure 6: Intervals of internal diameter of the Caribbean flamingo nests in Los Olivitos.

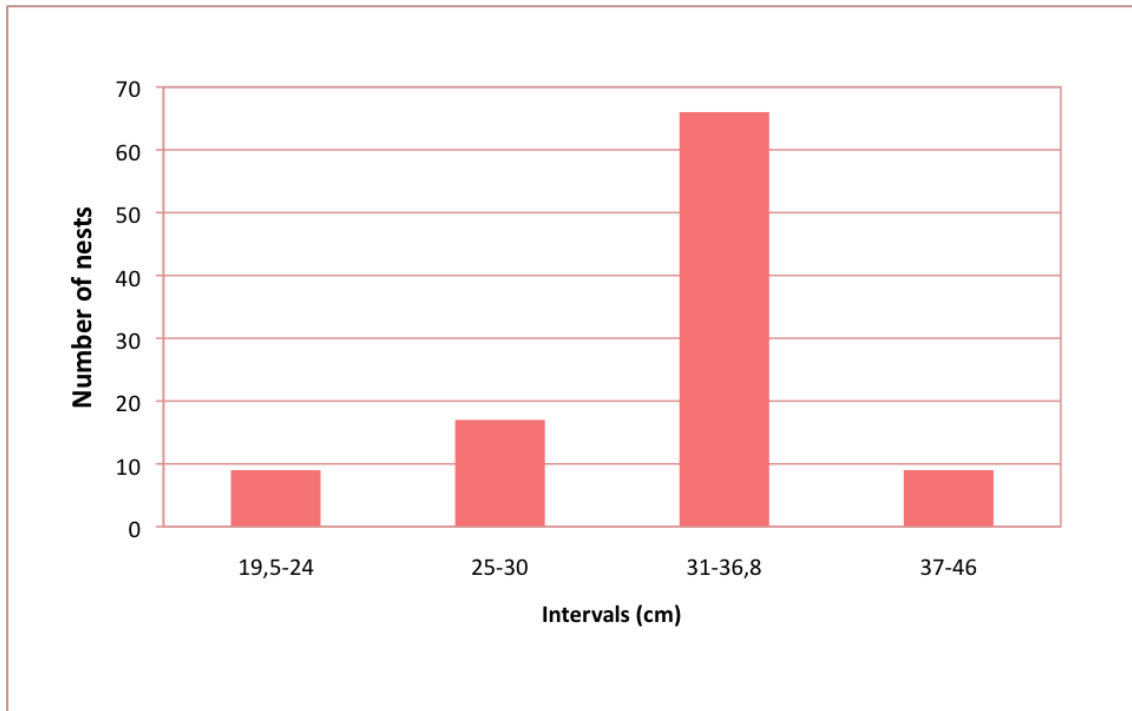


Figure 7: Intervals of external diameter of the Caribbean flamingo nests in Los Olivitos.

The external diameter of the nests had an average of 31.96 ± 4.18 , with maximum values of 46 cm and minimum values of 19.5 cm, of which 66% of the nests had diameters between 31 and 36, 8 cm, followed by a 17% interval between 25 and 30 cm; the intervals of 37 to 46 cm with 9% and finally the interval of 19.5 to 24 cm with 8% (Figure 7). The category of external diameter that

concentrated the greatest number of nests was that of the intervals of 31 to 36.8 cm, and the smallest quantity was that of the intervals of 19.5 to 24 cm and 37 to 46 cm. The average structure of Caribbean flamingo nests in Wildlife Refuge and Fishing Reserve Ciénaga Los Olivitos is 39.5 cm high, with an internal diameter of 23.63 cm and an external diameter of 31.96 cm (Figure 8).

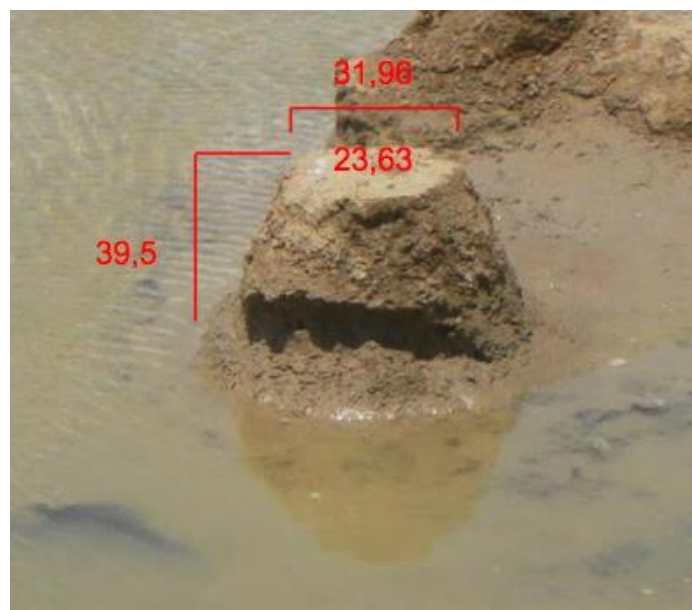


Figure 8: Average measurements of Caribbean flamingo nests in the Wildlife Refuge and Fishing Reserve Cienaga Los Olivitos.

Discussion

Sosa and Martín (2011), refer to the Laguna Llanquanelo Provincial Reserve in Argentina, which for the Chilean flamingo (*P. chilensis*), the number of nests found in this reserve exceeds those found in the refuge, with a total of 13,866 nests (all with signs of occupation), on an area of 10,800 m², smaller than that occupied by flamingos in Los Olivitos and an approximate density of nests of 1.3 n / m², the average of the external diameter of the nests (referred to these authors as internal diameter) was smaller with a value of 29.72 cm, while the average height of the nests was greater with 33.7 cm.

Porter and Forest (1974) refer to St. Lucia Lake in South Africa that for the greater flamingo (*P. roseus*), the approximate number of nests was 6000, the internal diameter of the nests was from 14.3 cm to 21 cm; the external diameter was 25.8 cm to 38.2 cm; the nest depression was 2 cm to 3.5 cm with a height of 1 cm to 8.7 cm. The variations between the dimensions of the nests between Chilean, greater and Caribbean flamingos is related to the size of the clutches, since usually the females of Caribbean flamingos only lay one egg, but in some nests of greater flamingos in South Africa, two eggs were found in the same nest (Porter and Forest, 1974). In turn, the size of the eggs varies according to the species; for Caribbean flamingos the average size of the eggs is 7.78 cm long and 4.41 cm wide and for greater flamingos was 8.9 cm long and 5.4 cm wide (Porter and Forest, 1974). The size of the nests is influenced by the size of the individuals of the species (it is positively correlated with the size of the species), since the individuals of the austral flamingo tend to be of smaller size than the individuals of the Caribbean flamingo and these in turn smaller than the individuals of the pink flamingo, which is the largest subspecies of flamingos of all (Bradford, 2014).

Conclusions

The nesting site of this flamingo species for the reproductive period 2013-2014, occupied an area of 2.9 ha, with a nest density of 0.3 n/m², the nesting population of Caribbean flamingos in Los Olivitos has 83% of active nests and 17% of inactive nests. The type of substrate that composes the nests is clay-loam, characteristic of flood-prone environments and the other elements consist of feathers, shells and inclusions of eggs without hatching, which indicate their reconstruction. The variation of the dimensions of the nests between Caribbean and Chilean flamingos is related to the size of the nest and that of the eggs, as well as the size between the species.

Acknowledgements

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Reintroduction of Caribbean flamingos to the Virgin Islands: Support systems for a successful colony on Necker Island, British Virgin Islands

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Flamingos of Necker Island: Sir Richard Branson's brilliant birds

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Abstract

Caribbean flamingos (*Phoenicopterus ruber*) were extirpated from the Virgin Islands in the 1960s. Reintroduction efforts, begun in the 1980s, have established two colonies in the British Virgin Islands: One on the historical breeding salt ponds of Anegada numbering approximately 200, and a second averaging 300 on the adapted natural salt ponds of Sir Richard Branson's private Necker Island as of the conclusion of this six-year study in 2014. Six roaming flamingos, part of the original reintroduction, make private Guana Island their home base. The Necker colony is free flying yet remains largely in situ year-round due to protected habitat, abundance of water, and supplemental feeding, allowing them to breed successfully since 2010. The reintroduction provides valuable information for restoration and reintroduction efforts in other areas where flamingos have historically been found but have not been observed of late.

Resumen

El flamencos caribeño (*Phoenicopterus ruber*) fue extirpados de las Islas Vírgenes en la década de 1960. Los esfuerzos de reintroducción, iniciados en la década de 1980, han establecido dos colonias en las Islas Vírgenes Británicas: una en las salinas de reproducción histórica de Anegada con aproximadamente 200 individuos, y otra con un promedio de 300 individuos en las salinas naturales de la Isla Necker, la isla privada de Sir Richard Branson, al concluir este estudio de seis años en 2014. Seis flamencos itinerantes, parte de la reintroducción original, se encuentran en Isla Guana. La colonia de Necker es de vuelo libre, pero permanece en gran parte durante todo el año debido al hábitat protegido, la abundancia de agua y la alimentación complementaria, lo que les permite reproducirse exitosamente desde 2010. Esta reintroducción proporciona información valiosa para los esfuerzos de restauración y reintroducción en otras áreas donde los flamencos se han encontrado históricamente pero no se han observado más recientemente.

Résumé

Les flamants roses des Caraïbes (*Phoenicopterus ruber*) ont disparu des îles Vierges dans les années 1960. Les efforts de réintroduction, entrepris dans les années 1980, ont permis, à la conclusion de cette étude en 2014, la création de deux colonies dans les îles Vierges britanniques: l'une sur les 200 étangs de reproduction historiques d'Anegada, et la seconde sur les étangs naturels adaptés de l'île privée Necker de Sir Richard Branson. Six flamants roses errants, faisant partie de la réintroduction initiale, ont élu domicile dans l'île privée de Guana. La colonie de Necker est constituée d'oiseaux libres de voler mais elle reste généralement occupée toute l'année en raison de la protection de son habitat, de son abondance en eau et de l'alimentation complémentaire, ce qui a permis la reproduction avec succès de l'espèce depuis 2010. La réintroduction fournit des informations précieuses pour les efforts de restauration et de réintroduction dans d'autres

sites fréquentés par les flamants dans le passé, mais où ils n'ont pas été observés récemment.

Introduction

Anegada is a flat, 39 km² limestone accretion island with a population of approximately 300 people and a tourist economy. A series of intermittent salt ponds dot the eastern end of the island. Seven, mostly interconnected and somewhat inaccessible salt ponds in excess of 460 hectares constitute one of the largest wetlands in the Lesser Antilles. (Scott and Carbonell, 1986; Jarecki, 2004). The Western Salt Ponds were declared a Ramsar protected wetland May 11, 1999. A coordinated effort in the 1980s led by Dr. James Lazell, president of The Conservation Agency, brought eight Caribbean flamingos reared at the Bermuda Aquarium, Museum and Zoo (BAMZ) to Dr. Henry Jarecki's private Guana Island to test the viability of a larger reintroduction. The test proved successful and in 1992, The Conservation Agency in collaboration with Dr. Numi Mitchell, James Conyers of BAMZ, Rondell Smith of Anegada, and the Guana

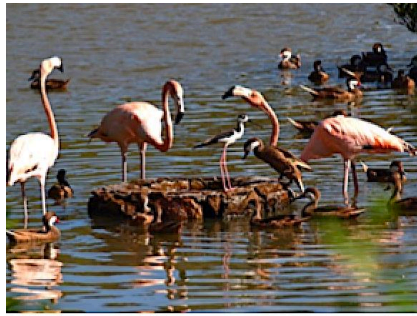
Flamingos and their habitats on Necker Island

Sir Richard's first two pairs of flamingos from the Camagüey, Cuba reserve arrived on Necker in January 2006 via private jet under the supervision of an ocean consultant and flamingo expert. Forty more flamingos arrived from Cuba in March 2007. The third and last shipment of 120 arrived in June 2009. The 120 flamingos were microchipped and lightly pinioned, allowing them limited flight. An effort was made to balance the sex ratio at 45% male and 55% female, all between two and three years of age (Bernier, 2011). Necker Island flamingos have two pond shape

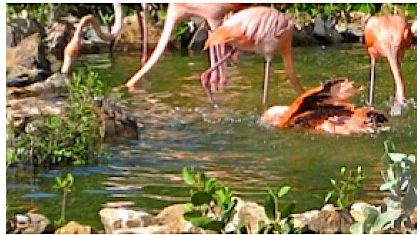
Island Wildlife Sanctuary released 22 flamingos on Anegada and eight on Guana Island. The British Virgin Islands National Parks Trust (NPT) is charged with monitoring the growing colony on Anegada.

On Necker Island, Sir Richard Branson's engineers expanded the two seasonal salt ponds on his 30 hectare home/resort island to a combined ~1 hectare size by 2014, plumbing them to the ocean with a levelling system of 8 cm PVC intake/outflow pipe in order drain excess water in hurricanes and heavy rains and add water in the dry season, thus maintaining valuable shoreline for flamingo propagation. Freshwater holds built into each pond supply clean drinking and bathing water for the birds. Both ponds are at most 0.8 metres deep with half-horsepower aerators in their centres to pull water up and return a fountain flow of 1.5 pounds of oxygen per hour around the clock (Robertson, 2011) to assist beneficial bacteria in processing waste.

choices; elliptical, mangrove encased "Long Pond" in the centre of the island, and the nearly round "Bali Hi Pond", with a sandy spit of northern shoreline and a mud lined inland southern shore (Figure 1). Long Pond was surveyed in 2011 to be 162 metres long and 53 metres wide, with a narrow neck at its western end. Bali Hi Pond runs 67 metres east/west and 56 metres north/south (Downing, 2011)- see Figure 2. Both ponds have since been slightly expanded; Long Pond's eastern sandy shore was dredged to create new areas of interest for waterbirds, and Bali Hi Pond had water added to achieve an optimal year-round level reaching just above mid-tibiotarsus at pond centre.



Long Pond Freshwater
Drinking & Bathing



Bali Hi Pond
Freshwater Hold



Figure 1: Caribbean flamingos on Necker Island using the two main ponds.



Bali Hi Pond
220' x 183'



Long Pond
532' x 173'



Figure 2: Geography of Necker Island's salt ponds.

Following the deaths of two flamingos from broken legs in August 2010, Sir Richard, his engineer and crew plucked forty to fifty backhoe buckets, at two tons of rock each, from the Bali Hi Pond surrounds where the flamingos mate and rear their chicks (Robertson, 2011) to provide flamingos with gentle pond bottoms and shorelines. The 10 metre height of the native black mangrove (*Avicennia germinans*) and sharp hillside rise

to the north, restricts flight from Long Pond to the fairway for take-off. Round Bali Hi Pond is open to the sea on the north. Remaining shores rise steeply and/or are covered with tall brush, cacti and palm trees. Flamingos may circle Bali Hi Pond in a spiral attempt at flight, but they cannot rise above its perimeters to leave the pond except to the north.

Bali Hi Pond, the flamingos' preferred nesting site, provides a clear view in all directions for protection, displays and socializing, with suitable mud and grass to build nests on protected shores. The bowl accommodates 300 flamingos comfortably. Dense scrub behind the nesting area enhances security. In the first two months of pre-mating displays the colony faces inland in wing salute. Perhaps they use the bowl's sound effects as echolocation to scan for danger, or to amplify their calls to ward off potential threats. The flamingos mate once they ascertain it is safe to do so and at that point, wing salutes either face the centre of the pond, or the nesting flamingos. Bali Hi Pond has one large, black mangrove tree dividing its southern shore in a 40/60, east/west split. This mangrove is an important physical feature for the colony and was wisely left intact when considering expanding available nesting area. It is a neighbourhood divider, social meeting place and source of fun for young birds to chase each other around. When in bloom, flamingos will eat the small sessile clusters of white flowers. Mangrove roots shelter crustaceans, fiddler and land crabs, and house white-cheeked pintails (*Anas bahamensis*). Dangling dark green seedpods entice flamingos to grab at the fruit for play. Tall grasses planted around the nesting shore secure the earth in

heavy rains and provide nest-building material. Flamingos strip and eat the grass seeds.

There are no significant predators on Necker Island. Laughing gulls (*Larus atricilla*) return annually for a summer breeding season and are suspected of absconding with weak flamingo chicks. Magnificent frigatebirds (*Fregata magnificens*) have hunted chicks on the pond, but barriers of tall, puffed out flamingos and sheltering trees thwarted their efforts. Human intrusion is the greatest threat, as it is on Anegada. Visitors to Necker are not allowed access to the nesting area. With reintroduction to outlying islands, people and their pets are potentially the greatest harassment risk to nesting flamingos.

Necker Island provides daily supplemental feedings of Extruded Flamingo Maintenance Diet tossed directly into Bali Hi Pond (Figure 3). In 2011 a nugget specially formulated to sink was used May into October during the annual migration of laughing gulls that are potential chick predators and a nuisance at feeding time. Since 2012, supplemental feeding during gull season switched to after dark when gulls return to their nests on the far side of the island.



Figure 3: Supplemental feeding of the flamingos on Necker Island.

Attempts to introduce brine shrimp have been largely unsuccessful. In March 2011 brine

shrimp cysts hatched near a water pipe after a rain but did not survive to the larval stage.

Necker's black mangrove thrives where salinity levels are highest, and brine shrimp cysts require fresh water to hatch. With the scarcity of brine shrimp in Virgin Island salt ponds, flamingos seek the abundant larvae of tiny salt pan fiddler crabs (*Uca burgersi*),

occasionally snacking on an adult near their nests (Figure 4). Necker's ponds were rimmed with these shore-cleaning, mangrove-aerating crustaceans. Flamingos grasp twigs and grasses beneath the water with their feet and run them through their bills to collect larvae.



Figure 4: Salt pan fiddler crabs.

Thick algal mats develop throughout both ponds. The mats are dispersed by flamingo foot traffic, and then eaten. Or they up-end into where a pond is deepest, bottoms up. Pintails collect the orts dredged up from the benthic layer by flamingos. An arcing swath of rich black mud supplying vitamins, minerals

and bacterial flora forms where the aeration fountain outflow ends on Bali Hi Pond (Figure 5). Male flamingos will march along the shore in pre-mating displays, females and immature flamingos feed in the mud for vitally important calcium derived from tiny decaying snail shells.



Figure 5: "Black mud crescent" in Bali Hi Pond.

In the first 19 years of reintroduction, the Anegada flamingo population grew from 22 to 187, with the NPT representative believing the ponds may have reached their self-sustained carrying capacity (Smith, 2011). Necker Island's introduced colony of 164 contributed

206 flamingos in its first eight years. The Guana Island birds are not known to have bred on Guana, but a male and female did find younger mates on Necker, with whom they produced healthy offspring (an example of which is shown in Figure 6).



Figure 6: Caribbean flamingo chick hatched on Necker Island.

Conclusions

Human occupation limits Caribbean flamingo nesting in former habitats. Installing flamingos on ponds they would not self-populate requires a diligent, continuous commitment to water quality testing and control. A mechanical system is needed to maintain water levels in seasonally-affected locations, and during drought conditions and torrential rains. Supplemental feeding will be needed to accommodate expanding populations anchored to limited resources. These support systems are expensive and impractical where electricity is an issue and private funds are not available.

Flamingos are long-lived and should not be pinioned in reintroduction; they will likely need to leave their location in a weather event (such the catastrophic hurricanes of 2017) or due to threats, or to relieve the pressure of eventual overpopulation. The Necker test ponds have demonstrated the limitations of flamingo flight from properly, topographically

landscaped breeding ponds. Narrow, mangrove-encased Long Pond allows flight only down its length. If the north shore of Bali Hi Pond were bermed and planted with vegetation 10 metres high or more, flamingos would find it difficult to lift out of deep water and gain enough speed to leave the pond. Should the flamingos need to leave their pond, trees or barriers could be removed.

A deep bowl-shaped habitat could eliminate pinioning and allow flamingos the space to congregate and breed in a manner most natural to them. The Necker and Anegada flamingos travel to neighbouring islands in both the US and British Virgin islands to the delight of the people living there (Figure 7). Then they leave and return, perhaps due to human over-exuberance at their sightings. The quality of the enhanced physical attributes and protection on Necker Island allows the hidden strength of the Necker colony, its ability to organise as a community, to flourish.



Figure 7: Flamingos in flight over Necker Island.

Acknowledgements

Sincere thanks go to Sir Richard Branson for allowing access to his treasured flamingos.

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Censo aéreo de flamencos en la aguna Mar Chiquita y bañados del Río Dulce, Córdoba, Argentina, en verano e invierno del año 2018

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Resumen

El extenso humedal conformado por la laguna Mar Chiquita y los bañados del río Dulce alberga tres de las seis especies de flamencos que existen en el mundo. En el marco del censo simultáneo de flamencos altoandinos (*Phoenicoparrus andinus* y *Phoenicoparrus jamesi*) y del proyecto de monitoreo del flamenco austral (*Phoenicopterus chilensis*) se desarrollaron los censos aéreos de verano y de invierno de 2018. Dada la magnitud de dicho humedal los monitoreos se realizan mediante censos aéreos. En el verano se contabilizaron 296.916 individuos de *P. chilensis*, 5.746 de *P. andinus* y 2.244 de *P. jamesi*. Durante el invierno se contabilizaron 258.650 individuos de *P. chilensis*, 11.607 de *P. andinus* y 4.277 de *P. jamesi*. Este humedal concentra la mayor cantidad de *P. chilensis* y es uno de los únicos sitios extra-andinos donde conviven las tres especies. Los datos colectados son de suma importancia para la justificación en el proyecto de creación del Parque Nacional Ansenuza.

Résumé

La vaste zone humide formée par le lac Mar Chiquita et le bassin de la rivière Dulce abrite trois des six espèces de flamants roses existant dans le monde. Dans le cadre du recensement simultané de flamants roses des Andes hautes (*Phoenicoparrus andinus* et *Phoenicoparrus jamesi*) et d'un projet de surveillance des flamants roses méridionaux (*Phoenicopterus chilensis*), nous avons effectué des relevés aériens d'été et d'hiver en 2018. En raison de la magnitude de cette zone humide, aérienne des enquêtes sont nécessaires pour couvrir les habitats connus des flamants. Au cours de l'enquête estivale, nous avons dénombré 296 916 flamants roses du Chili, 5 746 flamants roses des Andes et 2 244 flamants roses de la puna. Au cours de l'enquête hivernale, nous avons compté 258 650 flamants roses du Chili, 11 607 flamants roses des Andes et 4 277 flamants roses de la puna. Cette zone humide concentre le plus grand nombre de flamants roses du Chili et est l'un des seuls sites en dehors des Andes où les trois espèces coexistent. Les données collectées sont extrêmement importantes pour justifier la création du parc national d'Ansenuza.

Abstract

The extensive wetland formed by the Mar Chiquita lake and Dulce River basin is home to three of the six species of flamingos that exist in the world. In the framework of the simultaneous census of high-Andean flamingos (*Phoenicoparrus andinus* and *Phoenicoparrus jamesi*) and a monitoring project of Chilean flamingos (*Phoenicopterus chilensis*), we carried out summer and winter aerial surveys in 2018. Given the magnitude of this wetland, aerial surveys are necessary to cover known flamingo habitats. During

the summer survey, we counted 296,916 Chilean flamingos, 5,746 Andean flamingos, and 2,244 puna flamingos. During the winter survey we counted 258,650 Chilean flamingos, 11,607 Andean flamingos, and 4,277 puna flamingos. This wetland concentrates the highest number of Chilean flamingos and is one of the only sites outside the Andes where the three species coexist. These data collected are extremely important for the justification of the creation of the Ansenzuza National Park.

Introducción

En el cono sur de América del Sur habitan tres de las seis especies de flamencos que existen en el mundo: el flamenco austral (*Phoenicopterus chilensis*), la parina grande (*Phoenicoparrus andinus*) y la parina chica (*Phoenicoparrus jamesi*). El flamenco austral es la especie con mayor distribución (Bucher, 2006). Las otras dos especies, los flamencos altoandinos, presentan distribuciones más restringidas y hacen uso alternativo de humedales de altura y de tierras bajas. En verano utilizan lagos y salares altoandinos de Argentina, Bolivia, Chile y Perú para nidificar y alimentarse (Caziani et al. 2007). En invierno, cuando estos lagos se congelan, una alta proporción de sus poblaciones desciende a las planicies centrales de Argentina y la costa de Perú y al sur de Brasil (Caziani et al., 2007).

El Grupo de Conservación Flamencos Altoandinos (GCFA) es un grupo de trabajo internacional integrado por científicos y especialistas de Argentina, Bolivia, Chile y Perú, dedicado a la investigación y conservación de flamencos altoandinos y sus hábitats. En 2007, el GCFA lanzó el proyecto Red de Humedales de Importancia para la Conservación de Flamencos Altoandinos, apoyado por la Convención de Ramsar, concentrando las actividades del grupo en los sitios prioritarios de la Red. Actualmente, Natura International, una ONG dedicada a apoyar proyectos de creación de áreas protegidas y de conservación en Argentina, participa junto al GCFA en el monitoreo de las 3 especies de flamencos en la provincia de Salta y en la laguna Mar Chiquita y bañados del río Dulce. El extenso humedal conformado por la laguna Mar Chiquita y los bañados del río Dulce es parte de esta Red Humedales.

Este humedal, declarado sitio Ramsar y parte de la Red de humedales del hemisferio occidental (WHSRN), se encuentra ubicado al noreste de la provincia de Córdoba y sureste de la provincia de Santiago del Estero, Argentina. El área constituye la zona de mayor importancia para la concentración y nidificación del flamenco austral. Durante el invierno, también se encuentran grandes cantidades de parinas grandes y parinas chicas, aunque pueden observarse individuos durante todo el año (Torres, 2005).

Dada la gran movilidad de los flamencos altoandinos, los censos simultáneos se aplican para la obtención de parámetros poblacionales de estas especies, procurando cubrir su potencial área de distribución, es decir, los humedales altoandinos y los de tierras bajas de Argentina, Bolivia, Chile y Perú. Además, durante estos censos, es posible registrar las poblaciones y los sitios de nidificación del flamenco austral, así como las de otras aves que se encuentran en el humedal.

En el presente artículo se reportan los resultados de los censos de flamencos de verano y de invierno del 2018 en la laguna Mar Chiquita y bañados del río Dulce.

Área de Estudio

El área de censo se encuentra entre los 29.9° a 31.0° S y 62.1° a 63.4° O, al noreste de la provincia de Córdoba, Argentina (Figura 1). El humedal ocupa una superficie aproximada de 1 millón de hectáreas.

Metodología

En humedales de gran extensión como la laguna de Mar Chiquita y los bañados del río

Dulce, el muestreo más práctico para estimar la densidad poblacional de algunas especies es a través del censo aéreo. El conteo de flamencos se realizó siguiendo el protocolo establecido por el GCFA (Marconi et al., 2010), en los meses de marzo y julio de 2018 correspondientes a la temporada de verano e invierno, respectivamente. Este consistió en el conteo directo de individuos de *P. andinus*, *P. jamesi* y *P. chilensis*. El recuento de flamencos, se basó en la técnica del “aforo”, en esta técnica un censista experimentado estima de un golpe de vista el número de individuos que constituyen una bandada. Para ello, cuando el censista se enfrenta a una gran bandada, aísla mentalmente un subgrupo de aves, en el que puede contar casi todos los individuos uno por uno, para posteriormente extrapolar este subgrupo tantas veces como sea necesario

hasta englobar la totalidad del grupo a estimar. Durante los monitoreos también se recolectaron datos de otras aves del humedal.

Resultados

Se realizaron dos censos aéreos (Figura 1) en verano e invierno de 2018. El de verano, se realizó en 2.36 h con un recorrido total de 466.32 km y el de invierno, se realizó en 2.53 h con un recorrido total de 507.88 km.

La abundancia de las tres especies de flamencos censados en las dos temporadas del 2018 en la laguna Mar Chiquita y bañados de río Dulce, se muestran en la tabla 1 y en la figura 2. En la tabla 2 se presentan los datos del relevamiento de las otras especies de aves, muestreadas durante el censo.

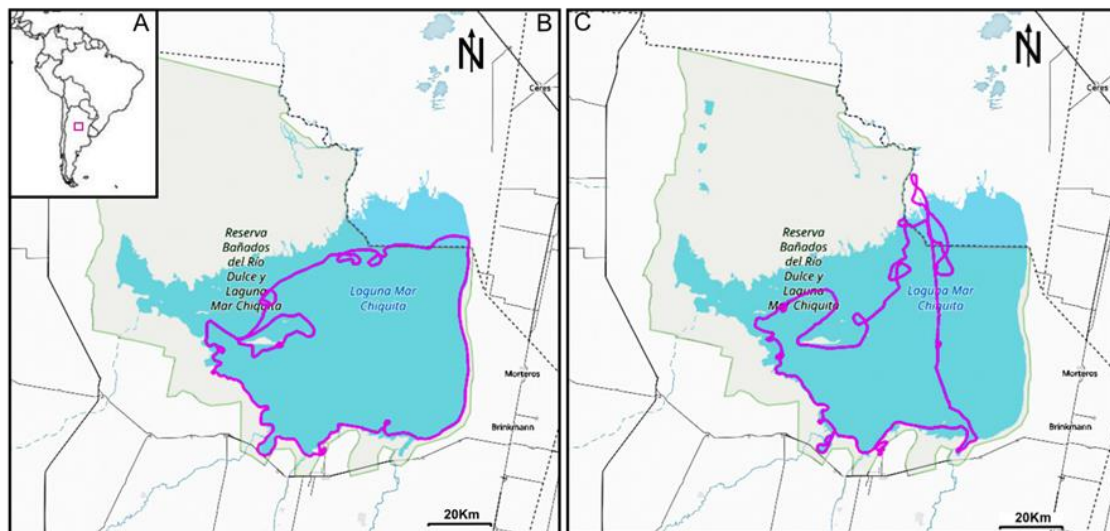


Figura 1: Recorrido realizado en los censos de flamencos en la laguna Mar Chiquita y bañados del río Dulce. (A) Ubicación global del sitio de muestreo; de color rosa se representa el recorrido del censo de verano (B) y el de invierno (C). De color celeste se representa el humedal y de color verde la Reserva Bañados del Río Dulce y Laguna Mar Chiquita de la provincia de Córdoba.

Tabla 1: Conteo final del censo aéreo de flamencos en verano y en invierno en la laguna Mar Chiquita y bañados del río Dulce.

Especie	Verano	Invierno
<i>P. chilensis</i>	296.916	258.650
<i>P. andinus</i>	5.746	11.607
<i>P. jamesi</i>	2.244	4.277

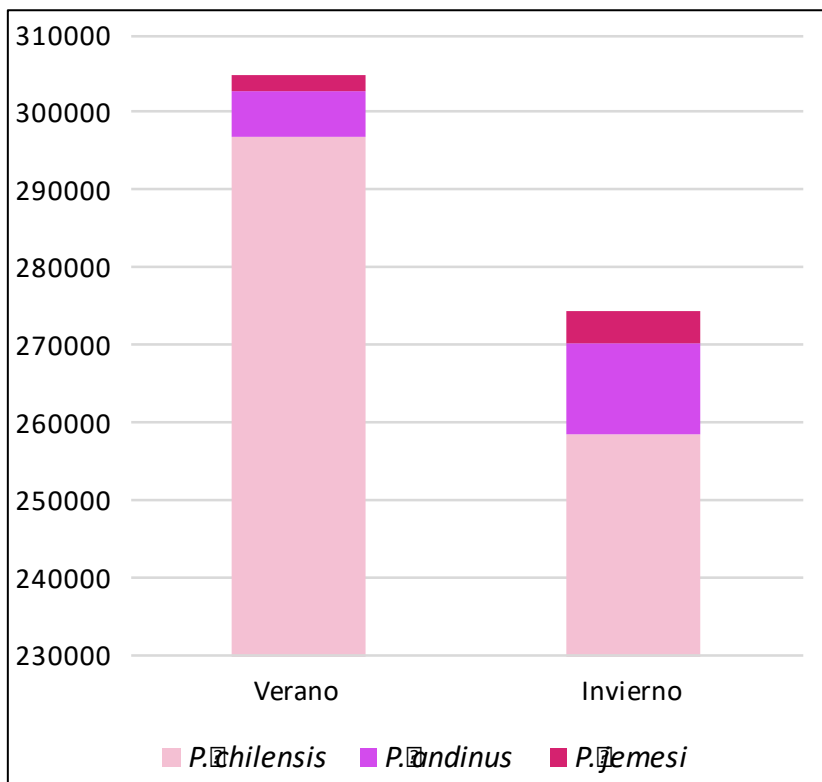


Figura 2: Gráfico de barra de la proporción de flamenco austral (*Phoenicopterus chilensis*), la parina grande (*Phoenicoparrus andinus*) y la parina chica (*Phoenicoparrus jamesi*) en los censos de verano e invierno de 2018.

Tabla 2: Cuento de aves, realizado durante censo aéreo de flamencos de verano e invierno en la laguna Mar Chiquita y bañados del río Dulce.

Especies	Verano	Invierno
<i>Anas bahamensis</i>		520
<i>Anas flavirostris</i>		21
<i>Anas georgica</i>		205
<i>Ardea alba</i>	10	
<i>Ardea cocoi</i>	1	40
<i>Calidris bairdii</i>	650	
<i>Caracara plancus</i>		13
<i>Chauna torquata</i>		4
<i>Chroicocephalus maculipennis</i>		950
<i>Ciconia ciconia</i>	4	
<i>Coscoroba coscoroba</i>	11970	5051

Tabla 2: Continuado

Especies	Verano	Invierno
<i>Cygnus melancoryphus</i>		5
<i>Egretta thula</i>	138	
<i>Falco peregrinus</i>	3	
<i>Fulica armillata</i>	3340	
<i>Himantopus mexicanus</i>		120
<i>Laridae spp</i>	17770	32
<i>Laridae spp.</i>		32
<i>Larus cirrocephalus</i>		420
<i>Phalacrocorax brasilianus</i>	6628	4120
<i>Phalaropus tricolor</i>	6000	40
<i>Phalcooenus chimango</i>		10
<i>Platalea ajaja</i>	97	12
<i>Plegadis chihi</i>		310
<i>Podiceps spp</i>	831	
<i>Rallidae spp</i>		3100
<i>Rynchops niger</i>	61	
<i>Venellus chilensis</i>		40

Discusión

Los censos aéreos de flamencos de verano y de invierno de 2018 en la laguna Mar Chiquita y bañados de río Dulce mostraron una dominancia de *P. chilensis* sobre las otras dos especies, principalmente en verano. En el censo de invierno puede observarse un aumento en las poblaciones de flamencos altoandinos, *P. andinus* y *P. jamesi*. Estos resultados concuerdan con los esperados, teniendo en cuenta que este humedal actúa como sitio de invernada, cuando los lagos altoandinos se congelan (Caziani et al., 2007). *P. jamesi* es la especie menos abundante (Figura 2) en ambas temporadas.

Históricamente los censos aéreos se consideraron una metodología poco exacta, ya que presentaban problemas inherentes a la velocidad y altura del avión, faja de muestreo cubierta, habilidad del observador, el piloto, condiciones del tiempo y hora del día que tienen efectos importantes sobre las estimaciones de los datos obtenidos (Marconi et al., 2010). Sin embargo, esta metodología parece ser la única manera práctica de estimar las poblaciones de especies en territorios extensos. Algunos métodos alternativos, como la utilización de drones o filmadoras de alta definición instaladas en la avioneta, podrían mejorar las estimaciones.

Este humedal no solo es uno de los sitios con mayor avifauna de la Argentina, sino que también sirve de sitio de invernada a muchas de las especies migratorias que vienen desde distintos lugares del hemisferio (Torres y Michelutti, 2006). Si bien el censo está enfocado principalmente en el conteo de las 3 especies de flamencos, a través de éste puede obtenerse información sobre las poblaciones de otras aves que habitan el humedal.

Al ser consideradas especies indicadoras, contar con estos números sumado a características intrínsecas del humedal a través del tiempo, ayudará a comprender patrones de movimiento, el estado en general de estas especies y del humedal. La información obtenida a partir del censo de flamencos, sirve de base para el actual Proyecto de creación del Parque Nacional Ansenusa. Este proyecto, busca colocar al humedal bajo la categoría de máxima protección legal que existe en Argentina, garantizando la conservación de este espectacular sitio, de las tres especies de flamencos y el resto de flora y fauna que coexisten en el lugar.

Agradecimientos

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SHORT REPORT

Counts of greater and lesser flamingos from Bagamoyo, Tanzania

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Abstract

The creation of shadow Ramsar sites requires regular visits to sites with the intention of recording 1% population criteria as often as possible and preferably for multiple species. During many visits to the salt pans north of Bagamoyo town on the coast of Tanzania I have counted numbers of Caspian terns and Madagascar pratincoles that qualify this site for Ramsar status. During each visit I count as many species as possible and both flamingos are relatively easy to count. I would never expect numbers of lesser flamingos to reach the minimum total of 20,000 but never the less the numbers can be used by researches looking at this species. Counts for greater flamingos are closer to 1% levels. These counts therefore contribute towards the creation of a shadow Ramsar site for the lower reaches of the Ruvu River where these salt pans are situated.

Resumen

La creación de sitios Ramsar en la sombra requiere visitas periódicas a los sitios con la intención de registrar el 1% de los criterios de población tan a menudo como sea posible y preferiblemente para múltiples especies. Durante muchas visitas a las salinas al norte de la ciudad de Bagamoyo, en la costa de Tanzania, he contado el número de gaviotines del Caspio y los pratincoles de Madagascar que califican este sitio para el estado de Ramsar. Durante cada visita cuento tantas especies como sea posible y ambos flamencos son relativamente fáciles de contar. Nunca esperaría que los números de los flamencos menores alcancen el mínimo total de 20,000, pero nunca menos los investigadores de esta especie pueden utilizar los números. Las cuentas para los flamencos mayores están más cerca de los niveles del 1%. Por lo tanto, estos conteos contribuyen a la creación de un sitio Ramsar en la sombra para los tramos más bajos del Río Ruvu, donde se encuentran estas salinas.

Résumé

La création de sites Ramsar ombrés nécessite des visites régulières sur les sites dans l'intention d'enregistrer le critère de population de 1% aussi souvent que possible et de préférence pour plusieurs espèces. Au cours de nombreuses visites dans les salines au nord de la ville de Bagamoyo, sur la côte tanzanienne, j'ai dénombré le nombre de sternes caspiennes et de pratincoles de Madagascar qui confère à ce site le statut de Ramsar. Lors de chaque visite, je compte le plus grand nombre d'espèces possible et les deux flamants sont relativement faciles à compter. Je ne m'attendrais jamais à ce que le nombre minimum de flamants roses atteigne le total minimum de 20 000 mais les chiffres peuvent néanmoins être utilisés par les chercheurs qui étudient cette espèce. Le nombre de flamants roses est plus proche de 1%. Ces décomptes contribuent donc à la création d'un site Ramsar ombré pour les tronçons inférieurs de la Rivière Ruvu où se trouvent ces salines.

Introduction

Tanzania hosts the only significant breeding site for lesser flamingos in East Africa on the flats of Lake Natron in the Rift Valley. Greater flamingos also breed "in numbers" at Lake Natron and also at other Rift valley lakes in Tanzania and Kenya. Counting flamingos on the large Rift Valley lakes is fraught with difficulties. Lake Natron is 52 km long and 12-15 km wide and with surface temperatures exceeding 50°C the heat haze is such that usually all one can see from the shore is a pink haze and often not even that. Lake Manyara to the south is 38 km long and 8-12 km wide. Lake Eyasi, 50 km west of Lake Manyara, is 68 km long and 10-16 km wide.

There are a further nine flamingo lakes in Tanzania (Baker & Baker 2002) and others in the Kenyan and Ethiopian Rift. It is well understood by anyone living near these lakes and from satellite tagging studies in recent decades that this population is constantly on the move, especially as water levels and salinity levels fluctuate between seasons. During every night of the year at least some birds from this population are in the air. The only way to accurately count these populations would be by a co-ordinated aerial count over a single day. This has often been talked about but has never been attempted. Counts of lesser flamingo in the literature vary between two and four million, but all of these have been estimated. Single site counts of one million birds can only ever be, at best, an educated guess (Baker 1997; Mlingwa & Baker 2007).

Mundkur & Nagy (2012) give 1% thresholds of 20,000 for lesser flamingos. For greater flamingos a population of 35,000 for the East African has been used for many years but I have long considered this too low, especially given a count of 101,518 from 7 teams in January 1995 (Baker 1997). The latest estimate from Wetlands International (2018) gives a population of 80,000 to 120,000 and a 1% criteria of 980 birds. From 2011 through to 2016 water bird counts were conducted

irregularly on commercial salt pans on the northern outskirts of Bagamoyo (6.4242 S - 38.8927 E).

Evaluation

Four-figure numbers of lesser flamingos were only counted three times; 1,000 on the 14th June 2015 (personal observation), 1,940 on the 15th December 2013 (Jude Jarvis) and 2,000 on the 5th July 2015 (personal observation). Even if the low thousands (maximum) that occasionally occur on the salt works at Saadani National Park are included the coastal population is unlikely to ever reach 10,000 birds.

For greater flamingos on the Bagamoyo salt pans a count of 350 has been exceeded five times. Three-hundred and sixty-two birds on 18th September 2011, 374 birds on 24th May 2015, 375 on 16th December 2012, 400 birds on 2nd January 2015 and 900 birds on 7th March 2014 (all personal observations).

The following monthly visits have been made to this site and other less frequented sites in the same general area. Maximum counts for greater flamingo are given for each month.

- January: 15 counts (maximum of 400 birds).
- February: Seven counts (maximum of <100 birds).
- March: 10 counts (maximum of 900 birds).
- April: Eight counts (maximum of 225 birds).
- May: Five counts (maximum of 374 birds).
- June: Six counts (maximum of 225 birds).
- July: Five counts (maximum of 128 birds).
- August: Four counts (maximum of 163 birds).

- September: Six counts (maximum of 362 birds).
- October: Six counts (maximum of 180 birds).
- November: Five counts (maximum of 180 birds).
- December: Five counts (maximum of 375 birds).

Conclusions

Satellite tracking studies of lesser flamingos in the Kenyan Rift Valley have shown considerable movement within the Rift Valley but no birds moving to the coast or to Lake Rukwa in southern Tanzania. (Childress et al. 2007). Data from three greater flamingos fitted with satellite tracking on lakes in northern Tanzania showed that one moved to the Kenyan coast for several months, and another for a shorter stay (Baker et al. 2007). Present knowledge suggests that the Bagamoyo salt works almost qualify as a shadow Ramsar site for greater flamingos and that the salt pans within Saadani National Park may also qualify. It is strongly encouraged that future satellite tracking is undertaken at peripheral sites such as coastal salt works and lagoons in Kenya and Tanzania and at Lake Rukwa, which might be a transit point for movement between the Rift Valley and southern Africa.

Acknowledgements

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SHORT REPORT

Five years of “Pink Celebration for Flamingos” at Porbandar, Gujarat, India

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Abstract

Porbandar is a coastal town in Gujarat state of India and well known as Surkhabi nagri in local Gujarati language where Surkhab means flamingo and nagri means city. Each year about 40,000 Lesser and about 9000 Greater Flamingos are recorded from wetlands of Porbandar during the Asian Waterbird Census by the Mokarsagar Wetland Conservation Committee. April to June is the courtship time for these birds and to celebrate this event MWCC has organised “Pink Celebration” since 2014 to raise the public’s awareness of the flamingos. The objectives of the event are i) to spread awareness on the importance of flamingos as a flagship wetland species, ii) to educate participants on the importance of wetlands, iii) to strengthen and develop knowledge and iv) to highlight unique wetlands of Porbandar for legal protection. MWCC has collaborated with various NGOs during these five years and have always received positive response from participants. “Pink Celebration” is a two-day event. Various expert talks and a field trip occur on Day One, with a morning field trip on the second day with the event ending after lunch. MWCC would like to organise a joint meeting of any Indian FSG members alongside of “Pink Celebration” in the future.

Resumen

Porbandar es una ciudad costera en el estado de Gujarat de la India y conocida como Surkhabi nagri en el idioma local de Gujarati, donde Surkhab significa flamenco y nagri significa ciudad. Cada año, cerca de 40,000 flamencos menores y alrededor de 9000 flamencos mayores se registran en los humedales de Porbandar durante el Censo Asiático de Aves Acuáticas por el Comité de Conservación de Humedales de Mokarsagar. De abril a junio es el momento del cortejo para estas aves y para celebrar este evento, MWCC ha organizado la "Celebración Rosada" desde 2014 para despertar la conciencia del público sobre los flamencos. Los objetivos del evento son: i) difundir la conciencia sobre la importancia de los flamencos como una especie emblemática de humedales, ii) educar a los participantes sobre la importancia de los humedales, iii) fortalecer y desarrollar el conocimiento y iv) destacar humedales únicos de Porbandar para protección legal. MWCC ha colaborado con varias ONG durante estos cinco años y siempre ha recibido una respuesta positiva de los participantes. "Celebración Rosa" es un evento de dos días. Se realizan varias charlas de expertos y un viaje de campo el primer día, mientras que el segundo día se realiza un viaje de estudio por la mañana y el evento finaliza después del almuerzo. MWCC desea organizar una reunión conjunta de cualquier miembro de la FSG de la India junto con la "Celebración Rosa" en el futuro.

Résumé

Porbandar est une ville côtière de l'état du Gujarat en Inde et bien connue sous le nom de Surkhabi nagri en langue gujarati locale, où Surkhab signifie flamant et nagri signifie ville. Chaque année, environ 40 000 flamands nains et environ 9 000 flamants roses sont répertoriés dans les zones humides de Porbandar lors du recensement des oiseaux d'eau asiatiques par le Comité de conservation des zones humides de Mokarsagar. Avril à juin

est la période de parade nuptiale pour ces oiseaux et pour célébrer cet événement, le MWCC organise «Pink Celebration» depuis 2014 pour sensibiliser le public aux flamants roses. Les objectifs de la manifestation sont i) de sensibiliser le public à l'importance des flamants roses en tant qu'espèce phare des zones humides, ii) de sensibiliser les participants à l'importance des zones humides, iii) de renforcer et développer les connaissances et iv) de mettre en valeur les zones humides uniques de Porbandar pour Protection légale. MWCC a collaboré avec diverses ONG au cours de ces cinq années et a toujours reçu une réponse positive des participants. «Pink Celebration» est un événement de deux jours. Divers exposés d'experts et une visite de terrain ont lieu le premier jour, avec une visite de terrain le matin la deuxième journée, l'événement se terminant après le déjeuner. Le MWCC aimerait organiser une réunion commune de tous les membres indiens du FSG à côté de la «célébration rose» à l'avenir.

Introduction

Mokarsagar Wetland Conservation Committee (MWCC) is a registered non-profit organisation, which aims to recognise Mokarsagar wetland complex of Porbandar. The objective of the committee is to develop a comprehensive management framework for Porbandar's Wetlands of international importance and to maintain the ecological character of Mokarsagar through conservation and wise use. Mokarsagar Wetland Complex (21.565433 N, 69.764237 E) is the largest wetland of Porbandar district of Gujarat and spread across more than 100 km². The wetland complex supports more than 200,000 waterbirds annually and therefore is shortlisted as a potential Ramsar site as well as Biodiversity Heritage Site. Recently, a Public Interest Litigation has been also filed in Gujarat High court to declare it as a wildlife sanctuary.

Porbandar is a coastal town in Gujarat state of India. Porbandar is well known as the birthplace of Mahatma Gandhi, the father of the Nation. Porbandar is also known as "Surkhabi nagri" in local Gujarati language where Surkhab means flamingo and nagri means city. In fact, a real flamingo city is situated in Rann of Kutch, Gujarat and Porbandar is called Surkhabi nagri due to its flamingos which count in thousands. Flamingos are found in abundance in the

vicinity of the human habitation in Porbandar. Each year about 40000 lesser and about 9000 greater flamingos are recorded from wetlands at Porbandar during the Asian Waterbird Census by MWCC. April to June is the courtship time for these birds and they perform the most stunning and beautiful courtship dance during this period wherein. A tightly-packed group of flamingo march and perform synchronized movements to attract a partner (Figure 1).

To celebrate this spectacular natural history event, MWCC in collaboration with various organisations have organised "Pink Celebration" every May since 2014 to raise public awareness of the flamingos. The number of participants rises every year and in 2018 we expected almost 80 to 90 participants from all over India. Every year, the event receives positive feedback from the participants, Forest Department, NGOs, conservationists, wildlife photographers and nature lovers of Gujarat. The Pink Celebration provides an excellent opportunity to observe the courtship dance of the lesser flamingos at Chhaya Wetland of Porbandar. With more than 10,000 flamingos congregating in one place, this is an unforgettable experience, so back in 2013, MWCC decided to organise an annual event for wetlands and flamingos. Mr Kishore Joshi, Co-founder, MWCC coined the term Pink Celebration for this event.



Figure 1: Breeding display of lesser flamingos at Porbandar wetlands. Photo credit: D. Vargiya.

Objectives of Pink Celebration

1. To spread awareness on the importance of flamingos as a flagship wetland species.
2. To educate participants on the importance of wetlands.
3. To strengthen and develop knowledge.
4. To highlight the unique wetlands of Porbandar for legal protection.

Schedule of the event

Every year, Pink Celebration is a two-day event. Day One starts with participants' registration and inauguration in the presence of local NGOs, Forests Department staff and participants. Inauguration is followed by expert talk with PowerPoint presentations on various aspects of birds and wetlands. Every year, a talk on the courtship dance of the flamingos is given by the author of this paper.

In the evening, a field trip to nearby wetland is organised. As an example, the talks organised in 2017 were: Courtship dance of Flamingos by Dhaval Vargiya; Bird call and its importance by Viral Joshi; Bird ringing by Dr Dishant Parasharya; Birds of Gujarat and key species identification by Ashok Mashru; E-birding by Dr Gaurang Bagda. Day Two starts with a field trip to Chhaya wetland for a flamingo watch and ends after lunch. We make sure that all participants watch and understand the steps involved in the flamingo's courtship dance. Chhaya wetland where flamingos are seen in their thousands is surrounded by human habitation, industry and other infrastructure. To raise awareness among locals, MWCC volunteers freely distributed a brochure about the flamingo's courtship dance to every home in the vicinity on World Environment Day 2016 (Figure 2).



Figure 2: Flamingo brochure distributed among locals on World Environment Day 2016. Photo credit: S. Sadrani.

Funding for Pink Celebration

Gujarat Council on Science and Technology (GUJCOST), Government of Gujarat, partially funded the event in 2014. Pink Celebration 2016 was fully funded by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), India, so there were no participation fees. It was jointly organized by Gujarat Forest Department, GIZ, India, and Mokarsagar Wetland Conservation Committee, Porbandar. It was a programme under Indo-German Biodiversity Programme's Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas in India (CMPA) project.

In 2015, 2017 and 2018, we raised 40% funding through participation fees and remaining expense were fulfilled by MWCC. We keep minimum participation fees of 500 Indian Rupees (around \$7) and provide a binocular bag or messenger bag, notebook, pen, all meals for the two days, brochures on the birds and an article on the wetlands of Porbandar. MWCC would like to organise a joint meeting of any Indian FSG members alongside of "Pink Celebration" in the future.

SHORT REPORT

New record of Chilean flamingos nesting at Laguna Las Tunas in south-eastern Córdoba province, Argentina

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Abstract

In July 2018, we observed a nesting colony of more than 4,000 Chilean flamingo (*Phoenicopterus chilensis*) nests from that year's breeding season at Laguna Las Tunas, a saline lake in central Argentina. This is the first record of a nesting colony at this site in 65 years. Nesting occurred after three El Niño years, characterized by high annual precipitation leading to high water levels, greater flooded surface area, and lower salinity. Our finding confirms the importance of Laguna Las Tunas for flamingo conservation in the context of the shifting mosaic of flamingo habitat availability at a regional scale.

Resumen

En julio de 2018, observamos una colonia de nidificación de más de 4.000 nidos de flamenco austral (*Phoenicopterus chilensis*) de la temporada de reproducción de ese año en Laguna Las Tunas, un lago salino en el centro de Argentina. Este es el primer registro de una colonia de nidificación en este sitio en 65 años. La anidación ocurrió después de tres años de El Niño, caracterizada por una alta precipitación anual que conduce a altos niveles de agua, mayor área de superficie inundada y menor salinidad. Nuestra observación confirma la importancia de Laguna Las Tunas para la conservación de flamencos en el contexto del mosaico cambiante de disponibilidad de hábitat para flamencos a escala regional.

Résumé

En juillet 2018, nous avons observé une colonie de reproduction de plus de 4 000 nids de flamants du Chili (*Phoenicopterus chilensis*) datant de la saison de reproduction de l'année à Laguna Las Tunas, un lac salin du centre de l'Argentine. Il s'agit de la première mention d'une colonie de nidification sur ce site en 65 ans. La nidification a eu lieu après trois années d'El Niño, caractérisées par de fortes précipitations annuelles entraînant des niveaux d'eau élevés, une plus grande surface inondée et une salinité moindre. Notre découverte confirme l'importance de la lagune de Las Tunas pour la conservation des flamants roses dans le contexte d'une mosaïque changeante de la disponibilité de l'habitat des flamants roses à l'échelle régionale.

Introduction

The western Pampas region of Argentina, extending across south eastern Córdoba province and southwestern Santa Fe province, is a large plain dotted with numerous brackish wetlands that are high biodiversity areas immersed within an agricultural matrix (Bilenca & Miñarro 2004, Romano & Brandolin 2017). Many of these wetlands are known for their high bird abundance and diversity, and for their importance for Andean (*Phoenicoparrus andinus*) and Chilean flamingo conservation (Di Giacomo 2005, Romano et al. 2008, 2009, Brandolin et al. 2011, Romano & Brandolin 2017). There are wide variations in habitat and landscape conditions among these wetlands (Romano et al. 2008, Brandolin & Blendinger 2016), and some of them are affected by artificial drainage channels (Brandolin et al. 2013). There are also large annual variations in the water level due to the effects of the El Niño Southern Oscillation (ENSO) (Romano et al. 2005, 2009).

Laguna Las Tunas, located in south eastern Córdoba province (33° 43'S, 62° 32'W, 112 m a.s.l., Figure 1), is a large saline, shallow wetland surrounded by saltmarshes and shrublands that supports a high bird diversity and is a wintering site for flamingos (Fundación Vida Silvestre 1992, Romano et al. 2008, 2009, 2011, Brandolin & Ávalos 2010, Bilenca & Miñarro 2004, Brandolin et al. 2016a, b). Chilean flamingos are common and have been recorded throughout the year at this lowland wetland, whereas Andean flamingos are rarely recorded (Fundación Vida Silvestre 1992, Romano et al. 2008, 2009, 2011, Brandolin & Ávalos 2010). At present, Laguna Las Tunas forms part of the Pampa de las Lagunas wetland complex, which is within the Network of Wetlands of Importance for Flamingo Conservation (Marconi & Sureda 2008) and is a private protected area (Reserva Natural Las Tunas; Crespo Guerrero & Peyroti 2016).

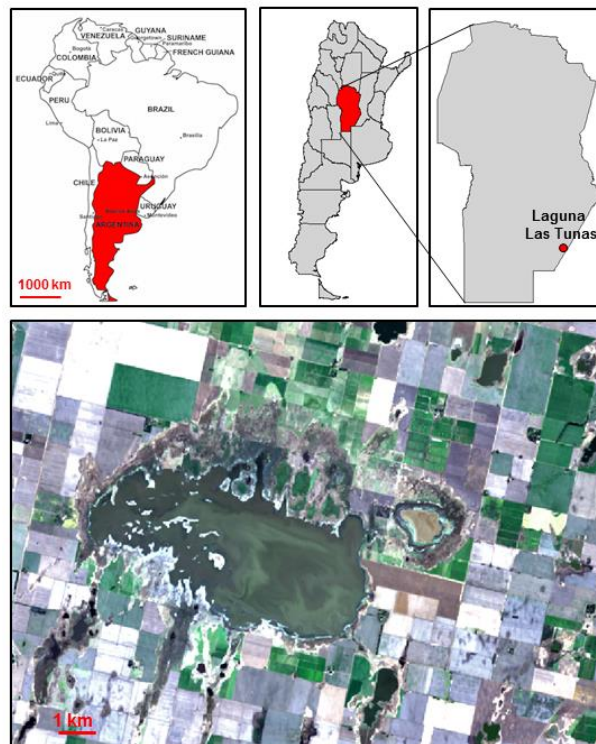


Figure 1: Location of Laguna Las Tunas in central Argentina in the southeast of Córdoba province.

Evaluation

In July 2018, we visited Laguna Las Tunas during a systematic winter survey for flamingos carried out at the Pampa de Las Lagunas wetland complex by the *Grupo de Conservación Flamencos Altoandinos-GCFA* (High Andes Flamingo Conservation Group), and recorded 3,251 Chilean flamingos and 20 waterbird species, including ducks, coots, grebes, swans, and herons, among others. Given the large size of the wetland, we counted from four observation points. At the farthest point to the west, we observed a

large group of juvenile Chilean flamingos and many shapes that resembled flamingo nests on islands in the distance. We approached the islets with kayaks and confirmed the presence of Chilean flamingo nests from the previous breeding season (February-March 2018). In three islets we counted more than 4,000 nests (Figure 2). Nearby we observed groups of juvenile flamingos that were not disturbed by our presence (Figure 3). In a previous visit during the summer (March 2018), we had estimated 8,000 Chilean flamingo adults at this site (M. Romano, pers. obs.).



Figure 2: Panoramic views of nesting colony in one of the islets at Laguna Las Tunas (Córdoba province, Argentina).



Figure 3: Juvenile Chilean flamingos near the nesting colony in one of the islets at Laguna Las Tunas (Córdoba province, Argentina).

We interviewed the owners of the land where Laguna Las Tunas is located, who told us there

were no records of flamingo nesting at the site for the past 65 years. The owners did recall

observing flamingo nests when they were young, in the 1950s. Several factors determine the establishment of flamingo nesting colonies, including availability of food resources; appropriate water levels that create islets that allow the nests to be isolated from terrestrial predators; low human disturbance; as well as the number of individuals. Flamingos breed opportunistically in response to local favourable conditions (McCulloch et al. 2003, Childress et al. 2004, Amat et al. 2005, Johnson & Cézilly 2007), and it appears that conditions were met last summer at Laguna Las Tunas.

Our finding confirms that Laguna Las Tunas is important for flamingo conservation in the context of the shifting mosaic of flamingo habitat availability at a regional scale. The Pampa de las Lagunas wetland complex had been affected by El Niño events for three consecutive years (2016-2018), characterized by high annual precipitation leading to high

water levels and greater flooded surface area, and lower salinity.

In contrast to other sites where flamingo abundance has been reduced (Romano et al. 2017), flamingo abundance at Laguna Las Tunas was higher during the last three winters compared to previous years (Table 1). These differences in flamingo abundance between lakes of the Pampa de las Lagunas wetland complex could be associated with the reduction in water salinity which changed Lagunas Las Tunas from a saline to a brackish lake and may have generated better conditions to sustain a greater abundance of individuals. Additionally, the change in weather affected the configuration of the landscape, with the appearance of isolated islands that could be used as nesting sites. The availability of mudflats and reduced salinity was also found to positively influence flamingo nesting in Mar Chiquita, a large wetland in central Córdoba province (Bucher et al. 2000)

Table 1: Abundance of Chilean Flamingos recorded at Lagunas Las Tunas from 2009 to 2018.

Winter	Abundance	Winter	Abundance
2009	1	2014	256
2010	313	2015	432
2011	611	2016	4000
2012	45	2017	7500
2013	1261	2018	3251

Conclusions

A wide range of animal populations respond to seasonal variations in habitat and large-scale climatic fluctuations such as those linked to the ENSO, NAO (North Atlantic Oscillation), and PDO (Pacific Decadal Oscillation) (Schmidt et al. 2014), including flamingos (Bechet & Johnson 2007). Flamingos move from one wetland to another and use the different available sites in an alternative and complementary way in response to habitat

fluctuations (Romano et al. 2009). The importance of conserving a network of wetlands becomes especially important in the context of global climate change which will induce variations in the occurrence, structure, pattern, process, and function of wetlands (Junk et al. 2013). Persistence of flamingo populations in the western Pampas of Argentina will depend on ensuring a spatially and temporally dynamic wetland complex that provides the necessary resources for flamingos throughout their life cycle.

Acknowledgements

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SHORT REPORT

Notes on the behavioural response to artificial nest mounds as environmental enrichment for greater flamingos

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Abstract

Artificial nest mounds were made to facilitate environmental enrichment and record the behavioural responses from 73 greater flamingos (*Phoenicopterus roseus*) through direct and indirect observation in Dubai Safari Park (Dubai, UAE). In a three-month observation period, significant interactions expressed through breeding behaviours from the birds were evident. These results support the effectiveness of the enrichment in stimulating a natural behaviour, as well as the potential reproductive management of this species.

Resumen

Se hicieron montículos de nidos artificiales para facilitar el enriquecimiento ambiental y registrar las respuestas de comportamiento en 73 flamencos rosados (*Phoenicopterus roseus*) a través de la observación directa e indirecta en Dubai Safari Park (Dubai, EAU). En un período de observación de tres meses, las interacciones significativas expresadas a través de los comportamientos de reproducción de las aves fueron evidentes. Estos resultados apoyan la efectividad del enriquecimiento en la estimulación de un comportamiento natural, así como el manejo reproductivo potencial de esta especie.

Résumé

Des nids artificiels ont été fabriqués afin de rendre l'environnement plus incitatif à la reproduction et enregistrer les réponses comportementales de 73 flamants roses (*Phoenicopterus roseus*) par observation directe et indirecte au Dubai Safari Park (Dubai, Émirats Arabes Unis). Au cours d'une période d'observation de trois mois, les interactions significatives exprimées par les comportements de reproduction des oiseaux étaient évidentes. Ces résultats confirment l'efficacité de l'enrichissement de l'environnement par la construction de nids dans la stimulation d'un comportement naturel, ainsi que le potentiel de gestion de la reproduction de cette espèce.

Introduction

The greater flamingo (*Phoenicopterus roseus*) the largest and is the most widespread species in the flamingo family. This water bird species mainly lives in saline or alkaline bodies in typically large congregations. Breeding cycle is well known and is dependent on appropriate available nesting site, temperature, and

rainfall (Brown et al. 2005), wild populations were recorded to have their breeding periods extending from March-July and specifically May- June in Southwest Asia & South Asia with Iran population sample (Childress et al. 2008). Captive populations on the other hand are highly dependent on various important factors such as flock size, sex ratio and age structure, the design of the enclosure and nest

site, manipulations of water levels and diet (Duplaix-Hall and Kear 1975). The flamingos on exhibit in Dubai Safari Park consist of sexually matured and two-year-old individuals together in a large open wading pool. The institution houses 34:39 greater flamingos, with occasional wild specimens joining the group. Currently, some individuals in the collection have been observed to show breeding behaviours; as small nest bowls were observed on the flat ground, courtship display, and vocalizations were also evident. Captive-bred Chilean flamingos at WWT Slimbridge first breed between two and ten years of age (Pickering 1992). Providing an enriching environment for animals to exhibit natural behaviours is an important task in any zoological institution. To further stimulate these natural behaviours, Nest mounds are placed in the island as well as mud substrate is added into the surrounding area of the mound to aid the process. A wet mix of sand and mud is necessary for nest building, at San Antonio Zoo a sand/clay mix is used in 50%

sand : 50% clay mix is used (Brown et al. 2005). The aim of this work was to provide an environmental enrichment program and breeding opportunities for the birds by the addition of appropriate substrates to uphold good behavioural health of the flamingos.

Evaluation

A total of ten nest mounds were prepared from concrete bases with sizes extending to about 20 cm tall and 38 cm for base diameter, these are placed in the nesting island as close as 1.5 metres to each other (Figure 1). A shallow depression is formed on the top as nest bowl. The exhibit is also fitted with sprinkler to allow muddy surrounding where the birds gather additional material for the mound and regulate temperature of the area. An excess of nest mounds are provided to allow the flamingos to select their own nests, and these nest are labelled accordingly for proper recording of observations.



Figure 1: Flock gathered around the nest island with mounds.

Nest cameras with motion sensors were used to assist data collection, recordings including photos and videos on site helped well in obtaining observations during dawn and dusk period where keepers are not present (Figure 2). Results from these observations on months

August-October showed a positive response of the flock to the enrichment provided, breeding behaviours such as nest building, clearing and picking up debris, stamping and sitting on the mounds were evident (Figures 3 and 4).



Figure 2: A pair of greater flamingo performing nest building (taken by an IR camera).

Although no egg laying behaviour was noted, some females have been recorded to be sitting on the nest while with males guarding their territory. These observed behavioural

interactions expressed by the flamingos could possibly lead to establishing pairings in the group and stimulating breeding success in the future.

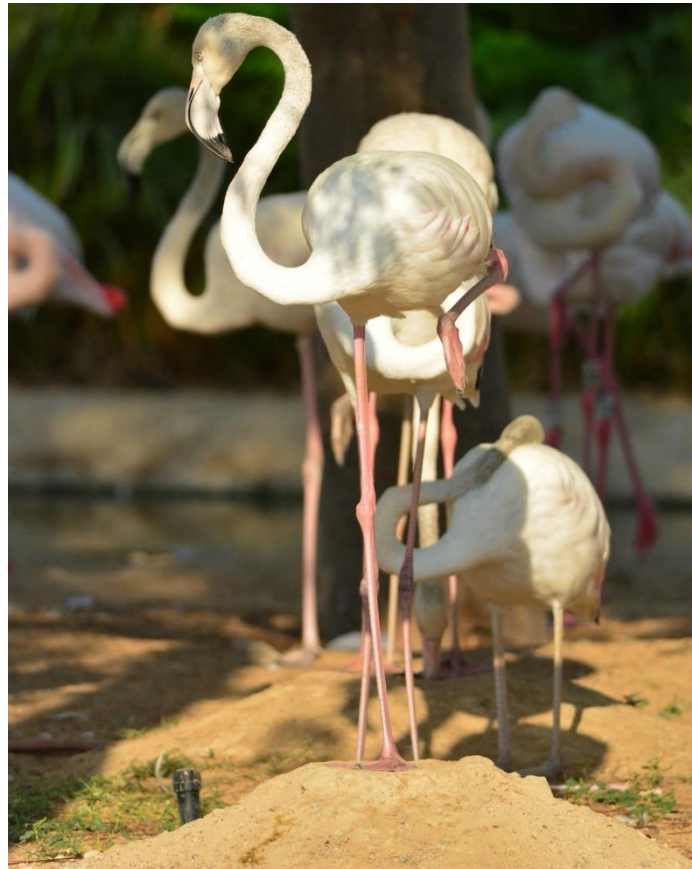


Figure 3: A young female greater flamingo standing on top of a “starter” nest.



Figure 4: Juvenile flamingos “prepping up” the nest sites.

Conclusions

Positive behavioural responses from these greater flamingos towards the nest mounds are evident in these records. Therefore, stimulation of natural behaviours that are beneficial to the general welfare of the flock was provided. These behaviours could also suggest possible initiation of pair bonding, and eventual reproductive success, which would help in creating a sustainable flock and contribute to the management of this species in captivity.

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SHORT REPORT

Towards understanding lesser flamingo unpredictability in East Africa; what might cause crashes of their major food item at a lake?

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Abstract

Very little is known about the factors which can cause collapse of the major food of lesser flamingos (*Phoeniconaias minor*) in East Africa, the cyanobacterium phytoplankton *Arthrospira* spp. (usually *A. fusiformis*), although it is known that collapses frequently occur. One possibility is infection by virus - cyanophages. We examined water samples from Lake Bogoria and found many different viruses, which could be infectious. We studied the density of *Arthrospira* spp. over a two-year period and found a crash in July 2016 at the same time as the maximum density of Virus-Like Particles (VLP) in the lake water; we achieved break-up of laboratory cultures grown in July 2016 lake water. We were not able to identify the virus with genetic analysis, but this is the first time that population collapse through cyanophage infection has been indicated.

Resumen

Se sabe muy poco acerca de los factores que pueden causar el colapso del alimento principal de los flamencos menores (*Phoeniconaias minor*) en África oriental, el fitoplancton de cianobacterias *Arthrospira* spp. (usualmente *A. fusiformis*), aunque se sabe que frecuentemente ocurren colapsos. Una posibilidad es la infección por virus - cianófagos. Examinamos muestras de agua del lago Bogoria y encontramos muchos virus diferentes, que podrían ser infecciosos. Se estudió la densidad de *Arthrospira* spp. durante un período de dos años y encontró un choque en julio de 2016 al mismo tiempo que la densidad máxima de partículas similares a virus (VLP) en el agua del lago; Logramos la ruptura de cultivos de laboratorio cultivados en julio de 2016 en el agua del lago. No pudimos identificar el virus con el análisis genético, pero esta es la primera vez que se indica el colapso de la población a través de la infección por cianófagos.

Résumé

On sait très peu de choses sur les facteurs susceptibles de provoquer l'effondrement de l'aliment principal des flamants nain (*Phoeniconaias minor*) en Afrique de l'Est, le phytoplancton à cyanobactérie *Arthrospira* spp. (généralement *A. fusiformis*), bien qu'il soit connu que des effondrements se produisent fréquemment. Une possibilité est

l'infection par des virus - les cyanophages. Nous avons examiné des échantillons d'eau du lac Bogoria et découvert de nombreux virus pouvant être infectieux. Nous avons étudié la densité d'*Arthrospira spp.* sur une période de deux ans et nous avons trouvé un crash en juillet 2016 en même temps que la densité maximale de particules pseudo-virales (VLP) dans l'eau du lac; nous avons réussi à reproduire des effondrements dans les cultures au laboratoire de souches cultivées en juillet 2016 de l'eau du lac. Nous n'avons pas été en mesure d'identifier le virus par analyse génétique, mais c'est la première fois qu'un effondrement de population dû à une infection à cyanophage est mise en évidence.

Introduction

The population of lesser flamingos (*Phoeniconaias minor*) in East Africa is believed to be about 1.5 million (Childress et al., 2007), but there has never been a concurrent census in all of the main countries where the species occurs (Ethiopia, Kenya, Tanzania). In the one country where regular counts are undertaken, Kenya, through the annual Nature Kenya/Kenya Wildlife Services water bird count, there have been major differences in the numbers counted on the accessible alkaline-soda lakes (Lakes Bogoria, Nakuru, Elementeita and Magadi) from one year to the next, between a few thousands and over a million (Owino et al., 2001). These dramatic differences have led some ornithologists to believe that the population is under decline (Harper et al., 2016). So too have irregular occurrences of population mortalities (Kock et al., 1999; Ndetei and Muhandiki, 2005; Straubinger-Gansberger et al., 2014).

Those that occurred in August through mid-November 1993 (Kock et al., 1999) and with several hundred thousand deaths in 2000-1 (Harper et al., 2003), were caused by infectious disease at the high densities of birds that can be stressed after flying in from a lake with declining food (Oaks et al., 2006; Harper et al., 2016). Irregular reproductive events in this species, at a single location - Lake Natron, Tanzania - are enough to replace such mortalities and, most recently (July 2018), over 1.1 million birds were counted at Lake Bogoria alone, so the likelihood of a serious population decline is low.

One main reason the birds are unpredictable in their occurrences is that the number of lakes where they can feed is few and their main food, the cyanobacteria *Arthrospira spp.* (commonly called Spirulina) that dominates the plankton can wax and wane unpredictably (Kaggwa et al., 2013). Some of the fluctuations in *Arthrospira* abundance are caused by hydrology, because many of the alkaline-soda lakes are shallow, fluctuating in area and in water chemistry considerably according to the rains (Krienitz and Kotut, 2010; Kaggwa et al., 2013). In others, such as Lake Bogoria, a moderately deep lake whose water chemistry is very consistent, crashes in the *Arthrospira* population cannot, at present, be explained by environmental factors (Harper et al., 2003). Large crashes have occurred in the past with locally-dramatic results; a crash in August-September 2004 (Tebbs et al., 2013), for example resulted in the complete de-oxygenation of the lake through decomposition of the cyanobacterial mass, producing an odour that was detected up to 10 miles away and resulting in a total departure of lesser flamingoes (William Kimosop, pers comm.).

Evaluation

Cyanophage causes of *Arthrospira* bloom collapse

We have been examining the possibility that *Arthrospira* crashes are caused by infection of viruses, cyanophages, because it has no grazers other than lesser flamingoes. It is known that cyanophages can control populations of marine cyanobacteria, but freshwater species have rarely been investigated before. We found that potential

agents were abundant in appropriately filtered water, examined under the Transmission Electron Microscope, TEM, (Figure 1). The dominant types of phage were

of the Siphoviridae, Myoviridae and Podoviridae morphotype, however a large proportion of indistinguishable phage types mean further anatomical study is necessary.



Figure 1: TEM photographs of virus from Lake Bogoria water. Scale bar = 100 nm; a) Myoviridae morphotype, b) Siphoviridae morphotype, c) Podoviridae morphotype

We collected weekly samples of water from the lake between May 2015 and May 2017, examining *Arthrospira* density and biomass as chlorophyll 'a'. The lake was very high during this period, due to heavy rains that have been experienced in this central part of the Eastern Rift Valley since 2010, and its conductivity was initially about half the 'normal' level due to dilution but rising from 41 - 66 mScm⁻¹ over this period, compared with the usual concentration of 72-77 mScm⁻¹. The biomass of *Arthrospira* was also lower than it had been recorded by several authors during the late 20th-early 21st Century, fluctuating between 180 and 350 µgL⁻¹, but gradually increasing with over the two years (Figure 2). We found that a population crash occurred in July 2016, which was coincident with Virus Like Particles (VLPs) resembling phages in the lake water detected at their highest density (1.755 x 10⁸ mL⁻¹) over the study period, using a 'NanoSight' instrument. VLPs were also detected within *Arthrospira* sections under Electron Microscopy. Laboratory cultures of *Arthrospira* in lake water with VLPs showed

symptoms of phage infection within 5 days of incubation, as appearance of visible fragments of filaments, which indicate of host cell lysis.

Conclusions

We have tried to identify the viruses using genetic sequencing, but metagenomic results showed no hit with any in the Genbank Database, most likely because the database does not contain enough virus genomes at present. The greatest probability is that the cyanophages may be RNA viruses ((+) ssRNA virus), based on their size. A natural progression of our study would thus be to perform RNA sequencing, as this would provide definitive evidence as to whether the particles observed in the lake water are phages, also those seen within *Arthrospira*, or just natural cell inclusions. Nevertheless, we provide here and will shortly publish in full, the first evidence that an *Arthrospira* population crash in one lake could well have been caused by virus infection.

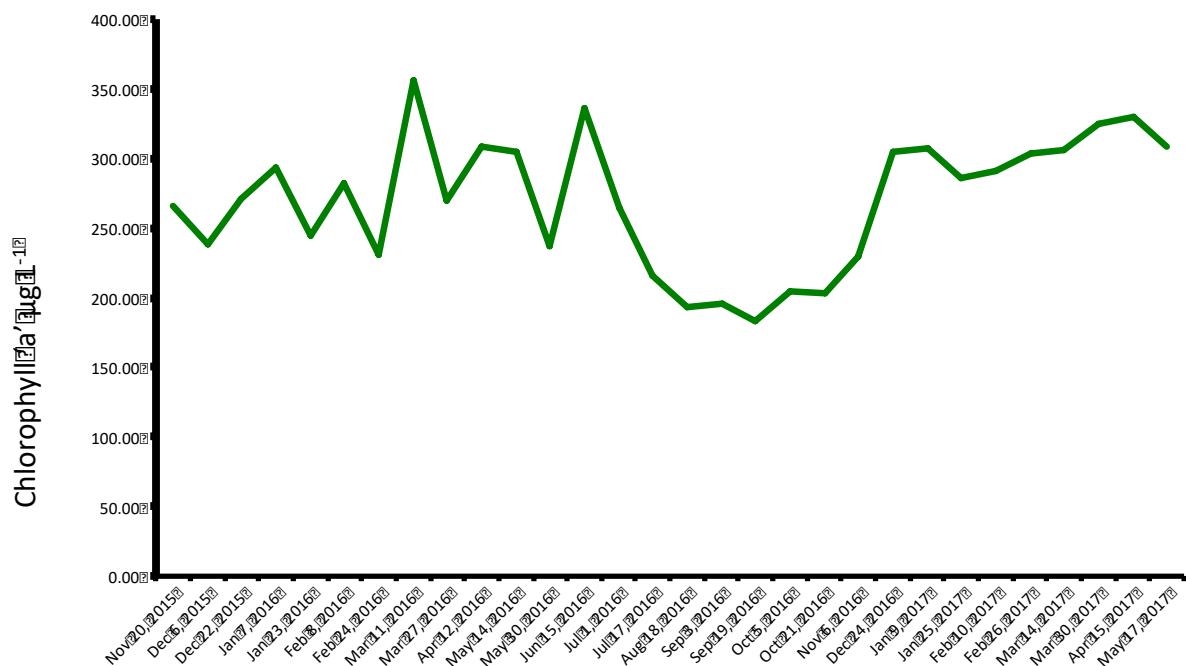


Figure 2: Arthrospira density at Lake Bogoria 2015-7 as Chlorophyll 'a' biomass calculated from Landsat satellite images using the formula of Tebbs et al. (2013).

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SHORT REPORT

ZIMS and flamingo management: Moving from data to decisions

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Abstract

Despite the popularity of flamingos within zoo and aquarium collections, the long-term sustainability of *ex situ* populations remains an issue owing to their poor rates of reproductive success. Flock size has already been identified as a key determinant of reproductive success, with larger flocks demonstrating greater reproductive success. In a bid to increase population sizes and reproductive opportunities it has been universally recommended that flamingos should be housed in minimum flock sizes of 20 birds and ideally in flocks of 40 birds. Although practical, these guidelines are based on a very limited body of knowledge and fail to consider species-specific differences in reproductive behaviour and many other factors (such as flock sex ratio and the latitude of and climatic conditions at each institution) thus potentially hindering the sustainable development of *ex situ* flamingo populations. Using the globally shared records generated from the network of more than 1,100 Species360 members, as part of their Zoological Information Management System (ZIMS), we hope to understand how flock size and structure influences reproductive success across latitudinal and climatic gradients, while also allowing us to unravel potential species-specific differences in reproductive behaviour. Results from this study will hopefully be incorporated into global flock management practices, improving the sustainability of *ex situ* flamingo populations.

Resumen

A pesar de la popularidad de los flamencos dentro de las colecciones de zoológicos y acuarios, la sostenibilidad a largo plazo de las poblaciones *ex situ* sigue siendo un problema debido a sus bajos índices de éxito reproductivo. El tamaño de la parvada ya se ha identificado como un determinante clave del éxito reproductivo, ya que las parvadas más grandes demuestran un mayor éxito reproductivo. En un intento por aumentar el tamaño de la población y las oportunidades reproductivas, se ha recomendado universalmente que los flamencos se alojen en el tamaño mínimo de 20 aves e idealmente en bandadas de 40 aves. Aunque son prácticas, estas directrices se basan en un conocimiento muy limitado y no tienen en cuenta las diferencias específicas de las especies en el comportamiento reproductivo y muchos otros factores (como la proporción de sexos de las bandadas y la latitud y las condiciones climáticas de cada institución), por

lo tanto, dificultan la Desarrollo sostenible de poblaciones de flamencos *ex situ*. Usando los registros compartidos globalmente generados desde la red de más de 1,100 miembros de Species360, como parte de su Sistema de Gestión de Información Zoológica (ZIMS), esperamos entender cómo el tamaño y la estructura de la bandada influye en el éxito reproductivo en los gradientes latitudinales y climáticos, al mismo tiempo que nos permite para desentrañar posibles diferencias específicas de la especie en el comportamiento reproductivo. Es de esperar que los resultados de este estudio se incorporen a las prácticas de manejo global del rebaño, mejorando la sostenibilidad de las poblaciones de flamencos *ex situ*.

Résumé

Malgré la popularité des flamants roses dans les collections de zoos et d'aquariums, la durabilité à long terme des populations *ex situ* reste un problème en raison de leurs faibles taux de réussite en matière de reproduction. La taille du troupeau a déjà été identifiée comme un déterminant clé du succès de la reproduction, les troupeaux plus grands montrant un plus grand succès de reproduction. Dans le but d'augmenter la taille des populations et les possibilités de reproduction, il a été universellement recommandé de placer les flamants roses dans des troupeaux d'une taille minimale de 20 oiseaux et idéalement dans des troupeaux de 40 oiseaux. Bien que pratiques, ces directives reposent sur un ensemble très limité de connaissances et ne tiennent pas compte des différences de comportement en matière de reproduction propres à une espèce et de nombreux autres facteurs (tels que le sex-ratio du troupeau et la latitude et les conditions climatiques de chaque institution) pourraient ainsi entraver la développement durable des populations de flamants *ex situ*. En utilisant les enregistrements partagés globalement générés à partir du réseau de plus de 1 100 membres de Species360, dans le cadre de leur système de gestion des informations zoologiques (ZIMS), nous espérons comprendre comment la taille et la structure du troupeau influent sur le succès reproducteur des gradients latitudinaux et climatiques, tout en nous permettant également. Démêler les différences potentielles de comportement de reproduction entre espèces. Nous espérons que les résultats de cette étude seront intégrés aux pratiques de gestion globale des troupeaux, améliorant ainsi la durabilité des populations de flamants roses *ex situ*.

Introduction

As global wildlife populations continue to decline, the sustainability of *ex situ* wildlife populations is of growing importance (Lees and Wilcken, 2009). Currently significant *ex situ* populations exist for four of the six species of extant flamingo (*Phoenicopteridae*), with IUCN statuses ranging from Least Concern to Near Threatened (Table 1). Despite their popularity with the public and their prevalence across zoo collections (Table 1), the sustainability of *ex situ* flamingo populations has been a concern among population managers, primarily due to their poor reproductive success (Stevens *et al.*, 1992; Whitfield, 2002). For example, despite

having been kept in captivity since the Roman period (Ogilvie & Ogilvie, 1986), the first captive breeding event did not occur until 1937 and the first successful rearing only occurred in 1942 (Pickering, 1992). This has created a deficit in the number of captive flamingos, with institutions consistently stating that they would like to hold more flamingos than there are available (King & Bracko, 2014).

As a result, there has been a call for increased knowledge surrounding the basic reproductive biology of all flamingo species (Johnson and Cézilly, 2008). It is well known within the zoo and aquarium community that a relationship exists between flock size and

reproductive success in captive flamingos, with larger flocks having greater reproductive success (Pickering *et al.*, 1992; Sandri *et al.*, 2018). In fact, the importance of flock size in determining reproductive success has become the central tenet of captive flamingo management for all species, being touted as “the most important factor for optimizing breeding” (King, 2008; King & Bracko, 2014). Therefore, it is generally accepted that a minimum flock size of 20 birds is required for

welfare purposes and that to achieve a reasonable chance of reproductive success flocks of 40+ birds should be maintained (Brown & King, 2005). This information has been incorporated into global flock management with some institutions going as far as to mimic such conditions through the use of mirrors to artificially increase flock size within enclosures, however results to date are not clear (Whitfield, 2002).

*Table 1: Summary statistics for each of the four Flamingo species maintained within the Species360 member institution network. Data is accurate to November 2016. * Includes deceased individuals*

Species	Count	Alive	Male*	Female*	Institutions*	IUCN	CITES
<i>Phoeniconaias minor</i> (Lesser flamingo)	2120	759	1375	745	119	NT	II
<i>Phoenicopterus chilensis</i> (Chilean flamingo)	7324	3730	3651	3673	294	NT	II
<i>Phoenicopterus roseus</i> (Greater flamingo)	6990	4541	3366	3624	251	LC	-
<i>Phoenicopterus ruber</i> (American flamingo)	7662	4131	3910	3752	257	LC	II
Total	24096	13161	12302	11794	566	-	-

Although the relationship between flock size and reproductive success is clear and consistent, the justification for the exact management recommendations is lacking, with the evidence supporting them being generated from a limited number of studies, often investigating single institutions and/or being species-specific (Stevens, 1991; Pickering *et al.*, 1992; Stevens & Pickett, 1994). As a result, many questions remain unanswered and the universal implementation of management decisions may be premature.

Filling knowledge gaps with ZIMS

In order to successfully manage *ex situ* flamingo populations and ensure their long-term viability, it is imperative that we understand what flock size and structure enhances reproductive success for individual species. The globally shared records currently contained within Species360’s Zoological Information Management System (ZIMS) provides a unique opportunity to investigate the relationship between flock size and reproductive success on a global scale, across not only the four flamingo species currently maintained in *ex situ* populations, but also across climatic and latitudinal gradients. The combined records from the more than 1,100 Species360 member institutions will allow us

to understand how flock size and structure influences reproductive success in order to gain a more holistic view of flamingo reproduction.

We hypothesise that reproductive success will increase with both flock size and an even flock sex ratio, however observed influences of flock demography, male wing condition, enclosure conditions, photoperiod, climate and species-specific differences mean that further work is needed to understand this system (Johnson and Cézilly, 2008; King,

2008). A preliminary analysis of Chilean flamingos at 167 Species360 member institutions in 2013 showed that flocks consisting of over 20 birds had higher reproductive success than those lower than 20. However, the rate of success increased significantly with flock sizes of more than 30 birds, Figure 1, (Teare, 2014). This single year study provides a base for further research and demonstrates the management information that can be generated from globally shared records.

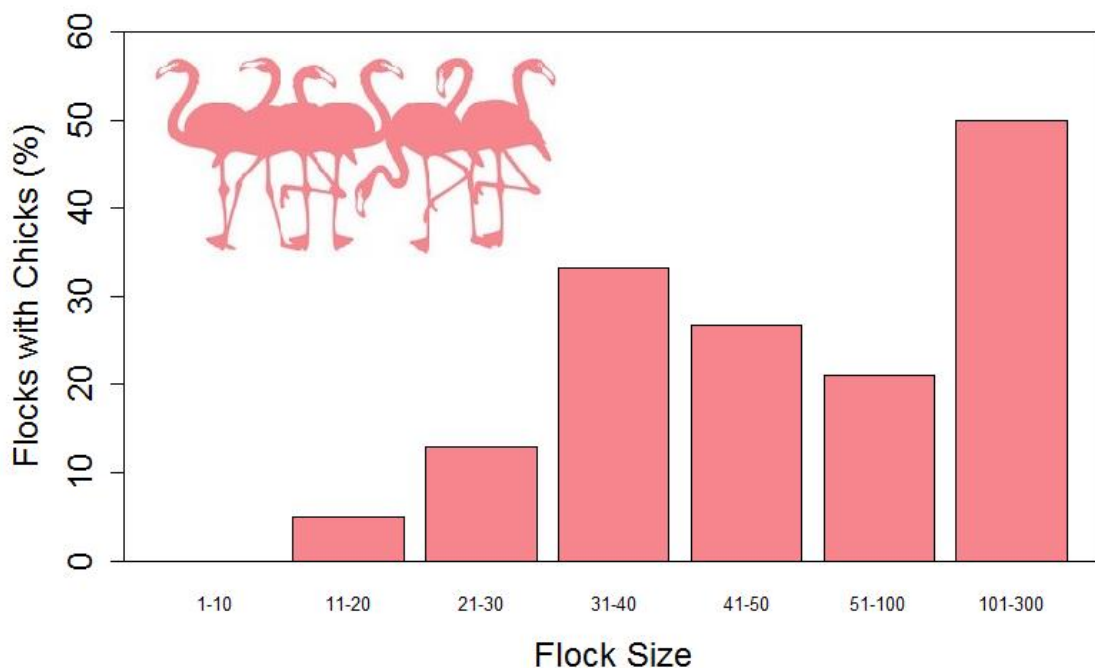


Figure 1: The relationship between flock size and reproductive success in Chilean flamingos across 167 Species360 member institutions for the year 2013 (Teare, 2014).

Flamingos represent an ideal candidate species for understanding the role of flock size on reproductive success as they are currently not under any form of contraception or management that would discourage breeding, particularly due to their continued demand within collections (King & Bracko, 2014). Once this study has been completed the results and methodologies could easily be applied to other species, such as the boat-billed heron (*Cochlearius cochlearius*), which are also proving difficult to reproduce in captivity.

Results from this study will have direct population management implications and will hopefully be incorporated into global flock management practices moving forward, improving the sustainability of *ex situ* flamingo populations.

Conclusion

Through this thorough exploration of the population dynamics and demographic processes underlying captive flamingo reproduction we hope to add to the global

body of knowledge on flamingo biology and ecology. This is in line with the integrated approach to species conservation promoted by the IUCN CPSG, their 'One Plan Approach' promotes the exchange of knowledge and collaboration between all parties involved in species conservation (Byers *et al.*, 2013). By connecting the power of globally shared *ex situ* records and management expertise with *in situ* conservation practitioners we will be able to jointly develop the most efficient conservation actions and potential management strategies to ensure flamingo populations remain sustainable both *in* and *ex situ* long into the future.

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Flamingo-related publications 2011-2018

Relevant publications relating to flamingos, their biology, behaviour, ecology, conservation, health and/or management.

2011

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- For short articles, please use the following structure:
Abstract. Introduction. Evaluation. Conclusions. Acknowledgements. References.
- For longer articles, please use the following structure:
Abstract. Introduction. Methodology. Results. Discussion. Conclusions. Acknowledgements. References.

First level headings should be sentence case and **bold**.

Second level headings should be sentence case and underlined.

Please use Calibri font size 12.

Left align all paragraphs with 1.5 line spacing.

Please use the species' binomial name when first referred to in the text; i.e. lesser flamingo (*Phoeniconaias minor*) and format the binomial name in italics.

Please use SI units throughout.

An example layout is provided below in Figure 1.

Layout (tables and figures)

Label all tables and figures consecutively (i.e. Table 1, Figure 1 etc.).

Please provide a label for each table (above) and a caption for each figure (below).

Include the table label and figure caption in italics.

Ensure that all tables and figures are referred to in the text.

Editorial

The editors reserve the right to make typographical, spelling and grammatical corrections without author consultation. Articles are not peer-reviewed but authors may be asked to clarify specific points.

Inappropriately or overly-formatted articles may be sent back to the authors for editing to the required layout.

Authors are required to proof-read and spell-check their own submissions.

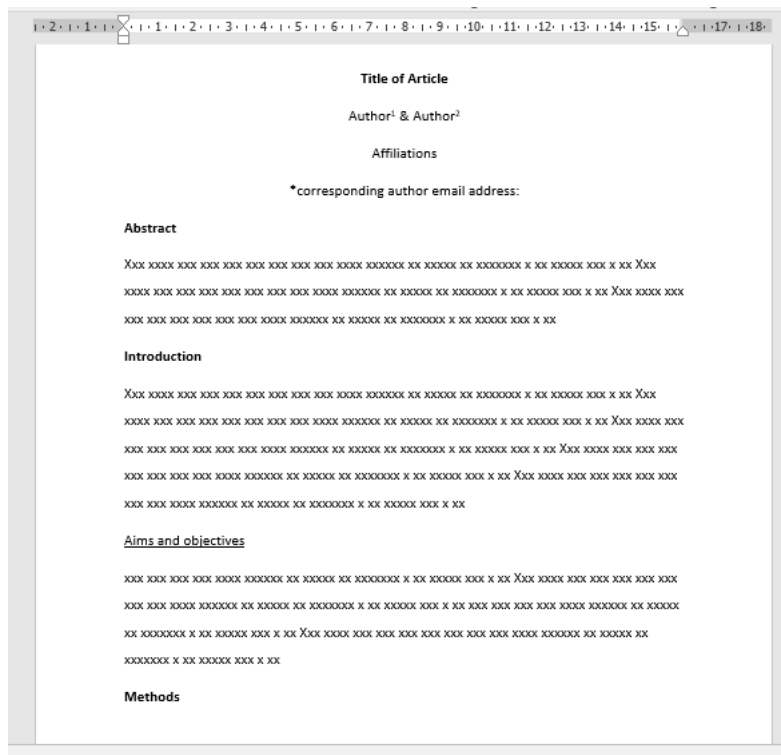


Figure 1: Example of article layout.

Submission

Please email articles in English to Dr Paul Rose: p.rose@exeter.ac.uk

Please email articles in Spanish to Dr Felicity Arengo: arengo@amnh.org

Please email articles in French to Dr Arnaud Béchet: bechet@tourduvalat.org

Articles will be considered for publication throughout the year.

Flamingo; instrucciones para autores

“Flamingo” publica artículos sobre poblaciones silvestres y en cautiverio de las seis especies de flamencos.

Tipos de artículos

Se aceptan trabajos experimentales, notas de campo, resultados de investigación, artículos de síntesis, informes breves y comentarios.

Temas para artículos

- Conservación / estado de las poblaciones
- Informes de avance sobre iniciativas de conservación o gestión a escala local o regional
- Biología, ecología e historia natural
- Manejo de hábitat
- Movimientos de flamencos, seguimiento, anillado y monitoreo
- Comportamiento y cuidado animal.
- Manejo y cría en cautiverio, y el rol de los flamencos en los zoológicos
- Educación, participación comunitaria, difusión e interacciones entre personas y flamencos

Límite de palabras

Máximo 2000 palabras incluyendo referencias y citas, toda la información en figuras y tablas (y sus leyendas), y el resumen.

Como guía para la longitud del artículo, hay aproximadamente 500 palabras por página impresa.

Los manuscritos de más de 2000 palabras serán devueltos a los autores para ser acortados. acortamiento.

Figuras

Por favor inserte todas las figuras (fotos, mapas, diagramas) en el texto. Imágenes a todo color son aceptables.

Idioma

Por favor envíe artículos en inglés, francés o español. Los artículos en español y

francés deben enviarse con una traducción del resumen en inglés.

Formato

Incluya el título (en negrita, usando mayúscula sólo al principio de la oración) en la primera página, seguido de los nombres de los autores y luego sus afiliaciones.

Alinee el título, los autores y las afiliaciones al centro.

Para todos los manuscritos, proporcione un resumen al comienzo.

- Para artículos cortos, utilice la siguiente estructura.
Resumen. Introducción.
Evaluación. Conclusiones.
Agradecimientos. Referencias
- Para manuscritos más largos, utilice la siguiente estructura:
Resumen. Introducción.
Metodología. Resultados.
Discusión. Conclusiones
Agradecimientos. Referencias

Los títulos de sección de primer nivel deben tener formato de oración (mayúscula sólo al principio) y **negrita**. Los títulos de sección de segundo nivel deben tener formato de oración y subrayados.

Utilice el estilo y tamaño de letra Calibri 12.

A la izquierda, alinee todos los párrafos con un espaciado de línea de 1.5.

Utilice el nombre binomial de la especie cuando se hace referencia por primera vez en el texto; es decir, flamenco enano (*Phoeniconaias minor*) usando tipografía cursiva.

Por favor use unidades SI en todo el trabajo.

Un ejemplo de formato se proporciona a continuación en la Figura 1.

Diseño (tablas y figuras)

Etiquete todas las tablas y figuras de forma consecutiva (es decir, Tabla 1, Figura 1, etc.).

Proporcione una etiqueta para cada Tabla (por encima) y un título para cada Figura (por debajo).

Incluya la etiqueta de la tabla y el título de la figura en tipografía cursiva.

Asegúrese de que se haga referencia a todas las tablas y figuras en el texto.

Revisión

Los editores se reservan el derecho de realizar correcciones tipográficas, ortográficas y gramaticales sin consultar a los autores.

Flamingo no es una revista con referato, sin embargo, se les puede pedir a los autores que aclaren puntos específicos. Artículos que no tengan el formato indicado se devolverán a los autores para su edición usando el formato requerido. Se requiere que los autores revisen y verifiquen la ortografía de sus propias presentaciones.

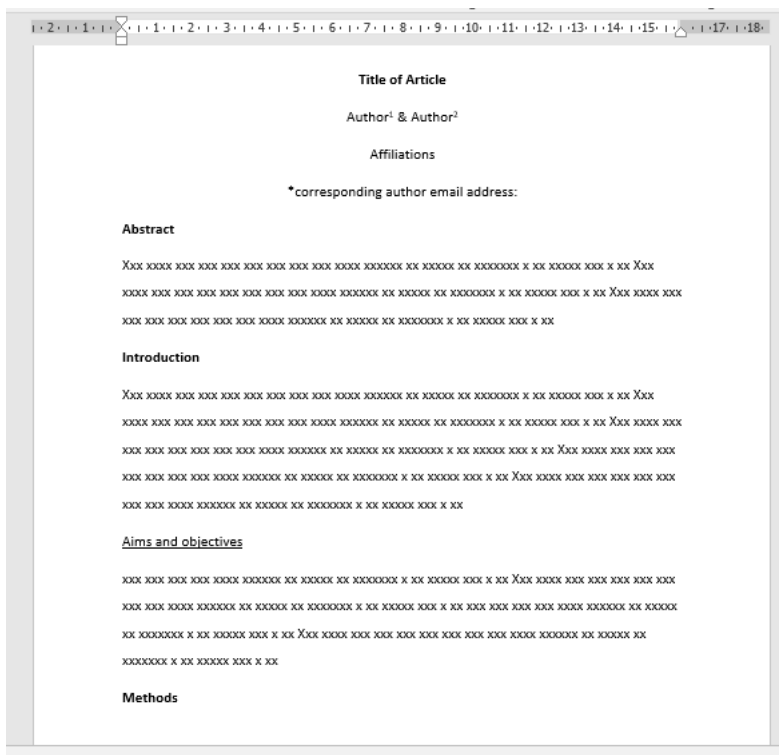


Figura 1: Ejemplo de formato del artículo.

Presentación

Envíe artículos en inglés por correo electrónico a Dr. Paul Rose: p.rose@exeter.ac.uk

Envíe artículos en español por correo electrónico a la Dra. Felicity Arengo:

arengo@amnh.org

Envíe artículos en francés por correo electrónico al Dr. Arnaud Béchet:

bechet@tourduvalat.org

Los artículos serán considerados para publicación durante todo el año.

Flamingo; instructions pour les auteurs

« Flamingo » publie des articles sur les six espèces de flamants existantes, provenant de populations sauvages et captives.

Types d'articles

Les articles rapportant des résultats de recherche, de suivis sur le terrain, les articles de synthèse, les rapports courts et les commentaires sont les bienvenus.

Thèmes pour articles

- Conservation / statut des populations
- Rapports d'avancement sur les initiatives de conservation ou de gestion à l'échelle locale ou régionale
- Biologie, écologie et histoire naturelle
- Gestion de l'habitat
- Mouvements d'oiseaux, baguage, suivis GPS...- Comportement
- Gestion en captivité et rôles des flamants dans le zoo
- Éducation, engagement communautaire et interactions homme-flamant

Limite de mots

Maximum de 2000 mots, y compris les références et les citations, toutes les informations dans les figures et les tableaux (et leurs légendes), et le résumé. En guise de guide pour la longueur de l'article, il y a environ 500 mots par page imprimée.

Les manuscrits de plus de 2 000 mots seront retournés aux auteurs pour être raccourcis.

Figures

Veillez incorporer toutes les figures (photos, cartes, diagrammes) dans le texte. La couleur est acceptable.

La langue

Veillez soumettre vos articles en anglais, français ou espagnol. Les articles en espagnol et en français doivent être

soumis avec une traduction du résumé uniquement en anglais.

Disposition

Inclure le titre (en gras) sur la première page, suivi par les noms des auteurs, puis leurs affiliations.

Veillez aligner le titre, les auteurs et les affiliations.

Pour tous les articles, veuillez fournir un résumé au début de l'article.

- Pour les articles courts, veuillez utiliser la structure suivante : Résumé. Introduction. Évaluation. Conclusions. Remerciements. Références.
- Pour les articles plus longs, utilisez la structure suivante : Résumé. Introduction. Méthodologie. Résultats. Discussion. Conclusions. Remerciements. Références.

Les titres de premier niveau devraient être en majuscules et en gras.

Les titres de deuxième niveau devraient être soulignés.

Veillez utiliser la police Calibri 12.

Alignez à gauche tous les paragraphes avec un interligne de 1,5.

Veillez utiliser le nom latin de l'espèce lorsqu'il est mentionné pour la première fois dans le texte; c'est-à-dire un flamant nain (*Phoeniconaias minor*) et formater le nom latin en italique.

Veillez utiliser les unités SI partout.

Un exemple de disposition est fourni ci-dessous dans la figure 1.

Mise en page (tableaux et figures)

Étiquetez tous les tableaux et les figures consécutivement (par exemple, le tableau 1, la figure 1, etc.).

Veillez fournir une légende pour chaque tableau (au-dessus) et une légende pour chaque figure (au-dessous).

Formater l'étiquette du tableau et la légende de la figure en italique.

Assurez-vous que tous les tableaux sont référencés dans le texte.

Éditorial

Les éditeurs se réservent le droit d'effectuer des corrections typographiques, orthographiques et grammaticales sans consultation d'un auteur.

Les articles ne sont pas revus par les pairs, mais les auteurs peuvent être invités à clarifier des points spécifiques.

Des articles inappropriés ou trop formatés peuvent être renvoyés aux auteurs pour être modifiés selon la mise en page requise.

Les auteurs sont tenus de relire et d'épeler leurs propres soumissions.

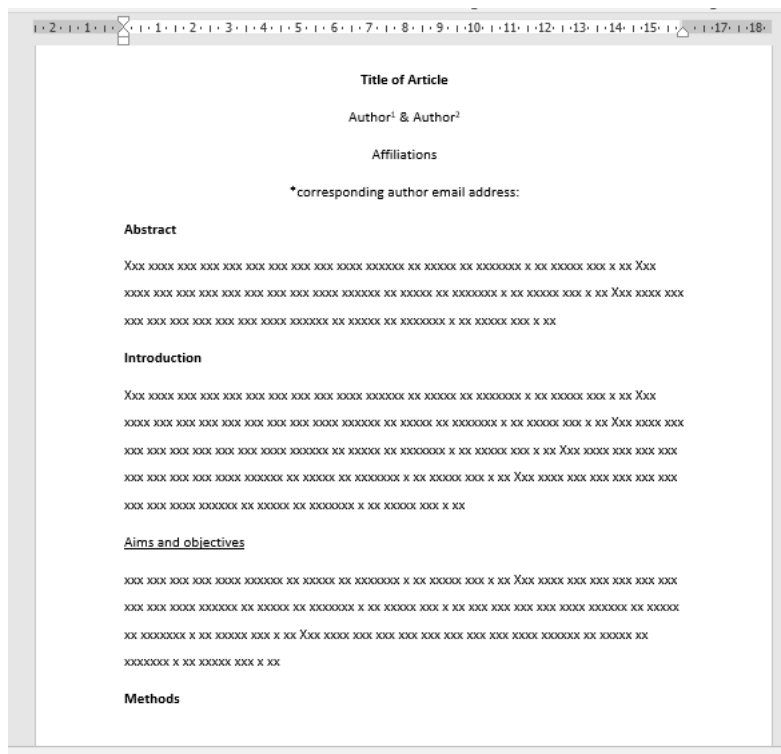


Figure 1 : Exemple de disposition d'article

Soumission

S'il vous plaît envoyer des articles en anglais à Dr Paul Rose: p.rose@exeter.ac.uk

S'il vous plaît envoyer des articles en espagnol au Dr Felicity Arengo: arengo@amnh.org

S'il vous plaît envoyer des articles en français à Dr Arnaud Béchet: bechet@tourduvalat.org

Les articles seront considérés pour publication tout au long de l'année.



Flamingo

Journal of the IUCN SSC WI Flamingo Specialist Group



Photo credits

Front cover: Greater flamingos (Paul Rose / WWT)

Back cover: Chilean flamingos (Paul Rose / WWT)

IUCN SSC / Wetlands International Flamingo Specialist Group

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