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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
Phoeniconaias minor (Lesser flamingo)	2,120	759	1,375	745	119	NT	II
Phoenicopterus chilensis (Chilean flamingo)	7,324	3,730	3,651	3,673	294	NT	II
Phoenicopterus roseus (Greater flamingo)	6,990	4,541	3,366	3,624	251	LC	-
Phoenicopterus ruber (American flamingo)	7,662	4,131	3,910	3,752	257	LC	II
Total	24,096	13,161	12,302	11,794	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.

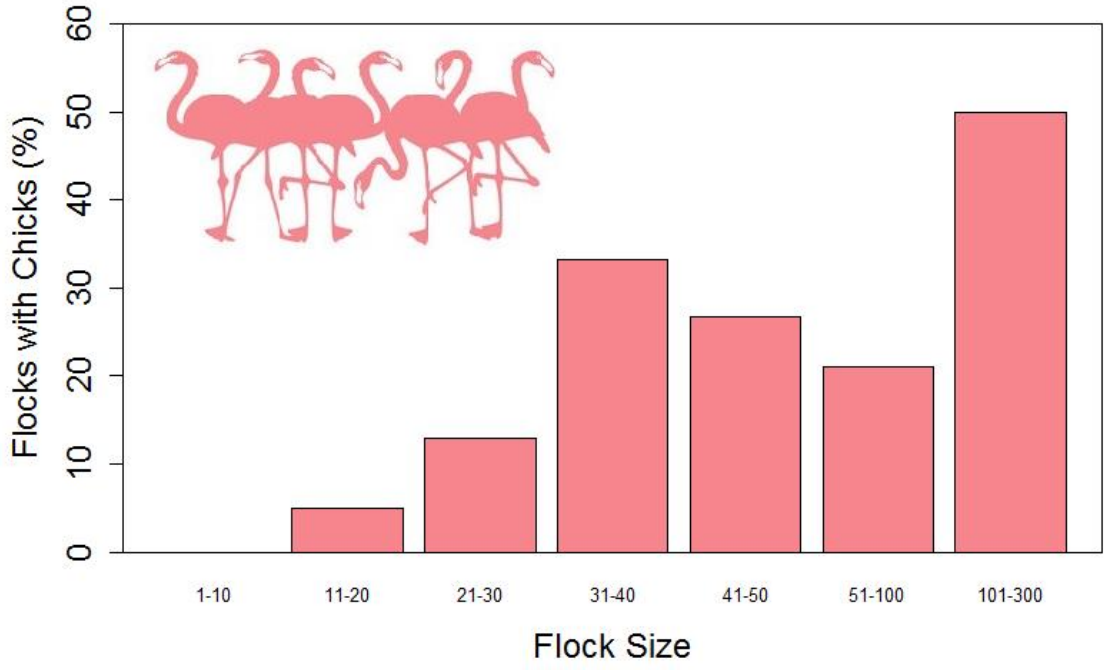

Figure 1: The relationship between flock size and reproductive success in Chilean flamingos across 167 Species360 member institutions for the year 2013 (Teare, 2014).

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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