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Evidence-based practice

Developing flamingo husbandry practices through workshop communication

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Abstract
Zoos are duty-bound to provide excellent welfare standards for the species that they keep. Curators and keepers have a role to play in ensuring that husbandry regimes are relevant and mimic a species' natural environment. This paper explains the key outcomes from ABWAK's (Association of British and Irish Wild Animal Keepers) first national flamingo keepers' workshop. Research on flamingo breeding is well documented in the literature, but research into other aspects of husbandry may develop flamingo welfare further. By engaging keepers and academics with a direct influence over flamingo management, questions relating to best practice can be answered to establish areas of common good practice as well as novel approaches. Topics presented for discussion at the workshop focused on 1) informed enclosure design, 2) relevant enrichment ideas and 3) "promotion" of flamingos to the zoo visitor, with the aim of having a positive impact on the birds' quality of life and their value as a zoo exhibit. Outcomes generated included the development of enrichment and husbandry modifications that may enhance flamingo activity patterns and their display to zoo visitors. Many aspects of regular flamingo husbandry can have an enriching influence on the birds' lives, therefore encouraging zoo professionals to share ideas may benefit many flamingos in many zoos. Through the medium of a workshop, husbandry techniques for specialist species such as the flamingo can be shared and developed.

Introduction

The modern zoo has four, oft-quoted aims of conservation, education, research and recreation (Hosey et al. 2009) that can be met by a policy of evidence-based husbandry (Maple 2014; Melfi 2009) to develop excellent standards of animal welfare. Welfare can be adversely affected when there is a discrepancy between a species' ecology, evolutionary biology and behaviour, and the delivery of husbandry, enclosure style and management routine. The ideal situation of a population experiencing an excellent welfare state and consequently thriving in the zoo is the gold standard to aim for (Melfi 2009). Any knowledge gap that exists for captive species can only be filled with wild studies, applied research and dissemination of knowledge between animal keepers (Hosey 1997; Hosey et al. 2009; Watters and Wielebnowski 2009). This paper describes the output from a keeper-led workshop, held in summer 2014, to further advance positive aspects of flamingo welfare, and provide evidence for good husbandry practice in captivity.

Sharing best practice to uphold positive welfare

Sharing knowledge and best practice between zoo keepers and encouraging dialogue amongst zoo professionals is one of the best ways to develop best practice, species-specific husbandry regimes. Such dialogue is also vital to help inform ways of upholding excellent standards of animal welfare. Published literature shows that evidence for improved animal management can come from dialogue and meetings between zoo stakeholders (Coe et al. 2009; Melfi and Hosey 2011; Ralls and Ballou 1986; Thompson and Bell 1998). The concept of behavioural husbandry (BH) is one way in which zoos can manipulate the environment of their animals in order to encourage positive welfare states (Hosey et al. 2009; Melfi and Hosey 2011). BH describes "the application of techniques to manipulate animal behaviour in order to enhance animal management and improve welfare" (Melfi and Hosey 2011), and includes the practice of environmental enrichment. As welfare is a continuum that an animal experiences (Broom 1988, 1991), changes to husbandry can have a measurable

impact on the quality of life, health status and reproductive success of an individual. Key features of enclosure design may be based on visitor needs or a traditional view of species' care (Melfi et al. 2005); to redress this, outputs from symposia and workshops help expand on the evidence for good practice to underpin future enclosure design and construction.

Creating a workshop to increase the focus on captive flamingo welfare

Flamingos, one of the most commonly exhibited zoo species, are highly relevant subjects for discussion on evidence-based management and uses of BH. The excellent flamingo husbandry guidelines by Brown and King (2005) provide zoos with the foundations required to help keep birds healthy and in good condition, and suggest ideas to encourage breeding. Much work has already been conducted on improving flamingo breeding success and evaluating foot health, and a there is a wealth of publications on such topics. In 2014, in San Diego, USA, a high-profile international flamingo symposium was held, and a dedicated "Avian Challenges" edition of the *International Zoo Yearbook* was published (Field et al. 2014). With this in mind, it seemed an ideal time to review other practical aspects of flamingo management to stimulate debate and discussion on the wider aspects of flamingo keeping in the modern zoo. The aim of the workshop described in this article was to encourage delegates to think about flamingo behaviour patterns and how these can be diversified within zoo enclosures. Three papers (King 2008; King and Bračko 2014; Rose et al. 2014) were used as a scientific basis for the meeting and they provided delegates with a framework of evidence on the biological and behavioural needs of the flamingo. These papers also directed specific flamingo research questions and guided discussion on how to make enclosure design and enrichment techniques more suitable for the birds themselves. Areas for further scientific investigation were proposed and reviewed with attendees alongside these existing pieces of literature. To foster debate and to ensure constructive output was produced from the workshop, some key questions were presented to delegates at the beginning of the day:

Table 1. Summary of husbandry and enrichment techniques used by flamingo keepers who attended the workshop. Enrichment categories from Bloomsmith et al. (1991). Percentage use is the number of zoos present at the workshop that use this form of BH or enrichment.

Enrichment category	Use by delegates (%)	Husbandry modifications used by zoological collections with a view to improving flamingo welfare
Nutritional	100	Seasonal changes to diet are widely used, encouraging birds to "colour up" and gain condition ready for breeding.
	75	Sinking pellet aids naturalistic filter-feeding methods in large expanses of water. As sinking pellet is less likely to be scavenged by pest species it can prolong foraging.
	50	Milled pellet may encourage prolonged filter feeding. Some collections encourage algal growth in pools, providing opportunities for filter-feeding. This is particularly valuable for deep-keeled flamingo species. Encouraging *Daphnia* spp. and other invertebrate populations to bloom in areas of sunlight encourages filter-feeding.
	25	Use of floating pellet to encourage filter-feeding behaviour.
Occupational	100	Estuary or river sand is widely used due to its purported health benefits in comparison to more abrasive substrates, such as concrete. Sand also provides opportunities for loafing, chick crèches and nest building. All but one collection allowed birds to parent rear their chick. Whilst this may not always be appropriate, based on chick predation rates, providing an opportunity to express parental care is an excellent source of enrichment. A pool of at least wading depth encourages birds to move freely around an exhibit across a range of surfaces.
	75	Flooded, shallow areas of mud and sand may encourage stamp-feeding. Water flow into enclosure allows alga and micro-organisms to travel into the flamingos' pool, giving seasonal and temporal complexity to foraging behaviours.
	25	Areas of deep water (>1 metre) encourage a wider variety of swimming and foraging behaviours, which may be of benefit to flamingo welfare.
Social (including breeding)	100	Encouraging courtship display. All collections actively managed enclosures (water levels, substrate type and amount) to ensure birds had suitable motivation to perform group courtship and nest building activities.
	50	Visual barriers around nest sites via strategic planting or bamboo canes may mimic the legs (and security) of a large flamingo flock, and have been shown to work in some flocks to promote nesting. Expanding enclosure size allows birds to mix preferentially and to have space to move away from conspecifics that are not favoured; especially important in indoor housing.
	25	Mirrors may encourage group display and are sometimes used. Several delegates spoke of their previous use but noted they are no longer used due to lack of a long-term effect. Audio playback of flamingo vocalisations is believed to encourage courtship but more research will help to reveal the efficacy of audio signals.

1. What is the social structure of the flock being managed and how important is each individual's place within that flock?
2. What scope do the birds have, within the confines of their enclosure, to change their activity patterns across the course of the day?
3. Where does aggression and conflict often occur and are there resource hotspots within an enclosure that promote antagonistic interactions?
4. How can naturalistic, biologically important, behaviour patterns (e.g. feeding, foraging, courtship display) be promoted within housing and the wider exhibit using an underpinning knowledge of flamingo behavioural ecology?
5. How can enclosures be modified to make the flamingo more appealing to zoo visitors?

Twenty-two delegates from eight institutions around the United Kingdom gathered at ZSL London Zoo in July 2014 for a day-long event run by the Association of British and Irish Wild Animal Keeper's (ABWAK), whose desire "…is to achieve the highest standards of excellence in animal welfare through communication, cooperation, training and development" (ABWAK 2014). Collections participating were: Blackpool Zoo, Bristol Zoo Gardens, Colchester Zoo, Marwell Wildlife, Sparsholt College Hampshire, WWT Slimbridge Wetland Centre, ZSL London Zoo and ZSL Whipsnade Zoo.

The workshop focused upon aspects of flamingo husbandry that would benefit from further research, including the relationship between natural behaviour and enrichment; the use of enrichment to improve welfare; how to make a flamingo exhibit engaging and interesting to the public; and how to educate, inform and spread the conservation message to those viewing flamingos in a zoo. To provide answers to the questions posed at the outset, delegates were split into groups based on their experience of flamingo care to discuss how the five questions could be answered by investigating indoor housing and diet presentation, natural behaviour and enrichment, small flock management and enclosure design. Each group then presented their key points to the remainder of the audience. These topics were chosen based on the perceived impact (from the experience of the organisers) that this feature of husbandry could have on zoo-housed flamingo behaviour and welfare.

Outcomes generated

Discussion on flamingo BH (aspects of enclosure design and husbandry practice considered enriching) produced much evidence of good practice common across the represented zoos, as well as some examples not used as often but worthy of an expanded use. The outputs within Table 1 were generated by the delegates themselves, with individuals explaining management techniques from their zoo and used on their birds, and then asking who else used a similar approach.

As shown in Table 1, numerous BH methods have been widely used across different zoos, which ultimately benefits flamingo welfare. The diversity of enrichment used for flamingos is heartening and shows the effort put in to day-to-day management, to provide a stimulating environment for the birds. Enrichment has not always been considered a husbandry tool for birds (King 1993), but this is definitely no longer the case. Husbandry routines themselves can be enriching (Field 1998; Mellen et al. 1997). The good practice highlighted from this workshop can be used by other zoos to further expand their range of BH methods applicable to the flamingos in their care.

Other enriching factors, such as increasing the depth of some flamingo pools to >1 metre, are not often used. These ideas have the potential to further improve welfare. In the specific case of pool depth, a deeper pond may allow flamingos to swim and vary their foraging activities, thus increasing behavioural diversity. Presently there are no peer-reviewed data available regarding pool depth and flamingo welfare, and hence the husbandry and enrichment review from this workshop has helped to identify new key areas for flamingo-centred research. However, research on wild birds shows the propensity towards swimming seen in flamingos (Bartholomew and Pennycuick 1973), strongly supporting the need for zoos to provide flamingos with water deep enough for swimming.

Delegates showed a keen interest in the hypothetical point scoring system developed by King (2008). The original system stated husbandry variables (e.g. flock size) that directly affect flock breeding success, weighted according to their importance. Points are attributed to each requirement met, giving zoo professionals a more informed idea whether their colony is likely to breed, and helping identifiy how to further improve enclosure design based on areas of lower scoring. Information from the discussion groups was collated to show how welfare measures can fit alongside of these original benchmarks (see Table 2).

Table 2 is not a replacement for the original hypothetical points system, which is clearly a very useful, appropriate tool for helping determine the most suitable husbandry needs of specific flock. What we aim to show is how scales like that developed by King (2008) can be applied to wider areas of flamingo behaviour and welfare. Hence zoos can judge what alterations to existing management are required to meet the biological needs of the birds.

Discussion

Applications of behavioural husbandry to captive flamingos

Totalling up the number of birds kept at the attendees' zoos shows that successful fulfilment of the aims of this event could potentially have a positive impact on the welfare of approximately 750 individual flamingos (as of current ISIS numbers, January 2016) across all six extant species. To continually enhance the standards of zoo animal care, there is a need to convert theoretical knowledge into practical management (Goulart et al. 2009), and zookeeper discussion provides a beneficial and open forum for information exchange (Melfi and Hosey 2011). Use of enrichment, enclosure design and flock management appear to be areas where improvements can be made quickly that may have positive welfare implications for flamingos. All delegates agreed that enrichment has a pivotal role to play in this cycle of husbandry practice sympathetic to animal behaviour = improved welfare state = public interest (Table 1). As has been shown with other species that perform specialised activity patterns, such as tapirs (*Tapirus* sp.), biologically relevant enrichment that encourages naturalistic activity budgets has a positive impact on the visitor's perception of the animal and its associated conservation or ecological story (Seitz 2002; Rose and Roffe 2013). Changes to the presentation of a flamingo flock to the viewing public can improve dwell time at the exhibit and ultimately provide a stronger conservation and educational message about the birds, their function in the zoo, and their role as ambassadors for free-living individuals.

Environmental and behavioural enrichment has been seen as a relatively new topic for managed bird species (King 1993; Nichol 1996) and there are many species that may benefit from further research into the most appropriate forms of enrichment (Field 1998). The outputs from this workshop are very encouraging and show that many flamingo keepers are constantly considering

Table 2. Factors affecting flamingo breeding success with relative importance as a point score (taken from King 2008) in the left-hand column, with welfare-themed examples based on this point score on the right.

Factors affecting flamingo breeding success	Welfare theme discussed around this point score
1. Colony size as a single-species flock (8)	Following the guidelines of 40 birds minimum for good welfare is very important. Research demonstrates that single-species flamingo flocks are more likely to breed, and as opportunity to reproduce is a way of heightening welfare state, keeping large flocks of one species in one enclosure allows for this to occur.
2. Security of flock within exhibit (6)	It is hypothesised that a flamingo flock that perceives its exhibit to be secure will use larger proportions of the space provided (thus increasing opportunities for foraging and locomotion) compared to an unsettled flock that will be found as a tighter-packed flock in one location.
3. Flock's sex ratio (4)	An equal mix of females and males allows all birds the potential to pair up; increased opportunity for mate choice can help spread opportunity for courtship display throughout the flock. As such a fuller behavioural repertoire is achieved, with its associated welfare benefits.
4. Wing condition of male birds (4)	The type and size of enclosure provided for the flamingo flock will determine whether birds are kept flight restrained or full-winged, and hence the range of behaviours that can therefore be performed.
5. Characteristics of water areas (4)	Delegates indicated that water provision was one of the most important aspects of a flamingo exhibit. A range of depths encourages a wide range of foraging behaviours including stamp-feeding, up-ending and swimming.
6. Hours of sunshine (4)	Orientation of the enclosure to achieve maximum exposure to sunlight benefits breeding success and can encourage a wide range of feeding activity (due to algal blooming) and social interactions (Figure 1).
7. Weather (4)	The climate that the zoo experiences will affect the number of days that flamingos need to be confined to indoor housing and therefore may restrict the birds' behavioural repertoire. Indoor housing should be large enough to provide the flock with the opportunity for perform social interactions, and to associate with preferred conspecifics (Figure 1), and opportunity for display.
8. Characteristics of nesting site (4)	A range of substrates to enable nest building and flat sanded areas to allow chicks to crèche in a clean, safe environment. Several delegates suggested that security in the form of visual barriers should be provided to incubating birds, to protect against abandonment of nests.
9. Characteristics of display area (4)	Delegates noted that an open expanse of water or a sanded area, in sunlight, seemed preferable for the birds. As flamingos will display all year round it is necessary to always maintain favoured display areas to ensure they are not obstructed.
10. Barriers within enclosure (4)	Especially important around nesting areas to mimic the security of a large colony for incubating birds. Barriers to prevent disturbance from zoo visitors can help with Factor 2.
11. Photoperiod (2)	Day length can be linked to feather condition, onset of moult and likelihood of courtship display. Specifically important for any indoor housing needs during inclement weather.
12. Substrate type (2)	An area of flamingo husbandry worthy of more investigation. However, some delegates report that estuarine sand (large, free draining particles that occur at the mouths of river), which is turned and raked for hygiene should be provided in loafing areas as it enhances foot health.

how to enrich their birds' lives. Measureable aspects of positive welfare (Yeates and Main 2008) can be incorporated into a plan for BH so that improvements to behavioural repertoires and enclosure usage, and any associated increase in visitor dwell time, are quantifiable. Thus by providing a state of heightened welfare that enables captive species to perform a wide range of biologically relevant behaviours, the educational message of the exhibit is enhanced, as explained further by Hill and Broom (2009). As such, zoo professionals should also consider the role that enhanced animal welfare plays in delivering the educational messages of the zoo as well as how it helps to add value to species that are on display.

Answering the workshop's key questions

The questions posed to delegates to guide the overall aim of the workshop were summarised by the organisers and reviewed with the group overall.

1) What is the social structure of the flock being managed and how important is each individual's place within that flock?

Observations by keepers help to identify flamingos that are central to the flock's cohesion and organisation. Collaboration between external research programmes and zoo staff can help to expand knowledge of individual flamingo behaviours and relationships with other birds. Long-term study can investigate how birds behave both in and outside the breeding season. Social structure can be especially important during the winter when, during periods of inclement weather, flamingos may need to be housed indoors. Reports of increased squabbling as birds are unable to stand or be near preferred partners need to be alleviated by good flock management and, if needed, movement of birds into other enclosures (P. Tovey, pers. comm.). Loss of juvenile condition due to overly aggressive adults, once youngsters are independent, has been noted by several collections, and has been rectified by moving birds into separate groups.

2) What scope do the birds have, within the confines of their enclosure, to change their activity patterns across the course of the day?

Provide the maximum amount of open space and sunlit areas for birds to use as the sun moves across their enclosure. Encourage use of open water by changing feeding style, providing a range of water depths and by implementing results (of behavioural studies) from question 1.

3) Where does aggression and conflict often occur and are there resource hotspots within an enclosure that promote antagonistic interactions?

Increase number of feeding areas to increase time spent foraging and reduce squabbling, as per Rose et al. (2014).

Figure 1. Different methods of filter feeding in captive Caribbean flamingos, and birds choosing to feed with certain enclosure-mates. Diversity within the flamingo's environment allows the birds to perform a range of foraging actions as well as exercise social choices. (Photo: P. Rose).

Provide opportunities, by manipulating distribution of birds, for preferential feeding associations to occur. Use space occupancy methods (Plowman 2003) to evaluate even or uneven enclosure usage to reduce hotspots of aggression around resources.

4) How can naturalistic, biologically important, behaviour patterns (e.g. feeding, foraging, courtship display) be promoted within housing and the wider exhibit using an underpinning knowledge of the flamingo's behavioural ecology?

Differences in the bill structure of flamingos affects the way in which each flamingo species is designed to forage. Provide a range of water depths and substrates that give the opportunity for different types of foraging in different locations. Likewise, ensure that indoor and outdoor pools have enough space for the whole flock to display together if required. Follow King's (2008) advice on bank incline to ensure easy access in and out of water to encourage group display. Provide light in indoor housing if birds need to be shut inside due to poor weather conditions.

5) How can enclosures be modified to make the flamingo more appealing to zoo visitors?

The prominent location of flamingo flocks in many zoos allows for high foot-fall of visitors past enclosure. With increased usage of enrichment and by providing birds with more opportunities for high profile behaviours (e.g. courtship display), a better interpretation of flamingo natural history, biology and conservation can be given. Novel viewing, such as "through the legs" viewing of birds by placing visitors in sunken hides, is valuable; for example, the new "Flamingo Lagoon" exhibit at WWT Slimbridge (M. Roberts, pers. comm. 2014).

Future topics for discussion and investigation

Discussion at this workshop identified several key areas for future research projects, as identified in Table 2 and above. Several keepers indicated that estuarine sand can be of benefit to flamingo foot health (especially when chicks are crèched). Flamingos with access to pools with natural mud substrates do not develop severe foot lesions (Wys et al. 2013). The welfare benefits of estuarine sand require more investigation, and substrate is likely to be one of many factors affecting flamingo foot condition (King and Bračko 2014; Wys et al. 2014). The effects of substrate on flamingo activity and associated benefits for foot health remain an area for investigation.

Discussion of ponds raised an interesting point about an increased diversity of foraging behaviours in response to deep water. Swimming and up-ending are seen in wild birds, and their performance has positive welfare implications. Through regular observations of flamingos, keepers develop a good understanding of their birds' needs. Keeper opinion is not peer-reviewed data, but as they have a strong understanding of their birds keepers can make excellent suggestions on areas of focus. To make use of keeper insight, research projects can be instigated to determine whether specific husbandry and enrichment types are beneficial to welfare.

Whilst mentioned by several delegates as a BH method for flamingos, salted areas in enclosures were not currently used by any of the institutions represented at the workshop, although they had been used by several zoos to alleviate foot problems in the past. Spreading salt around nesting areas, on foraging islands and in shallow flooded sections of a flamingo's enclosure mimics the natural habitat of all species. Such a salty environment may have long-term health benefits, but the empirical evidence for this is currently lacking. This example highlights one of the many new areas of applied research that should be a focus in captive flamingo populations, and supports the potential use of captive flamingos as scientific research populations (King 2000).

Directed research areas provide strong foundations to help guide flamingo-centric workshops in their task of answering specific husbandry-based, welfare-focused questions (see King and Bračko 2014; Rose et al. 2014). As 95% of delegates said that they would definitely recommend this form of workshop to a colleague, it is clear that keepers are keen to engage in more discussion on BH, and to continue exploring all aspects of flamingo management. Survey methods help identify best-practice husbandry approaches across zoos (Bračko and King 2014; King and Bračko 2014) and confirm a link between BH and good animal welfare. Getting zoo professionals together to share the knowledge that they possess further enhances the dissemination of good practice, and can help and support collections that may be newer to keeping flamingos in their goals for maintain a flock of these birds.

Workshop feedback

From feedback collected at the end of the workshop, all respondents were extremely positive about the event and its outcomes, and of these 72% felt that the content was excellent. When asked if the workshop would help respondents in their role in their respective zoos, 88% felt it would help during their day-to-day husbandry. Such data demonstrate the important role that keeper-led workshops have in furthering the attainment of high animal welfare standards in all zoos. It is evident that flamingo

keepers valued the opportunity to meet with their peers and share information and ideas on the best way to manage these birds. The following list outlines the most important aspects of the event that encouraged delegates to participate in the workshop:

- A good opportunity to network with others flamingo keepers
- Interested in knowing more about managing a small flamingo flock (to encourage it to grow in size)
- The overall programme of talks and events
- Flamingos are a focal species for institution
- Planning and designing a new flamingo exhibit
- Considering flamingos as a new species in the zoo.

It is hoped that other flamingo keepers, and other institutions, will recognise the importance of enclosure design and its complexity for these long-lived birds. With careful management and maintenance, exhibits can be made into an environment that provides interesting and stimulating outputs for behaviour all year round. Both keepers and zoo managers are interested in growing smaller flocks, and this is beneficial to the future sustainability of captive flamingo populations. Larger flock sizes also provide more behavioural enrichment opportunities for the birds themselves and hence further develop positive welfare states.

Encouraging dissemination of best practice that ultimately enhances an animal's quality of life in the zoo is well explained by Bloomsmith (2009); uptake of useful information to change husbandry and the exhibition of species also improves the connectivity of the audience (zoo visitors) with nature (Patrick et al. 2007), thus potentially further strengthening the value of zoos' animal collections (and the four underpinning aims of zoos). The use of research projects to enhance the husbandry of flamingos is a beneficial form of collaboration between zoos and academic partners that encourages further development of evidence-based management practice. Such relationships between zoos and universities ultimately help guide applied research that enhances the lives of the species kept, improves the visitor experience and positively impacts upon the day-to-day role of animal keepers (Fernandez and Timberlake 2008).

Conclusions

1. Flamingo keepers are already using a range of environmental and behavioural enrichment techniques to improve the birds' quality of life and to enhance the display of flamingos to zoo visitors. Communication through this workshop has helped to advance the knowledge of these keepers further.
2. The hypothetical points system designed by King (2008) has a real value in helping keepers identify positive and negative aspects of enclosure layout and to make changes accordingly.
3. BH can be useful in helping to manage a flamingo flock at different times of the year as well as encouraging flamingos to engage in a range of different behaviour patterns.
4. Workshops have been shown to be a valuable communication tool for advancing captive flamingo husbandry, and may be of use for developing BH protocols for other zoo species.

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