BIAZA awards 2019
Celebrating Excellence
Submission form

Please refer back to required marking criteria when completing this form.
MAX 2000 WORDS, including abstract, excluding references

Award category	**Research**
Name of zoo or aquarium	WWT Slimbridge
Contact name	
Position	
Email address	
Tel number	01453 891900
Title of project	**An evaluation of flamingo nocturnal activity**

ABSTRACT *(max 250 words)*

- *The background to the investigation that supports the aims and hypothesis.*
- *The key aim of the research that supports the methods chosen.*
- *The methods used to collect data and the species/ system used for data collection.*
- *The important results that have been generated from raw data.*
- *The overall conclusions and key "take-home" message from the research project.*

Observational data are commonly used to evaluate the appropriateness of husbandry and housing for zoo animals, normally collected during daytime opening hours. However, animal behaviour is not often monitored overnight. Measurement of time-activity budgets and enclosure usage across a 24-hour cycle would yield helpful data on "behavioural normality" in the zoo. This project built on previous research investigating captive flamingo welfare and behaviour- using data on daytime activity budgets calculated at WWT Slimbridge Wetland Centre alongside of published data on nocturnal behaviour of wild flamingo flocks. This project presents results for two species (greater, *Phoenicopterus roseus,* and lesser, *Phoeniconaias minor,* flamingos) and provides an extension to this research method using a third species- the Andean flamingo *(Phoenicoparrus andinus)*. Night-vision trail cameras placed in and around each enclosure took photos of the birds at given intervals, with behavioural data being recorded by a scan sampling protocol similar to that used in first-hand observations. Results show that flamingos can be more active in the evening and overnight compared to during the daytime, and that wider enclosure usage is noted overnight. Species differences are apparent in findings and lesser flamingos housed indoors had a more restricted nocturnal activity pattern compared to greater flamingos with 24-hour outdoor access. If flamingos are housed indoors for long periods during disease outbreaks (for example) such evidence on preferential zone usage and degree of nocturnal activity when not space restricted can be useful for enabling naturalistic time budgets when animal health considerations are influencing management practice.

Project Aims
(Include: rationale and specific aims)

- *What is the question being answered by this research project?*
- *What is the objective of the project? How is the aim being addressed?*
- *Why was this species/ study system chosen?*
- *(if relevant) What null (H0) and alternative (H1) hypotheses were suggested and tested by the methods?*

There were three key reasons for undertaking this project:

i) To learn more about flamingo behaviour across a full 24 hr period.
ii) To provide evidence for best practice husbandry during period of disease outbreak and enforced indoor housing.
iii) To answer a previously published research question related to advancing positive welfare states in zoo flamingos.

There is wealth of information present on time-activity budgets of animals during the daylight opening hours of the zoo (Hosey, 1997), but relatively few papers on nocturnal behaviour and enclosure usage after zoo staff have gone home. Mammals predominate the output from behavioural research in zoos (Rose, 2018a) and in those papers on in-zoo nocturnal activity (Brockett et al., 1999; Duggan et al., 2016; Tennant et al., 2018; Wilson et al., 2006); this project could find no peer-reviewed articles on nocturnal (zoo) bird time-activity budgets.

Based on a literature search for previous work on the behavioural diversity and enclosure usage of flamingos held at WWT Slimbridge (Rose et al., 2018a), several sources were located that document the nocturnal activity of wild Caribbean *(Phoenicopterus ruber)*, greater and lesser flamingos (Britton et al., 1986; Rendón-Martos et al., 2000; Robinson, 2015; Tindle et al., 2014). Each paper suggests a wide range of locomotory and foraging activities to be present at night.

Therefore, the aim of this project was to determine the nocturnal time budget and enclosure usage of a commonly-housed, non-mammalian zoo animal, using two flamingo species that, in the wild, are noted has having differing nocturnal time to diurnal time budgets.

Based on changes to husbandry caused by outbreaks of Avian Influenza in the UK across the winters of 2016/2017 and 2017/2018, it was felt necessary to understand “what do flamingos do” at night when they are being confined to indoor houses for the full duration of an Avian ‘Flu episode. Given that some data were collected prior to this period of enforced housing, there was evidence for the importance of key enclosure resources and their influence on behaviour, that could be evaluated alongside of behavioural data when access to these resources was restricted.

Finally, a paper written by WWT and University of Exeter researchers for the International Zoo Yearbook posed a range of research questions that should be answered to further evidence good in-zoo flamingo husbandry (Rose et al., 2014). Assessment of nocturnal activity was one of these questions.

The hypotheses for this study were:
That “empty” or less frequently used enclosure areas (during daytime) will be occupied more frequently over-night.
That captive flamingos can follow a cycle of nocturnal activity noted in free-living flocks if provided with *ad lib* outdoor access.

The key objective was to record behaviour across a 24-hour timescale using remote cameras, without the need for an observer. As the flamingos at WWT Slimbridge can have continual outdoor access (except in cases of disease outbreak or periods of inclement weather), and are therefore not spatially restricted, remote cameras provided a more complete dataset on bird location and activity than a human recorder using specific sampling intervals.

Partnership organisations/funders

- *Who else was involved in organising and creating the project, collecting data, accessing study specimens, providing supervision and producing a final report?*
- *Who provided financial help and assistance with the implementation of the research project?*

This project was in collaboration with WWT, the University of Exeter and Sparsholt College Hampshire (SCH). Night-vision cameras were provided by the University of Exeter and by SCH. MSc students at the University of Exeter and at SCH coded behavioural data from photographs, after training at WWT.

WWT provided access to the birds, maps and details of each exhibit and allowed placement of the cameras in and around the enclosures of these two flocks. The main investigator (Paul Rose) was responsible for maintaining cameras, sharing photos with students and supervising the experimental design and final project write-ups.

James Brereton at SCH volunteered on the greater flamingo study, coding behavioural data from photos that the first student did not include in her thesis and received the same training as the MSc students.

The main investigator then re-evaluated any data analysis from these completed datasets and worked with the students on publication of conference papers and a journal article, as well as on dissemination of the project's findings across more keeper-focussed forums.

Project Description

(Include: dates and timeframe, completed/ongoing, clear and replicable methodology)

- *Species/study system chosen and why.*
- *Timeframe for data collection including all relevant information on the chronology of data collection.*
- *Relevant information on study location and replicates (if relevant).*
- *Details of how hypotheses were tested based on methods of data collection.*
- *If changes to animal husbandry were involved, explanation of how and why this was performed (including ethical considerations for upholding good welfare).*
- *Any information on direct sampling or invasive sampling needs to be detailed alongside of appropriate legislation and licensing and should provide clear details on permits (when obtained, for how long and for whom).*
- *Personal involved in data collection and completion of the research (i.e. undergraduate students, postgraduate students, zoo staff, zoo researchers, external researchers). Provide details on all collaborations.*
- *Ensure that methods are valid and repeatable and that all details of inferential analyses are provided for each study question in turn.*

Greater flamingos are common in captivity and are therefore representative of flamingos across zoos. Lesser flamingos are a specialised species with a poorer record of breeding and population sustainability (Bračko & King, 2014; King & Bračko, 2014), and therefore investigating a full 24-hour activity pattern may help further decipher their specific needs when housed in the zoo.

Project planning commenced in September 2015, with cameras obtained in January 2016 for the greater flamingo flock. Cameras were tested January-February before data collection from March-July 2016. An MSc student conducted diurnal observations (April to July) to feed into a wider study on flamingo sociality and compared her diurnal time budgets against camera data to check the validity of the observation methods.

For the lesser flamingo project, data collection commenced in January 2018 (during the Avian Influenza containment period) and ran until the end of July 2018. This MSc student did no direct observation, as the previous project on the greater flamingos showed that behavioural data could be collected in sufficient detail from the cameras alone.

Both students used a pre-defined ethogram available in Rose et al. (2018a) and zoned enclosures based on this paper too. The only change to enclosure zoning for the greater flamingo project was that areas of the pool were categorised by depth (flamingos could wade up to their ankle, up to their knee or had to swim). These pool classifications are detailed in Rose et al. (2018b).

The project's extension (to look at time spent on nests and tending to young by foster parent Andean flamingos given Chilean flamingo, *Phoenicopterus chilensis*, eggs/chicks) used one camera that was not required for observations on the lesser flamingo enclosure. This extension project ran for the month of July 2018 and data have been sorted but not yet analysed.

Data collection and analysis

Four Denver 1080p 8MP night-vision cameras were obtained for these projects. For greater flamingo data collection, three cameras were fixed around the outside enclosure only. For lesser flamingo data collection, one camera was placed in the flamingo house and two covered the outside enclosure. A spare camera was used for Andean flamingo observations. The mild winter in 2016 meant that the greater flamingos were not inside during observations, whereas the lesser flamingos were housed indoors until March and then had *ad lib* access between house and outside enclosure. Cameras were set to be activated once every five minutes, and behaviour recorded as per an instantaneous scan sample (Martin & Bateson, 2007). Cameras were calibrated to the same time and the number of birds at each activated sample point counted (location and what they were doing). Batteries and memory cards were changed every two weeks. The main investigator was responsible for this as it meant liaising with animal keepers to service the indoor lesser flamingo camera when daily cleaning/feeding was occurring or when the birds were not inside.

Data Analysis

The total visible population across all cameras were counted and proportions of behaviours recorded. Enclosure usage for both lesser and greater flamingos was calculated using the modified Spread of Participation Index (Plowman, 2003). Repeated-measures and mixed-effects models where run in R studio. The influence of time of day on behaviour and enclosure usage was analysed using a repeated measures ANOVA with date blocked as a random factor. Changes across season (and influences on behaviour and enclosure usage, and the interaction between them) was analysed using mixed effects models, via the lmerTEST package in R studio (Kuznetsova et al., 2016). Time-activity budgets of the flamingos across date, season and time were presented graphically, and mean flock-wide SPI values were plotted against time of day. From the analysis on overall activity patterns, differences in foraging activity was further analysed (again using a repeated measures ANOVA) as influences in time spent foraging with time of day was most prominently noted in the literature. Zone occupancy and number of foraging birds was then plotted to determine the trends, over time of day, of where feeding behaviour was likely to occur. The number of birds seen in different areas of the pool was then analysed using chi-squared testing.

Project Outcomes

(Include: results, evidence of impact)

- *What results have been generated from data collection to answer your aims and hypotheses?*
- *How do results meet the aims, objectives and rationale of the research project?*
- *How is practice or the academic literature enhanced by this project?*
- *What areas for future extension could arise from this project?*

Greater flamingos had higher rates of foraging at specific times of the night and displayed more even enclosure usage compared to daylight hours. Birds are using land areas for loafing, preening and resting during the daytime, and then spreading over a wider area of their pool during the night. Change in pool use is apparent throughout the course of the day and night, suggesting that different areas of water depth are used by these flamingos at different times. These greater flamingos also increased nocturnal foraging in their pool during the breeding season, which may be explained due to increasing demands from their chick for crop milk.

A significant influence of time of day on the overall proportion of flamingos seen active ($F_{23, 2735.3}$= 18.578; r^2= 59.6%; P< 0.001) was found, with significant increases in activity occurring specifically in the evening, 5pm to 9pm, (estimate= 0.4478; SE= 0.03186; t= 14.052; P< 0.001). Significant differences in enclosure zone occupancy are also apparent ($F_{23, 3736.3}$= 106.42; P< 0.001) with lower SPI values more likely at night (estimate= -0.5560; SE= 0.02894; df= 0.003272; t= 19.21; P< 0.001).

A significant relationship for time of day and number of birds foraging ($F_{23, 3734.3}$= 41.66; r^2= 63.8%; P< 0.001) was detected, with more flamingos foraging at 22:00 compared to 08:00 (estimate= 11.65; SE= 2.42; df= 3734.94; t value= 4.81; P= 0.0004). And fewer flamingos foraged at 02:00 compared to 20:00 (estimate= -22.34; SE= 4.73; df= 3735.85; t value= -4.73; P= 0.0006). To remove any influence of feeding area (and hence availability of flamingo pellet) on the number of flamingos observed foraging, the feeding area within the pool was separated as a specific zone. The occupancy of this feeding area does not spike at specific points of the day, suggesting that flamingos are using the wider areas of their pool to forage and come in to trickle feed on their flamingo pellet. This result is available in Rose et al. (2018b).

Pool usage changes across time, and a significant difference in foraging site occupancy (when pool zone is blocked by time of day) is apparent (χ^2= 35.49; df= 23; P= 0.046). More birds use the deeper areas of the pool during the evening and overnight. Again, please see Rose et al. (2018b) for the graph of this result.

The behaviour of lesser flamingos is more difficult to specifically categorise, with birds potentially being cathemeral. Mixed-effect models found that both indoor and outdoor SPI was significantly affected by time code- $F_{5, 869.12.70}$= 3.49; r^2= 21.10%; P= 0.004 and $F_{5, 735.28}$= 14.63; r^2= 22.5%; P< 0.001 respectively, with wider enclosure apparent in the evening. Location within the enclosure influenced activity, as well as time of day for the lesser flamingos. when flamingos were observed indoors, activity was higher during the day yet when recorded outdoors, it was highest in the evening and at night ($F_{5, 832.6}$= 7.13; R^2= 17.77%; P< 0.001 and $F_{5, 742.96}$= 13.57, R^2= 22.75%; P< 0.001 respectively. Please see Chapman et al. (2018) for the graphs supporting these results. A behavioural benefit to the outdoor access to pools for increased activity (foraging?) maybe important for this species, especially as literature on wild lesser flamingo behaviour notes a wider range of foraging (especially foraging whilst swimming) performed by this species at night (Robinson, 2015).

Finally, to further support the need for continued investigation into night-time observation of captive flamingos, photographic records from the camera directed at the Andean flamingo flock during their chick rearing process showed evidence of crop milk feeding in the middle of the night. These photos were presented to bird keepers at the BIAZA Bird Working Group meeting in October 2018, available in Rose (2018b). This insight into the breeding behaviour of a specialised flamingo, captured for the first time using nocturnal cameras (as far as the author is aware), provides clear evidence that husbandry regimes need to provide for the performance of such essential behaviours overnight if they are important to survival and breeding. Changes to enclosures to increase pool access, to give a wider choice of pool depth and more space for birds to forage naturally without harassment may encourage more successful reproductive events in species such as the lesser flamingo in the future.

Wild flamingos demonstrate time-activity budgets of feeding, preening and resting (Espino-Barros & Baldassarre, 1989) and loafing flocks spend the majority of their time asleep, usually in the middle of the day (Boukhriss et al., 2007). Increased foraging and movement seen overnight (Britton et al., 1986) demonstrates a difference between diurnal and nocturnal activity patterns. Our study shows that captive flamingos can follow a natural activity pattern that equates with wild birds. The increase in enclosure usage (lower nocturnal SPI values) and the increase in evening/night-time foraging shows these flamingos following a similar activity pattern to wild birds (i.e. more use of water compared to loafing and preening in one location during the day). This project therefore evidences an example of good animal welfare and biologically-relevant husbandry and enclosure design, whilst noting the importance of species-specific differences in behavioural ecology that must be factored in to how animals are maintained in *ex situ* populations.

Dissemination
(Include internal and external)

- *Papers (scientific peer-reviewed articles, magazines, technical/subject-specific publications, popular press).*
- *Conference papers (posters, talks, abstracts, proceedings).*
- *Book chapters.*
- *Online e-magazines, official zoo blogs or similar.*
- *Internal reports and/or evidence that practioners have had access to the output from the research (e.g. dissemination of student theses to relevant animal departments).*

The main findings of the greater flamingo study were published in Zoo Biology in 2018, following on from an article covering the time-budgets of flamingos published in Applied Animal Behaviour Science in 2018.

The PhD thesis of the main investigator contained a chapter on nocturnal flamingo behaviour (Rose, 2018c), and two MSc theses (one on greater and one on lesser flamingos) have also been completed and disseminated to WWT flamingo keeping staff for their interest.

Several conference papers have been presented on from this work. A paper that told the story of the relevance of understanding what animals do when their keepers go home (using the greater flamingo data as an example) was presented at the European Conference on Behavioural Biology in Liverpool in August 2018, and a summary of the lesser flamingo project was presented at the Association for the Study of Animal Behaviour winter meeting at ZSL in December 2018.

A presentation was given by the main investigator at the 2018 BIAZA Bird Working Group meeting to update zoo staff on the importance of over-night pool usage. This presentation also included information on the extension to the project- the fostering behaviour in the Andean flamingos. Some nocturnal data, including information on both greater and lesser flamingos, was presented at ABWAK's 3rd Flamingo Keepers' Workshop in July 2016 (Rose, 2018d) and this information was also included in a write-up of this event for ABWAK's journal "Ratel" (December 2018).

The project also featured on WWT's media channels: In the WWT Flamingo Diary and as a story for "WildWatch" (WWT's video blog). This has brought the project to the wider attention of the visitors and the general public outside of the zoo world or scientific circles.

Support material enclosed
(Please list here, only include material which provides significant additional evidence of meeting the judging criteria)

- *All output from the research project that has been referred to in the report should be listed here. Full copies of projects, papers, posters, abstract etc. are not required in the submission but MUST be available if requested by the judging panel after submission. Failure to provide full copies of all outputs may result in your submission being unsuitable for judging.*

<u>Peer-reviewed papers</u>

Rose, P. E., Lloyd, I., Brereton, J. E., & Croft, D. P. (2018). Patterns of nocturnal activity in captive greater flamingos. *Zoo Biology, 37*(5), 290-299.

Rose, P. E., Brereton, J. E., & Croft, D. P. (2018). Measuring welfare in captive flamingos: activity patterns and exhibit usage in zoo-housed birds. *Applied Animal Behaviour Science, 205*, 115-125.

<u>Academic conference presentations</u>

Chapman, J., Brereton, J. E., Riley, L. M., & Rose, P. E. (2018). *The challenges of collecting behavioural data 24/7: Using a novel camera trap methodology to investigate nocturnal behaviour*

in captive flamingos. Paper presented at the ASAB Winter Conference, ZSL London Zoo, London, UK.

Rose, P. E., & Croft, D. P. (2018). *Considering behaviour 24/7; nocturnal activity and animal welfare in the zoo.* Paper presented at the ECBB 2018, Liverpool John Moores University, Liverpool, UK.

Presentations to keepers and zoo professionals

Rose, P. E. (2018b). *WWT flamingo science update*. Paper presented at the BIAZA Bird Working Meeting 2018, Marwell Wildlife, Marwell, UK.

Rose, P. E. (2018d). *Greater flamingos at night*. Paper presented at the ABWAK 3rd Flamingo Keepers' Workshop, ZSL London Zoo, London, UK.

A write-up of the outcomes of the ABWAK flamingo keepers' workshop, including the relevance of nocturnal observation to flamingo husbandry was published in Ratel in December 2018.

University theses

Chapman, J. (2018). *The nocturnal behaviour and enclosure usage of captive lesser flamingos at WWT Slimbridge Wetland Centre.* (MSc Applied Zoo Biology), University Centre Sparsholt, Sparsholt, UK.

Lloyd, I. (2016). *Nocturnal behaviours of captive flamingos and implications for welfare.* (MSc Animal Behaviour), University of Exeter, Exeter, UK.

Rose, P. E. (2018c). *Investigating the behaviour and welfare of captive flamingos (Phoenicopteridae).* (PhD), University of Exeter, Exeter, UK.

Popular press / media

WWT flamingo diary entries. When results were documented: https://www.wwt.org.uk/wetland-centres/slimbridge/diaries/flamingo-diary/2018/02/27/flamingos-are-they-owls-or-larks/14299 and at the start of the project: https://www.wwt.org.uk/wetland-centres/slimbridge/diaries/flamingo-diary/2016/09/13/a-day-in-the-life-of-a-wwt-flamingo-keeper/11208

On the University of Exeter website https://www.exeter.ac.uk/news/research/title_680541_en.html this story was picked up by several global media outlets, highlighting the public's interest in the goings-on of zoo animals after hours.

References
(To support rationale)

- *Please list all publications that have been used within your submission (that are not outputs from the research project itself) that have been used to explain, evidence, support and validate the background, aims, rationale, hypotheses, methods and experimental design of your study.*
- *Hard copies of supporting literature are NOT required but please ensure that full, complete and accurate reference information is given for each and every citation.*

Boukhriss, J., Selmi, S., Bechet, A., & Nouira, S. (2007). Vigilance in greater flamingos wintering in Southern Tunisia: age dependent flock size effect. *Ethology, 113*(4), 377-385.

Bračko, A., & King, C. E. (2014). Advantages of aviaries and the Aviary Database Project: a new approach to an old housing option for birds. *International Zoo Yearbook, 48*(1), 166-183.

Britton, R. H., de Groot, E., & Johnson, A. R. (1986). The daily cycle of feeding activity of the greater flamingo in relation to the dispersion of the prey Artemia. *Wildfowl, 37*, 151-155.

Brockett, R. C., Stoinski, T. S., Black, J., Markowitz, T., & Maple, T. L. (1999). Nocturnal behavior in a group of unchained female African elephants. *Zoo Biology, 18*(2), 101-109.

Duggan, G., Burn, C. C., & Clauss, M. (2016). Nocturnal behavior in captive giraffe (Giraffa camelopardalis): a pilot study. *Zoo Biology, 35*(1), 14-18.

Espino-Barros, R., & Baldassarre, G. A. (1989). Activity and habitat-use patterns of breeding Caribbean flamingos in Yucatan, Mexico. *The Condor, 91*(3), 585-591.

Hosey, G. R. (1997). Behavioural research in zoos: Academic perspectives. *Applied Animal Behaviour Science, 51*(3–4), 199-207.

King, C. E., & Bračko, A. (2014). Nineteen years of management for Phoenicopteriformes in European Association of Zoos and Aquaria institutions: The Fabulous Flamingo Surveys and strategies to increase reproduction in captivity. *International Zoo Yearbook, 48*(1), 184-198.

Kuznetsova, A., Brockhoff, P., & Christensen, R. H. B. (2016). lmerTest: Tests in Linear Mixed Effects Models. R package version 2.0-33. . https://CRAN.R-project.org/package=lmerTest.

Martin, P. R., & Bateson, P. P. G. (2007). *Measuring behaviour: an introductory guide* (3rd ed.). Cambridge, UK: Cambridge University Press.

Plowman, A. B. (2003). A note on a modification of the spread of participation index allowing for unequal zones. *Applied Animal Behaviour Science, 83*(4), 331-336.

Rendón-Martos, M., Vargas, J. M., Rendón, M. A., Garrido, A., & Ramírez, J. M. (2000). Nocturnal movements of breeding greater flamingos in southern Spain. *Waterbirds: The International Journal of Waterbird Biology, 23*(Special Publication 1: Conservation Biology of Flamingos), 9-19.

Robinson, V. J. (2015). *The ecology of East African soda lakes: implications for lesser flamingo (Phoeniconaias minor) feeding behaviours.* (PhD), University of Leicester, Leicester, UK.

Rose, P. E. (2018a). Ensuring a good quality of life in the zoo. Underpinning welfare-positive animal management with ecological evidence. In M. Berger & S. Corbett (Eds.), *Zoo animals: Behavior, welfare and public interactions* (pp. 141-198). New York, USA: Nova Science Publishers Inc.

Rose, P. E., Croft, D. P., & Lee, R. (2014). A review of captive flamingo (Phoenicopteridae) welfare: A synthesis of current knowledge and future directions. *International Zoo Yearbook, 48*(1), 139-155.

Tennant, K. S., Segura, V. D., Morris, M. C., Snyder, K. D., Bocian, D., Maloney, D., & Maple, T. L. (2018). Achieving optimal welfare for the Nile hippopotamus (Hippopotamus amphibius) in North American zoos and aquariums. *Behavioural Processes, 156*, 51-57.

Tindle, R. W., Tupiza, A., Blomberg, S., & Tindle, E. (2014). The biology of an isolated population of the American flamingo Phoenicopterus ruber in the Galapagos Islands. *Galapagos Research, 68*, 15-27.

Wilson, M. L., Bashaw, M. J., Fountain, K., Kieschnick, S., & Maple, T. L. (2006). Nocturnal behavior in a group of female African elephants. *Zoo Biology, 25*(3), 173-186.

Any other comments

- *Any other information that supports and upholds the project, its outputs and applications.*

Information on how to these methods and how to record nocturnal behaviour of flamingos (specifically how to look at the breeding behaviour of lesser flamingos when indoors) has been provided to researchers in EAZA looking to investigate behavioural influences on breeding success

in this species over the next year or so. Changes to the lighting of the Caribbean flamingo house at WWT Slimbridge, and alterations to roosting and bathing areas have been implemented since this project ran to increase space for the birds when housed inside as well as encouraging more time spent foraging (photos of these housing alterations are available on request).

Office use only	
Date received	
Date of selection panel	
Outcome	