

EMPLOYMENT OF WEB-BASED IMAGES AND A LIVE WEB CAM IN THE EXAMINATION OF LATERAL NECK-RESTING PREFERENCES IN THE AMERICAN FLAMINGO (*PHOENICOPTERUS RUBER*)

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Abstract: When flamingos rest they typically lay their heads on their backs. This forces the birds to curve their neck to either the right or left of their center of gravity. Previous research revealed that American Flamingos (*Phoenicopterus ruber*) on exhibit at the Philadelphia Zoo (Philadelphia, PA, USA) demonstrate a significant population-level preference for resting their necks to the right. In the present report efforts were made to replicate this finding in other flamingo populations, as well as evaluate the potential utility of several novel methodologies in behavioral studies. Study 1 employed an archival web-based image search technique, and yielded a slight, but non-significant, preference for resting the neck to the right for all flamingo species. Study 2 utilized a live web cam at the Smithsonian National Zoological Park (Washington, DC, USA) to more systematically observe a single flock of American Flamingos, and successfully demonstrated a significant preference for right neck-resting. The results of these two studies suggest that this preference is generalizable to other populations of American Flamingo, and perhaps may be present in other flamingo species as well. Advantages and disadvantages of the two employed techniques are discussed.

Key words: American Flamingo, archival research, images, laterality, *Phoenicopterus ruber*, resting, web cam

Resumen: USO DE IMÁGENES EN VIVO Y DE LA WEB PARA EXAMINAR LAS PREFERENCIAS DE DESCANSO DEL CUELLO EN POSICIÓN LATERAL DEL FLAMENCO AMERICANO (*PHOENICOPTERUS RUBER*). Generalmente cuando descansan, los flamencos ubican sus cabezas sobre sus espaldas. Esto fuerza a las aves a curvar sus cuellos, ya sea a la izquierda o derecha de su centro de gravedad. Investigaciones anteriores revelaron que el Flamenco Americano (*Phoenicopterus ruber*) en exhibición en el Zoo de Filadelfia (Filadelfia, PA, USA) muestra una preferencia significativa a nivel poblacional por descansar sus cuellos sobre el lado derecho. En el presente reporte se llevaron a cabo esfuerzos para replicar estos resultados en otra población de flamencos así como para evaluar la utilidad potencial de varias metodologías nuevas en estudios conductuales. En el estudio 1 se empleó una técnica de búsqueda de imágenes archivadas en la web y se encontró una ligera, pero no significativa, preferencia de descansar el cuello hacia la derecha en todas las especies de flamencos. El estudio 2 utilizó una cámara web en tiempo real en el Smithsonian National Zoological Park (Washington, DC, USA) para observar con más sistematicidad un bando de flamencos y demostró exitosamente, una preferencia significativa por descansar el cuello hacia el lado derecho. Los resultados de ambos estudios sugieren que la preferencia es generalizable a otras poblaciones de Flamenco Americano y quizás esté presente en otras especies también. Se discuten las ventajas y desventajas de las dos técnicas empleadas.

Palabras clave: descanso, cámara web, Flamenco Americano, investigación de archivo, imágenes, lateralidad, *Phoenicopterus ruber*

Résumé : UTILISATION D'IMAGES INTERNET ET D'UNE WEBCAM POUR L'OBSERVATION DES PREFERENCES DANS LA POSITION LATÉRALE DE REPOS DU COU CHEZ LE FLAMANT DES CARAÏBES (*PHOENICOPTERUS RUBER*). Lorsque les flamants se reposent, ils posent de manière caractéristique leur tête sur leur dos. Cela les oblige à courber leur cou vers la droite ou vers la gauche de leur centre de gravité. Des recherches antérieures ont montré que les Flamants des Caraïbes (*Phoenicopterus ruber*) du zoo de Philadelphie (Pennsylvanie, États-Unis) préféraient significativement courber le cou vers la droite. Dans la présente étude, il a été tenté de répliquer ces résultats sur d'autres populations de flamants et d'évaluer l'utilité potentielle de plusieurs nouvelles technologies pour les études comportementales. La première étude a utilisé une technique de recherche basée sur des images d'archives sur internet et a montré une préférence légère mais non-significative de la courbure du cou vers la droite chez toutes les espèces de flamants. La deuxième étude a utilisé une webcam placée au Parc Zoologique National Smithsonian (Washington, District de Columbia, États-Unis) pour observer plus systématiquement un groupe de Flamants des Caraïbes. Une préférence significative de la courbure du cou vers la droite a ainsi été démontrée. Les résultats de ces deux études suggèrent que cette préférence est généralisable à d'autres populations de l'espèce et pourrait être présente chez d'autres espèces de flamants. Les avantages et les inconvénients des deux techniques font l'objet d'une discussion.

Mots clés : Flamant des Caraïbes, images, latéralité, *Phoenicopterus ruber*, recherche d'archives, repos, webcam

Behavioral laterality occurs when one half of an organism's body is more dominant or preferentially employed when engaging in a specified behavior. The most well known example of lateral behavior is the handedness displayed by humans (e.g., Corballis 1989, Bryden *et al.* 1997), but it is by no means the only instance of this phenomenon. Behavioral laterality is presumed to be indicative of underlying neurological asymmetries and hemispheric dominances (e.g., Rasmussen and Milner 1977, Amunts *et al.* 1996) and, as such, its observance may provide some insight into the workings of the brain.

Whereas, behavioral and neurological asymmetries were once assumed uniquely human (e.g., Corballis 1993), countless recent investigations have suggested such asymmetries exist in a variety of non-human animal species. These range from more frequently encountered animals such as the domestic chick (e.g., Dharmaretnam and Andrew 1994, Casey and Martino 2000), homing pigeon (e.g., Skiba *et al.* 2002), and horse (Austin and Rogers 2007), to more exotic ones such as elephants (Martin and Niemitz 2003) and baboons (Casperd and Dunbar 1996). Indeed, studies employing such animal subjects have provided much insight into the function and development of laterality (for review see Güntürkün 2005, Halpern *et al.* 2005, Vallortigara and Rogers 2005).

Two levels of behavioral laterality can be distinguished. First are individual-level lateral preferences, in which an organism displays a preference for performing some act with one side over the other. For example, any one domestic chick may preferentially employ its left eye when scouting for aerial danger and its right when looking for food (e.g., Evans *et al.* 1993, Rogers *et al.* 2004). The obvious functional advantage of such laterality is that it permits the individual to multitask and reduces neurological redundancy (e.g., Rogers 2000, Vallortigara and Rogers 2005, Rogers *et al.* 2004).

In addition to laterality at the individual level, population-level lateral preferences occur, in which the majority of individuals from a group display similar lateral asymmetries. Just as the majority of humans are right handed (e.g., Corballis 1989, 1993), most domestic chicks display the behavioral preferences described above (e.g., Rogers 1990). The functions of population-level asymmetries are not as intuitively obvious, but are thought to allow for coordination (Bisazza *et al.* 2000) and social cohesion (Rogers and Workman 1989) across the members of the group.

To further examine the possibility that group-

level laterality serves some social function, we recently undertook a series of studies examining laterality in the highly gregarious American Flamingo (*Phoenicopterus ruber*). Flamingos are some of the world's most highly social animals, occurring in the wild in flocks of hundreds to thousands of birds (Kear and Duplaix-Hall 1975, Ogilvie and Ogilvie 1986, Johnson and Cézilly 2007). If group-level laterality serves some social function, one would expect to obtain evidence of population level lateral preferences in flamingos. When flamingos rest, they typically lay their heads on their backs. To achieve this positioning, they are forced to curve their necks to either the right or left of their center of gravity (in the shape of an 'S'; Fig. 1). In an observational study of flamingos conducted at the Philadelphia Zoo, Anderson *et al.* (2009) recently demonstrated both individual and population-level lateral preferences for resting the neck to the right. Further studies revealed that those birds that preferred to rest their necks to the left, differing from the majority of birds in the flock, were more likely to be involved in aggressive encounters (as either aggressor or target) than those preferring to rest their necks to the right (Anderson *et al.* 2010). Whereas these findings are clearly in support of a social function of population-level laterality, additional research examining flamingos outside of the Philadelphia Zoo is necessary to determine whether the preference for right neck-resting is specific to this flock or generalizes to additional groups of flamingos.

Thus, in the present report we attempted to obtain evidence of a right neck-resting preference in American Flamingos beyond those held at the Philadelphia Zoo. To achieve this goal, we employed two unique methods: an archival web-based image search, and an observational study implementing the flamingo web cam maintained by the Smithsonian National Zoological Park (Washington, DC). In addition to determining the generalizability of the right neck-resting preference of American Flamingos, we attempt to document the benefits and difficulties encountered when employing such methods.

STUDY 1: AN ARCHIVAL STUDY OF NECK-RESTING PREFERENCES IN FLAMINGOS EMPLOYING WEB-BASED IMAGE SEARCH

Anderson *et al.* (2009, 2010) found that American Flamingos at the Philadelphia Zoo prefer to rest their necks to the right as opposed to the left. The present study attempted to establish the generalizability of this finding by obtaining a broad sample of images of resting flamingos from the six flamingo

species. Multiple raters then scored these images to determine the existence of a broad neck-resting preference.

METHODS

Materials.—The software package WebImageGrab Pro (Version 5 for MAC OS X; developed by sas21; Hamburg, Germany) was used to obtain images of resting flamingos. WebImageGrab Pro is an image search browser that allows the user to take a snapshot, of sorts, of all images available online at a given moment. The user defines the search terms and parameters, and the software downloads all images found by Google Images (<http://images.google.com>; retrieved 17 February 2009) at that particular point in time directly to the user's hard drive or other destination as designated by the user. As online content is constantly changing, this program allows one to temporarily save all images

presently available online so that they may be employed in archival research. With this program, users are able to set several parameters for searches and downloads, as well as employ various filters. The searches described in the present report utilized the default choices established by the software developer for each of these options with one exception: the "Download Limit" was changed from "100" (the default choice) to "1000" in order to maximize the number of obtained images.

Procedure.—Prior to the analysis of those images obtained for the study proper, M. J. Anderson trained three other individuals (J. L. Urbine, C. Wilson, and L. Calabro) to serve as raters with several sample images (not included in the present research sample) containing flamingos resting their necks either to the right or left. Raters were instructed to count only those birds which could be clearly seen resting their heads on their backs and having their



Fig. 1. American Flamingos (*Phoenicopterus ruber*) resting their necks to the left (closest to camera) and right. Anderson *et al.* (2009) have demonstrated both individual and population-level lateral preferences for right neck-resting. Photo by M. J. Anderson.

necks curved in either direction. The raters were told to not count birds for which there was any degree of uncertainty. WebImageGrab Pro was used to conduct an archival search of resting flamingo images. On 17 February 2009 at approximately 1100, pictures of flamingos were obtained via WebImageGrab in two searches with the terms “sleeping flamingos” and “resting flamingos.” The files obtained via these searches were pooled to provide as many images as possible ($n = 1,324$). The four independent raters (Anderson, Urbine, Wilson, and Calabro) viewed these files and counted the number of flamingos seen resting their necks to the right and left. The number of right and left observations for each file was averaged across the four raters. The vast majority of the photos failed to contain any flamingos whatsoever. Ultimately, only 151 (11%) of the photos were rated by at least one of the raters to contain a resting flamingo (resting flamingos observed in any one of the 151 images: $\bar{x} = 2.47$, $SD = 3.12$ after averaging across raters for each image). The average numbers of right and left neck-resting flamingos were totaled across all 151 images, and the total number of observations of right neck-resting was analyzed with a binomial test (normal approximation) (cf., Anderson *et al.* 2009, Lacreuse *et al.* 1999, Lonsdorf and Hopkins 2005, Westergaard *et al.* 1997, Westergaard and Lussier 1999, Westergaard *et al.* 2003).

Immediately following the evaluation of the images by the raters, all files were deleted. As might be done by anyone when browsing the internet, the images were simply viewed and deleted, and thus were not displayed, presented, or used in any way that may have violated copyright laws.

RESULTS AND DISCUSSION

The attempt at replicating our earlier observations (Anderson *et al.* 2009, 2010) of a population-level preference for right neck-resting was inconclusive. Indeed, of those 375.4 birds that were determined by the raters to be resting, a total of 191.0 (51%) were to the right and 184.4 (49%) were to the left. These numbers were rounded to the nearest integer in order to allow for binomial analysis (with normal approximation), which revealed a slight, but non-significant, preference for right neck-resting ($z = 0.310$, one-tailed $P > 0.05$). The preference for neck-resting to the right has been shown not to be all-or-none, with an individual flamingo being capable of resting its neck to either the right or left, despite typically preferring the right (Anderson *et al.* 2009, 2010). This characteristic of the behavior in

question may itself have promoted the inconclusive result obtained in the present study. Additionally, given that numerous limitations were encountered when employing the present methodology, one should not conclude the previous studies were flawed.

Limitations of the employed technique for archival research of the specific nature of the present study were many. Given the poor resolution, camera angle, distance, and/or view-point of the images, it was not possible to determine which of the six flamingo species were pictured in many of the images with any degree of certainty (although each species seems likely to have been represented). A lack of knowledge regarding the origin of the image also contributed to these difficulties. The original observation of a preference for resting the neck to the right was demonstrated in American Flamingos (Anderson *et al.* 2009, 2010). It is possible that some members of the other five flamingo species do not share this preference. Thus, the presence of other flamingo species in the obtained sample of images may have influenced the results. Other potentially serious limitations of the present methodology are that observers have no control over the conditions in which the image was captured, and that the sample may have contained repeated images saved under different filenames. Indeed, during the process of scoring the obtained images the raters detected approximately 15 repeated images of flamingos. These were either excluded from the study prior to analysis, or in the event that images were scored multiple times prior to identifying them as replicas, the multiple scores of one rater were averaged before engaging in the analysis described above. Despite these efforts, it is possible, however, that some replicas were missed. It seems likely any of these drawbacks could have influenced the present results.

Despite the limitations encountered when attempting to apply this form of archival research to the issues presently under investigation, it would appear to have several positive features that would allow it to serve effectively in other studies. Easily the greatest benefit of this technique is its ability to gather a large sample quickly. This is likely to be especially true if the behavior or subjects in question are of general interest and more likely to be photographed and posted online, or if the behavior or subject is a common one. The WebImageGrab Pro software is likely to be highly applicable if the search terms employed in a study allow for little ambiguity. Indeed, future studies might simply em-

ploy a broader term such as “flamingos” instead of the highly specific terms employed in the present study. This may allow for an even greater number of images to be obtained, following elimination of those unrelated images. Generally, image-based archival research would appear to be best suited for investigations of behaviors or behavioral states that are relatively static or stable, and would not be as effective for actions.

STUDY 2: AN OBSERVATIONAL STUDY OF NECK-RESTING PREFERENCES IN FLAMINGOS EMPLOYING WEB CAM TECHNOLOGY

In Study 2, we used a method that would allow us better control for the species under observation and more precisely replicate the conditions under which our earlier results were obtained (Anderson *et al.* 2009, 2010). Thus, in Study 2 observations of American Flamingos at the Smithsonian Zoological Park (Washington, DC) were gathered via a live web cam.

METHODS

Materials.—We employed the live flamingo web cam maintained by the Smithsonian National Zoological Park (nationalzoo.si.edu/Animals/Birds/default.cfm?cam=Flam). The cam is fixated on a set location within the exhibit that is frequently inhabited by numerous members of the captive flamingo flock. The cam feed was viewed on a Macintosh computer (OS X operating system) via the Firefox (Version 1.5.0.1; Mozilla Foundation) internet browser and Windows Media Player for Mac OS X (Version 9.0.0 (3307); Microsoft Corporation). As soon as the cam was turned on, the live feed was paused and the displayed image was captured and saved as a .TIFF file by means of Grab (Version 1.3.1) (Apple Computer, Inc.) screen grabbing software.

Subjects.—The Smithsonian National Zoological Park houses about 60 American Flamingos of various ages (Smithsonian Institute flamingo cam website: nationalzoo.si.edu/Animals/Birds/default.cfm?cam=Flam; retrieved 31 July 2009). The exhibit housing the birds is approximately 1,300.64 m² and includes a 278.71 m² fresh water pool (Smithsonian Institute exhibit description website: nationalzoo.si.edu/Animals/Birds/Focus_on_flamingoes/exhibit_description.cfm; retrieved 31 July 2009).

Procedure.—Ten once-daily observations were collected from 1200–1500 during 17 March to 24 April 2009. Observations were made at midday because previous research has suggested that flamin-

gos typically rest at this time (e.g., Bildstein *et al.* 1991, Anderson *et al.* 2009). The web cam was loaded via Firefox and the live feed was immediately paused. The displayed image was captured and saved as a .TIFF file with Grab screen grabbing software. This allowed the image to be saved and subsequently scored by four independent raters in a manner similar to a scan-sampling technique (Altmann 1974). The same raters (Anderson, Urbine, Wilson, and Calabro) served in both studies. As in Study 1, each of the four raters independently determined the number of flamingos resting their neck to the right and left. These numbers were then averaged across the raters for each image, and the total numbers of flamingos resting their necks to the right and left across all 10 images were calculated. The number of right neck-resting observations was analyzed with a binomial test (normal approximation) (cf., Anderson *et al.* 2009, Lacreuse *et al.* 1999, Lonsdorf and Hopkins 2005, Westergaard *et al.* 1997, Westergaard and Lussier 1999, Westergaard *et al.* 2003). Again, the images were deleted following the scoring by the observers to avoid any copyright violations.

RESULTS AND DISCUSSION

Of the 43.5 total resting flamingos appearing in the 10 images (resting flamingos observed in any one image: $\bar{x} = 4.35$, $SD = 2.55$ after averaging across raters for each image), 27.5 (63%) were resting their necks to the right and 16.0 (37%) were resting to the left, evidencing a significant preference for right neck-resting (following rounding to nearest integer, $z = 1.658$, one-tailed $P < 0.05$). Because the web cam technique employed in this study allowed for a near perfect replication of the conditions under which the original results (Anderson *et al.* 2009) were obtained, it can be concluded with some certainty that the lateral preference for right neck-resting is present in at least two flocks of American Flamingos (Philadelphia Zoo and Smithsonian National Zoological Park).

Especially when working with an isolated group of more exotic species or a small number of animals as may be found in a zoo setting, it is desirable to have a means by which to assess the generalizability of findings beyond the available subjects. Generally, the web cam methodology employed in Study 2 would appear to offer a substantial advantage over an archival-based image search in that one typically has knowledge of the location and image content of the cam. Knowledge of a cam's location could enhance awareness of numerous environmental condi-

tions that may influence behavior (e.g., weather variables, time of day). Web cams offer an additional benefit in that they allow one to choose when and how to conduct observations of either an active behavior or a more stable behavioral state. Finally, given the general availability of a web cam, enhanced possibilities for replication by other investigators is likely. Web cams are perhaps only limited by their resolution. Indeed, whereas we were able to demonstrate a population level neck-resting preference in the present study, it was not possible to identify the numbered leg bands of the captive flamingos appearing on the cam. Thus, it was not possible to track individual-level behavior across the multiple observations. Additionally, the image search technique may be more applicable when large amounts of data are desired.

CONCLUSIONS

Anderson *et al.* (2009, 2010) demonstrated a population-level lateral preference in American Flamingos, whereby most birds prefer to curve their necks to the right of their individual center of gravity when resting. The studies described in the present report were aimed at attempting to replicate this observation in flamingos outside of those held at the Philadelphia Zoo, where the original observations were made. Whereas an archival web-based image search (Study 1) proved inconclusive, only yielding evidence of a slight preference for neck-resting to the right, employment of a live web cam (Study 2) allowed for more precise observations, and resulted in a significant preference for rightward neck-resting.

The present results are important for a variety of reasons. The general lateral tendencies reported in the present studies confirm the earlier observations of a right neck-resting preference, and strongly suggest that this lateral behavioral preference is shared with other American Flamingos (Study 2), and perhaps even with other flamingo species (Study 1). Given the apparent generality of this lateral preference, it would appear that the rightward preference is not flock specific, and may thus have its origins in some early sensory (cf., Skiba *et al.* 2002) or motor (cf., Casey and Martino 2000) experience, or genetic influence (cf., Corballis 1997) that is common to all flamingos. Future research is needed to further explore these possibilities.

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