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Behavior of Cuban Flamingo Reproductive Indicators in Natural and Semi-confined Habitats

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ABSTRACT

The behavior of Cuban flamingo (*Phoenicopterus ruber ruber*) reproductive indicators was assessed in two habitat systems: natural, at the Máximo River in Camagüey, Cuba; and semi-captive, at the San Diego Zoo, US, under similar climatic conditions (temperature and season). A randomized design was used, and the treatments were determined by the location of the habitats and the years of study (2004-2008). The percent data were altered by the square root arcsine of the proportion. Central tendency and dispersion statgraphics were developed, and variance analysis was performed using professional SPSS version 11.5.1, for Windows. The hatchability values were 87.77 and 31.73 % for Máximo River and San Diego, respectively, with significant differences ($P \leq 0.05$); also for incubation percents (88.67 and 36.14 %, respectively. Pigeon mortality showed no significant differences, but it was high in both locations. The clear eggs and dead embryo percents were high, with significant differences between the areas under the study.

Key Words: *flamingo, reproduction, semi-captivity, wild, hatchability*

INTRODUCTION

Richardson, Pickering and Shannon (2001) reported the existence of six species of flamingos (*Phoenicopterus ruber ruber*, *Phoenicopterus ruber roseus*, *Phoenicopterus chilensis*, *Phoenicoparrus andinus*, *Phoenicoparrus jamesi* and *Phoenicopterus minor)*. Some authors claim that there are five flamingo species coexisting, the greater of which is the greater flamingo (*Phoenicopterus ruber*), with two quite different subspecies: *Phoenicopterus ruber ruber* and *Phoenicopterus ruber roseus*. *Phoenicopterus ruber ruber*, also known as American, Caribbean, Cuban or pink Flamingo, populates the Caribbean from Yucatan and the East Indies, to the northwest coast of South America, where it is also reproduced in captivity (Seaworld Education Department Program, 2005; BirdLife International, 2008; Zoological Society of San Diego, 2009).

Cuba has the largest flamingo flocks in the Caribbean, located in the Máximo River Wildlife Refuge, in the province of Camagüey. The abovementioned report also points out that these species find shelter and food at the Máximo River Project, which covers 41 000 ha, and that it received a grant by the Conservation Program of British Petroleum (BP).

Over the last 15 years several studies have been conducted on several flamingo species. Most studies were carried out on *Phoenicopterus ruber roseus*, in their natural habitats, in India (Ramesh and Ramachandran, 2002); Algeria (Samraoui *et al.*, 2006; Nissardi *et al.*, 2007; Máñez *et al.*, 2007; Guadalquivir and Curcó *et al.*, 2007), on the Ebro River delta.

Few reports have been made on captive flamingo studies, especially on Andean, Chilean and James flamingos (Sabat, Novoa and Parada, 2001).

Indeed, all flamingo species may suffer a quick population decline, because they form large colonies in very fragile wetlands, which may be polluted or fragmented. The worst enemy of flamingoes is man, due to the changes of natural processes that occur in the areas (depth and water quality and salinity) (Wildlife Trust, 2000).

The aim of this study was to assess the behavior of the main reproductive indicators of the Cuban flamingo in wild and semi-captive conditions.

MATERIALS AND METHODS

Location

The work was carried out at the natural ecological wild bird reserve, at the Máximo River, Camagüey, Cuba, and in semi-captive conditions at the San Diego Zoo, US.

Design and treatments

A completely randomized design was used, and the treatments were determined by the location of the reserves (Máximo and San Antonio Rivers), and the years of study (2004-2008).

Procedure

The data were collected from the records in both areas, which include: nests with or without eggs, number of eggs, hatched eggs, born animals, animal survival and dead animals.

From the data collected, the percents were calculated as follows:

Death percent = (No. of deaths/number of animals) * 100

- Born percent = (No. of animals/number of eggs)* 100
- Survival percent = (No. of surviving animals/number of animals) * 100
- Clear eggs/dead embryos = number of eggs – number of animals
- Empty nests = number of nests – number of eggs

The following indicators were calculated as well:

- Incubation percent = (No. of animals/ number of eggs) * 100
- Hatchability = (number of surviving animals/number of fertile eggs) * 100

Statistical analysis

The percent values were transformed by the arcsine and square root of the proportion. Statgraphics were generated for dispersion central tendency, and variance analyses were performed, along with Tukey´s mean multiple comparisons (when necessary), by using professional software SPSS version 15.0 for Windows.

RESULTS AND DISCUSSION

Table 1 shows the behavior of the reproductive indicators studied. The arcsine of the empty nests had no significant differences for the two locations, which may mean that it is non-dependent on environmental conditions; rather, it is more related to the group´s sexual behavior, in spite of having somewhat different behaviors. The main factor causing this behavior may be same-sex mating (males). A study developed by Stevens and Pickett (1994) reports that large flocks of flamingoes are more likely to experience productive success than small flocks do. It was also observed that there is a positive relationship within group driven stimulation, which enhances or inhibits reproductive events.

The arcsine of hatchability had a significant difference ($P < 0.05$) in favor of the Máximo River habitat (over 50 %). All this pointed to the fact that the environmental conditions in the location were more suitable for incubation than in San Diego; therefore, more increased temperature settings should be provided to achieve appropriate conditions in the nest and develop the embryo inside the egg. According to Perry (2001), the optimum temperature for egg development is 37.5 ^{o}C inside the nest. This corroborates that the temperature at the Máximo River is more suitable (30 ^{o}C-22 ^{o}C).

The arcsine percent of incubation indicator shows significant differences, and the percents observed were very close to hatchability. This behavior indicates that almost all fertile eggs in the nests produced the expected results at the Máximo River location, and it is also a confirmation of the influence of environmental conditions on egg incubation, previously noted in this paper. The two indicators had very low values in San Diego, and they were related to deficient environmental factors for suitable embryo development of eggs in the nests.

Regarding the arcsine of pigeons, superiority of the Máximo River location was corroborated, with a 92.30 % value. This behavior indicates that the incubated eggs had favorable development conditions and later hatching. This value is slightly higher than the values achieved by Guerra (2006) (87 %), for born chicks, in an incubation study in hens. However, for the San Diego habitat, the values achieved are low, always depending on the environmental conditions mentioned above.

The values for the born pigeons at the Máximo River location are slightly lower than the ones achieved by Máñez *et al.* (2007) in Guadalquivir in the year 2004, with 97.63 %. San Diego showed lower values than the Máximo River loca-

tion, but the values were higher than others achieved by the same author in 2007 (18.6 %). At another location, Nissardi *et al.* (2007) reported lower values than those achieved in the Máximo River habitat, and higher than the Dan Diego area, for the period 2004-2007, with values between 78 and 91 %.

The dead embryos had no significant differences for the areas studied. In both cases, they have permissible behaviors when comparing with artificial incubation candidates in hens (13 % loss in the process) (Guerra, 2010).

Regarding the arcsine indicator for the surviving pigeons, the values observed are high in both locations and no significant differences were seen. This is an indication that contrary to the conditions for incubation, there are favorable conditions for pigeon growth and development at post-hatching. This indicator showed similar results to reports by Curcó *et al*. (2007).

When assessing the arcsine indicators for clear eggs and dead embryos, they showed a significant difference ($P \leq 0.05$), with better results for the Máximo River location, though this value can be considered high as well. As mentioned above, the San Diego habitat is dependent on environmental conditions and flamingo sexual behavior when mating. When mating is female-female, they can build a nest and even lay eggs, though infertile.

Stevens and Pickett (1994) noted that the arrival of fresh flamingoes can increase bird fertility and flock activity. Moreover, Perry (2001) claimed that flamingoes are monogamous and suggested that there are birds that have switched partners in different years.

Table 2 demonstrates that the indicators had no significant differences in the period studied.

The first indicator, arcsine in eggless nests, has relatively low values, as most couples lay eggs in the areas studied, and that male-male couples were few, though there may be other causes for the occurrence of eggless nests, related to nutrition and animal age. The latter has been studied in other species and young birds are often known to skip laying (Guerra, 2006).

Arcsine for hatchability and incubation percentage, closely related, as well as other indicators in table 2, are slightly lower than reports for other species artificially incubated, whose breeding occurs in captivity, like turquinos and campero birds, though 2007 showed some valued for these animals (Haymart, 2003).

The remaining indicators may have similar causes to the ones given for these indicators, since incubation is directly or indirectly related to them.

CONCLUSIONS

The behavior of the main reproductive indicators of wild flamingoes showed better values than in semi-captivity conditions, where the number of years assessed had no influence. Hatchability and born pigeons were higher for the Máximo River habitat, compared with the San Diego location, affected by clear eggs and dead embryos and no differences in mortality, which was observed to be high.

RECOMMENDATIONS

Hatchability and incubation percent as indicators of Caribbean flamingo reproductive activity and other varieties of the same species should be used, along with the proposed calculation methodology.

A study of the possibility to induce heterosexual partnership to decrease empty nest occurrence and infertile eggs should be conducted.

Import of some flamingo couples with high reproductive performance in the San Diego Zoo is also recommended to eliminate consanguinity.

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Table 1. Results of reproductive indicator behavior in the two locations studied.

Parameters	San Diego		Maximo River		Sig
	Mean	ET	Mean	ET	
Arcsine in empty nests	0.27 (14.29)	.113	0.25 (6.34)	.0187	NS
Arcsine of hatchability	.5955[a] (31.73)	.04319	1.2033[b] (87.77)	.01927	*
Arcsine of incubation percentage	.6416[a] (36.14)	.05231	1.2996[b] (88.67)	.02683	*
Arcsine of born pigeons	.6416[a] (36.13)	.05231	1.3012[b] (92.30)	.02683	*
Arcsine of dead pigeons	.1442 (10.82)	.06298	.2335 (6.20)	.00777	NS
Arcsine of surviving pigeons	1.3136 (89.18)	.11271	1.3277 (93.80)	.00741	NS
Arcsine of clear eggs and dead embryos	0.93[a] (63.87)	.052	0.27[b] (11.24)	.027	*

Different letters in the same row indicate significant differences between the means for $P < 0.05$, according to Tukey´s multiple comparisons

Table 2. Results of reproductive indicators for the period 2004-2008 in Cuban flamingo reproduction.

Parameters	2004	2005	2006	2007	2008	ET	Sig.
Arcsine of empty nests	.1521	.2914	.1201	.3443	.2525	.06008	NS
	(4.49)	(8.41)	(2.83)	(13.21)	(11.70)		
Arcsine of incubation capaci-	.8233	.8910	.8788	.9894	.8749	.10181	NS
ty	(53.12)	(58.56)	(58.33)	(67.22)	(56.41)		
Arcsine of incubation percent	.8935	.9368	.9697	1.0540	.9148	.10829	NS
	(59.11)	(61.33)	(66.33)	(71.48)	(58.46)		
Arcsine of born pigeons	.8935	.9458	.9697	1.0540	9148	.10892	NS
	(59.11)	(61.79)	(66.33)	(71.48)	(58.46)		
Arcsin of dead pigeons	.1988	.1203	.2846	.2074	.1022	.03271	NS
	(3.91)	(2.84)	(8.00)	(4.26)	(2.06)		
Arcsine of surviving pigeons	1.2046	1.4462	1.1965	1.3166	1.4658	.05356	NS
	(85.35)	(96.96)	(85.80)	(93.61)	(97.83)		
Arcsine of clear eggs and	.6772	.6250	.6011	.5168	.6560	.10892	NS
dead embryos	(40.89)	(38.21)	(33.67)	(28.52)	(41.54)		

Different letters in the same row indicate significant differences between the means for $P < 0.05$, according to Tukey´s multiple comparisons.