

Chapter 4

Reproduction

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Introduction

Flamingos are exhibited in nearly all zoos, generally as one of the first or featured exhibits. However, the captive populations are aging, and reproductive levels are insufficient and not reliable enough to support the movement of genetic material from zoo to zoo or maintain population levels and achieve captive self-sustaining populations (Shannon, 1996a, 1996b; Hawk, 1999a, 1999b). The development of successful reproductive programs in captive populations of flamingos is possible for all taxa, and important. Due to the uniqueness of the reproductive biology of flamingo species in the wild, all the species are vulnerable to the disturbance and encroachment by man's activities. Two species, Andean and James', are now found in only low numbers and in extremely remote areas, a fraction of their historical range. Already efforts are under way to re-introduce them to lakes and areas that have been abandoned, using techniques that have much to gain from captive reproductive programs. Zoos can no longer freely remove flamingos from the wild to provide interesting exhibits. Zoo and aquarium bird collection managers need to seriously concentrate our efforts toward learning more about flamingo biology, in particular reproductive biology. Current collection populations are not self-sustaining and so we must work in collaboration with each other, field naturalists, researchers and conservationists sharing our knowledge.

The following chapter is intended to provide information on the little we know about captive breeding biology of flamingos and help flamingo managers develop protocols conducive to successful breeding programs.

Breeding Season

Why flamingos nest in colonies of many thousands of pairs is not known. There are probably significant selective advantages in nesting in large colonies in terms of avoiding avian predation, although limited suitable nesting habitats may also encourage large concentrations of breeding birds particularly in unpredictable environments. It has been suggested that a minimum flock size is required to achieve the level of display activity needed to stimulate breeding behavior. There is some evidence that larger flocks display more frequently (Brown & Root 1958, Studer-Thiersch, 1974; Stevens, 1991; Pickering & Duverge, 1992). In captivity flock size seems to be an important factor in ensuring a group of flamingos will breed. Pickering et al (in press) showed that in Britain and Northern Ireland breeding Caribbean and Chilean flamingo flocks are significantly larger than non-breeding flocks. Also larger flocks breed more frequently than smaller flocks (Pickering et al, 1992). All Chilean flocks containing more than 40 birds have bred successfully at least once, but one flock of only 4 Chilean Flamingos has reared a chick. In contrast all Caribbean flocks in Britain and Northern Ireland with more than 20 birds have successfully reared chicks yet the smallest Caribbean flock to rear a chick was one of 14 birds, although one flock with only four birds has laid eggs.

Flamingos in the wild are opportunistic breeders, taking advantage of conditions that are favorable for building nests and raising chicks. Whenever weather conditions (generally rainfall) are correct, large numbers of colonial flamingos can quickly bring themselves into reproductive condition.

Colonial flamingos achieve synchronous breeding through the use of ritualized displays: head-flagging, wing salute, twist-preen, inverted wing-salute, wing-leg stretch, marching, false feeding, broken-neck, marching (Kahl, 1975; Studer-Thiersch, 1975; Ogilvie, 1986). These displays precede breeding by months. They can also occur during breeding and may occur when no breeding takes place. However, the displays are good indices of impending breeding. The San Antonio Zoo's Caribbean flamingos begin displaying in October and peak in display intensity and duration in February. Copulations begin in March, early April (Perry, unpublished data). Observing copulations indicates the birds are ready to begin nest building.

In the temperate parts of their range, the seasonal window of opportunity is restricted compared to the tropical areas. Flamingos can be easily put off breeding by changes in weather conditions, loss of food supply, or disturbance by man or storms. In captivity, this can make flamingos fickle breeders. Changes in weather, hotter or colder than normal, too wet or too dry, can result in an earlier or later than normal season, or preclude it altogether. When flamingos are housed indoors, permanently or temporarily for the cold months of the year, breeding can occur at unusual times, even during the winter months. However, because more control over these variables can be achieved in captivity, relatively predictable breeding seasons can be established (Tables 1 and 2).

Mating

Flocks should ideally have equal sex ratios although female-female pairs appear to be able to rear chicks. Unpaired male greater flamingos may cause considerable disturbance to a breeding flock by persistently attempting to rape incubating birds. Unpaired male and female Chilean flamingos have been observed smashing and eating unguarded eggs at The Wildfowl & Wetlands Trust, Slimbridge.

Unlike wild greater flamingos (1995), captive flamingos tend to breed with the same partner each season (Studer Thiersch 1975, Shannon 1985, Wilkinson 1989, Pickering 1992) although the degree of fidelity appears to decrease as flock size increases (Pickering 1992). While paired birds are often seen associating in the non-breeding season (Studer-Thiersch 1975) pairs can form very rapidly during the breeding season (Wilkinson 1985) and birds losing their first egg may re-pair with a different bird in the same season (Pickering 1989).

Factors regarded as important in breeding flamingos in captivity are flock size, sex ratio and age structure, the design of the enclosure and nest site, manipulations of water levels and diet (Duplaix-Hall and Kear 1975).

The first documented breeding of a flamingo in captivity was when the semi-feral flock of Caribbean flamingos at Hialeah racetrack, Florida USA laid eggs in 1937. The first chick was successfully reared there in 1942. The first zoo bred flamingo was reared at San Antonio Zoo in 1952. Since then the number of collections breeding flamingos has increased (Kear & Duplaix-Hall 1975); in Britain there are at least 30 flocks of flamingos that have bred once or more in the last five years (Creighton and Stevens-Wood 1990).

TABLE 1

SPECIES	DATE OF FIRST LAYING PER SEASON			DURATION OF LAYING (DAYS)		
	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
Caribbean	16-May	13	21 Mar - 8 Jun	50	11	35 - 74
Greater	1-May	24.5	26 Mar - 18 Jun	46.2	21	24 - 71
Chilean	7-Jun	12.3	13 May - 2 Jul	69	26	17 - 112
Lesser	15-Jun					
Andean	7-Jun	18.5	17 Apr - 2 Jul	38.8	21	13 - 70
James	13-Jun	25	30 May - 8 Jul			

Table 1. Mean date of first egg laid in a season and duration of laying season in flamingos at Slimbridge. (Pickering, 1992).

TABLE 2
CARIBBEAN FLAMINGOS

Copenhagen Zoo, Denmark

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1999	24-May	21-Jun	2-Jul	11-Jul	11
2000	28 Jun	28-Jun	None	None	1
2001	28-May	28-Jun	20-Jul	20-Jul	9

National Zoo, Washington D.C.

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH *	TOTAL # OF EGGS
1992	25-Apr	5-Jun	8-Jun	8-Jun	7
1993	11-Jun	19-Jun	13-Jul	15-Jul	8
1994	12-May	28-Jun	20-Jun	30-Jun	16
1995	10-May	16-Jun	15-Jun	13-Jul	16
1996	23-Apr	19-Jun	28-May	18-Jun	22
1997	17-May	29-May	19-Jun	27-Jun	14
1998	10-May	17-Jun	8-Jun	15-Jul	18
1999	10-Apr	20-Jun	7-May	23-Jun	32
2000	15-May	11-Jun	13-Jun	21-Jun	26
2001	25-Apr	5-Jun	24-May	11-Jun	28

*Last hatch dates for 2000 and 2001 were of eggs kept at the National Zoo. Some of the last eggs laid for those two years were sent to the Baltimore Zoo.

Rotterdam Zoo, The Netherlands

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1992	6-May	14-May	5-Jun	-----	3
1993	12-May	8-Jun	26-Jun	7-Jul	3
1994	17-May	19-Jun	-----	-----	12
1995	5-Jun	11-Jul	6-Jul	9-Aug	10
1996	23-May	4-Jul	22-Jun	3-Jul	12
1997	3-May	3-Aug	1-Jun	-----	10
1998	5-May	20-Jun	3-Jun	26-Jun	17
1999	5-May	9-Jul	3-Jun	18-Jun	13
2000	30-Apr	14-Jun	23-Jun	26-Jun	14
2001	13-May	23-Jun	11-Jun	26-Jun	13

San Antonio Zoo, Texas

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1981	21-May	---	22-Jun	15-Aug	---
1982	25-May	---	29-Jun	28-Jul	---
1983	5-May	22-Jul	3-Jun	8-Aug	29
1984	5-May	25-Jul	11-Jul	1-Aug	35
1985	24-Apr	6-Jul	3-Jun	21-Jul	43
1986	24-Apr	11-Jul	27-May	11-Aug	45
1987	19-Apr	11-Jul	30-May	7-Aug	43
1988	No Breeding				
1989	2-Jun	4-Jul	4-Jul	20-Jul	12
1990	26-Jun	16-Jul	24-Jul	12-Aug	13
1991	No Breeding				
1992	16-Jul	27-Jul	14-Aug	14-Aug	5
1993	No Breeding				
1994	2-May	11-Jul	14-Jun	9-Aug	14
1995	4-May	11-Jul	6-Jun	12-Jul	16
1996	12-Apr	18-Jul	20-May	10-Jul	40
1997	No Breeding				
1998	29-Apr	17-Jun	27-May	15-Jul	22
1999	5-Jun	20-Jul	8-Jul	16-Aug	13
2000	16-May	26-Jun	18-Jun	23-Jul	37

Sea World Orlando, Florida

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1987	15-Jun	19-Sep	5-Sep	5-Sep	11
1988	No Breeding	No Breeding	None	None	0
1989	12-May	4-Jul	12-Jun	26-Jun	17
1990	13-May	15-Jul	20-May	30-Jul	42
1991	11-May	8-Jul	20-Jun	9-Jul	32
1992	No Breeding				0
1993	No Breeding				0
1994	No Breeding				0
1995	No Breeding				0
1996	~29 May	~29 May	25-Jun	25-Jun	3
1997	n/a	n/a	n/a	n/a	1
1998	No Breeding				0
1999	No Breeding				0
2000	No Breeding				0
2001	No Breeding				0

n/a = not available

Zoological Garden Dvur Kralove nad Labem, Czech Republic

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1988			17-Jun	27-Jun	
1992	16-May	27-May	13-Jun	18-Jun	14
1993	17-May	6-Jun	22-Jun	7-Jul	13
1994			15-Jun	23-Jun	
1995			21-Jun	12-Jul	
1996			7-Jul	9-Jul	
1997	11-Jun	18-Jun	8-Jul	16-Jul	9
1998	25-May	8-Jun	24-Jun	6-Jul	12
1999	1-Jun	7-Jun	30-Jun	30-Jun	9
2000	16-May	4-Jun	13-Jun	30-Jun	14
2001	22-May	2-Jun	20-Jun	29-Jun	14

GREATER FLAMINGOS

Disney's Animal Kingdom (Tree of Life) Orlando, Florida

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1998	12-May		9-Jun		6
1999	13-Apr		8-Jun		9
2000a	4-Mar		9-Apr		14
2000b	15-Nov		6-Jan		8
2001	2-May		3-Jun		10

Los Angeles Zoo, California

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1989	22-Apr	3-Jun	7-Jun	7-Jun	11
1990	23-Mar	5-Jun	21-Jun	21-Jun	13
1991	16-Mar	27-Apr	8-May	31-May	6+*
1992	20-Mar	2-May	12-May	29-May	8
1993	3-Mar	8-May	30-May	20-Jun	12
1994	5-Mar	11-Mar	17-Apr	20-Apr	4
1995	No Breeding	No Breeding	None	None	0
1996	8-May	21-May	7-Jun	7-Jun	5
1997	27-Mar	21-Apr	27-Apr	22-May	8
1998	18-Apr	3-May	None	None	7
1999	22-Apr	16-Jun	23-May	22-Jun	23
2000	22-May	30-May	21-Jun	24-Jun	6
2001	29-Apr	22-May	30-May	4-Jun	12

Note - These are the eggs we can account for. The nesting areas do not allow us to see all parts of the enclosure without disturbing the birds, therefore it is possible that some eggs may be broken without the keepers seeing and recording them.

*There was not a good record taken that year.

Rotterdam Zoo, The Netherlands

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1992	26-Apr	18-Jun	4-Jun	5-Jun	13
1993	30-Apr	10-Aug	10-Jun	1-Jul	19
1994	12-May	4-Jul	19-Jun	31-Jul	14
1995	10-Jun	12-Jul	24-Jul	9-Aug	9
1996	12-May	11-Jun	11-Jun	10-Jul	12
1997	1-May	26-Jul	1-Jun	13-Aug	17
1998	4-May	21-Jun	3-Jun	20-Jul	21
1999	6-May	13-Jun	6-Jun	7-Jul	17
2000	25-May	14-Jun	30-May	3-Jul	21
2001	7-May	1-Jul	13-Jun	28-Jun	26

Sea World San Diego, California

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1992	27-May	15-Jul	23-Jun	28-Jul	49
1993	7-Jun	20-Jul	13-Jul	17-Aug	27
1994	14-Jun	25-Jul	15-Jul	31-Jul	27
1995	10-May	6-Jul	11-Jun	31-Jul	46
1996	15-May	2-Jul	12-Jun	17-Aug	55
1997	23-May	21-Jul	25-Jun	3-Aug	52

1998	20-Jun	18-Jul	18-Jul	10-Aug	47
1999	3-Jun	7-Aug	1-Jul	3-Sep	87

Zoological Garden Dvur Kralove nad Labem, Czech Republic

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1988			1-Jul	1-Jul	1
1992	12-May		10-Jun	10-Jun	1
1993	17-May		14-Jun	14-Jun	1
1994			14-Jun	14-Jun	1
1995	21-May				1
1996	3-Jun		2-Jul	2-Jul	1
1997	13-Jun		11-Jul	11-Jul	1
1998	28-May		25-Jun	25-Jun	1
1999	1-Jun		30-Jun	30-Jun	1
2000	17-May		14-Jun	14-Jun	1
2001	23-May	24-May	20-Jun	20-Jun	2

CHILEAN FLAMINGOS

Caldwell Zoo Tyler, Texas

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1989			4-Sep	8-Oct	
1990-1993	No Records				
1994			6-Aug	24-Oct	
1995			9-Jul	30-Aug	
1996			13-Jun	11-Aug	
1997			13-Jun	1-Aug	
1998	6-Jun	20-Jul	7-Jul	16-Aug	27
1999	27-May	15-Jul	24-Jun	10-Aug	49
2000	18-May	20-Jul	19-Jun	4-Aug	39
2001	21-Jul	21-Aug	22-Aug	16-Sep	33

Los Angeles Zoo, California

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1999	3-Jul	19-Jul	15 Aug*	15 Aug*	4
2000	5-May	26-Jul	3-Jun	5-Aug	24
2001	22-May	19-Aug	8-Jul	14-Aug	32

*The chick that hatched this year is of unknown species. The Chilean and American flocks had not been separated when this egg was found and put into the incubator. It may be a hybrid. There is a DNA test pending to try to determine his species. At this time the chick has the appearance of a Chilean.

Re´Serve Africaine de Sigean, France

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1991	26-Jun	18 Sep?	20 Jul	17-Oct	30 (chicks)
1992	29-May	7-Sep	28 Jun	10-Sep	26 (chicks)
1993	11-Jun	24-Sep	13 Jul	26-Sep	24 (chicks)
1994	15-May	-----	10-Jun	3-Sep	30 (chicks)
1995	End of Apr	-----	16 Jun	22-Aug	27 (chicks)
1996	End of Jun	Beg. Of Sep	11 Jul	11-Aug	26 (chicks)
1997	Beg. Of Jun				flood in Jun
				13 Sep (art. inc.)	
1998	End of May	?	30 Jun		26
1999	Beg. Of Jun	?	5 Jul	4-Sep	54 (chicks)
2000	4-Jun	?	5 Jul	26-Aug	52 (chicks)

Note: The nesting area is an island on a 10 hectare lake. Observations are difficult, even with binoculars.

Rheine Zoo, Germany

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1987	22-May	25-Jun			17
1988	6-May	30-Jun			20
1989	30-Apr	6-Jul			19
1990	15-May	7Jun, 5 Jul			16
1991	15-May	8-Jul			21
1992	31-May	23-Jul			17
1993	12-Jun	26-Jul			27
1994	6-Jun	5-Aug			20
1995	17-Jul	20-Aug			10
1996	16-Jun	14-Aug			30
1997	18-Jun	11-Aug			34
1998	31-May	1-Aug			38

San Antonio Zoo, Texas

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1997	1-Jul	1-Nov	29-Jul	30-Nov	13
1998	No Breeding				
1999	2-Aug	6-Nov	31-Aug	23-Dec	11
2000	25-Jul	1-Aug	18-Aug	18-Aug	3

Sea World Orlando, Florida

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1977 or					
1978	n/a	n/a	n/a	n/a	33
1979	n/a	n/a	n/a	n/a	30
1980	?7 Jun (one collected)	n/a	n/a	n/a	20
1981	n/a	n/a	n/a	n/a	13
1982	30-Jun	30-Jun	~27 Jul	~27 Jul	1
1983	No Breeding				0
1984	24-Jun	1-Aug	~6 Aug	~29 Aug	24
1985	n/a	n/a	n/a	n/a	32
1986	9-Jun	1-Aug	n/a	n/a	23
1987	2-Jun	13-Sep	12-Jul	8-Oct	63
1988	3-Jun	7-Sep	16-Jul	21-Sep	66
1989	10-Jun	11-Sep	10-Jul	9-Oct	55
1990	8-Jun	26-Sep	7-Jul	15-Oct	81
1991	11-Sep	19-Dec	16-Oct	10-Jan-92	56
1992	27-Jun	25-Sep	25-Jul	25-Oct	134
1993	24-Jun	n/a	n/a	n/a	114
1994	23-Aug	n/a	n/a	n/a	81
1995	28-Jul	31-Oct	7-Sep	30-Oct	134
1996	17-Sep	9-Dec	16-Oct	4-Jan-97	99
1997	No Breeding				0
1998	No Breeding				0
1999	No Breeding				0
2000	No Breeding				0
2001	3-Aug	15-Aug	2-Sep	11-Sep	6

Zoological Garden Dvur Kralove nad Labem, Czech Republic

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1992	23-May		22-Jun	22-Jun	1
1993	20-May		22-Jun	22-Jun	1
1994			21-Jun	21-Jun	1
1995			27-Jun	27-Jun	1
1996	7-Jun		7-Jul	7-Jul	1

LESSER FLAMINGOS

Sea World San Diego, California

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1989	25-Jun	31-Jul	26-Jul	26-Jul	3
1990	21-May	1-Jul	7-Jul	7-Jul	7
1991	18-Apr	21-Jul	24-May	15-Aug	18
1993	17-May	17-May	0-Jan	0	1
1995	9-Jul	9-Jul	0-Jan	0	1
1997	5-Jun	30-Jun	6-Jun	30-Jun	6
1999	25-Jun	18-Jul	12-Jul	12-Jul	8
2000	30-May	15-Jul	5-Jun	5-Jun	8
2001	27-May	30-Jun	27-May	27-May	8

Sea World Orlando, Florida

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1988	26-Apr	26-Apr	None	None	1

HYBRID - AMERICAN X GREATER FLAMINGO

Rotterdam Zoo, The Netherlands

SEASON	FIRST EGG	LAST EGG	FIRST HATCH	LAST HATCH	TOTAL # OF EGGS
1992	22-Apr	27-May			5
1993	5-May	18-Jun			10
1994	20-May	4-Jun	20 Jun		3
1995	5-Jun	28-Jun	-----		3
1996	1-Jun	4-Jul	8 Jul		7
1997	26-Jun	14-Jul	-----		4
1998	10-May	1-Jul	10 Jun		4
1999	4-May	26-May			9
2000	25-Apr	14-Jun			21
2001	16-May	23-Jun			9

Table 2. Laying and hatching data from American, greater, Chilean, lesser and hybrid flamingos from several zoos

Egg Laying and Incubation

Timing of egg laying appears to be dependent on latitude and local weather conditions (Duplaix-Hall & Kear 1975). Onset of egg laying is approximately a month later for every 10 degrees north; the egg laying season extends for approximately half a year at any latitude. It has been suggested that flamingos are inhibited from breeding when there is less than 12 hours daylight (Duplaix-Hall & Kear 1975). At any given latitude each species tends to lay at different times during the summer . Clutch size of one is normal but birds will re-lay after losing an egg. A maximum of five eggs laid by one female Chilean flamingo has been recorded (Liggett 1989). The period between egg loss and relaying is highly variable, 6-90 days, but is typically between 10 and 15 days (Pickering 1992).

At the beginning of the egg laying period, particularly in large flocks, there is often considerable fighting over nest sites even when there is an excess of nesting space and nest bases. Egg loss due to fighting can be very high (Pickering 1990). Vulnerable eggs can be removed to an incubator (see 2.4.3) and replaced with dummy wooden or clay eggs. Flamingos appear to be unable to recognize their own egg and will incubate any object roughly the correct size and shape.

Although they have relatively thick shells and often become covered in mud, eggs can be easily candled at approximately 10 days. Infertile eggs (or the dummy eggs on the parents' nest) can then be removed to encourage birds to relay. Pairs producing infertile first eggs will often produce fertile second eggs (Pickering 1992). An alternative strategy is to give fertile eggs to infertile pairs and encourage proven fertile pairs to relay.

Fertility of captive flamingos varies between different flocks, species and seasons (Duplaix-Hall & Kear 1975, Yoshitake, M. Suuki, T., Yasufuku, M. & Murata, K. 1988, Pickering 1992). It has suggested that pinioned males may find difficulty balancing when mating. Captive pinioned male greater flamingos certainly fall off when mating more frequently than full winged wild greater flamingos (Pickering 1992), although there is considerable variation between individual males (Pickering 1990). Also there was an increase in hatching success in greater, Chilean and Caribbean flamingos at Kobe Oji Zoo after the practice of feather cutting stopped when the birds were placed in an aviary.

The share of incubation is almost equal between male and female parents. In trios one bird often takes a greater share of incubation than the other two. Incubation period is 28-30 days. Incubating Flamingos stand and turn eggs 3-8 times during daylight hours.

Nests

Nesting Area Sites

It is essential that all routine maintenance work is carried out to a regular pattern in tune with the flock's breeding cycle. All concrete edges to ponds and nest islands should be checked and repaired annually to avoid sharp edges where birds may damage their legs. Silting up of ponds is an inevitable problem with large numbers of birds in large enclosures and sludge should be pumped out when necessary. Generally horticultural work is disruptive but with care and consideration disturbance can be minimized and flocks can become accustomed to regular work programs.

Greater flamingos seem to prefer open, sunny areas for nesting and resting (Studer-Thiersch, 2000). Caribbean and Chilean flamingos seem to prefer shaded areas. The nest site should also

be separated from the resting and feeding areas. The same should apply to separation from the public, either by space or visual barriers. Ideally, the nest site should have minimal disturbance from the keeper while performing daily routines. Many times this can be accomplished by having the nest site on an island, surrounded by water. This would also serve as a protection from predators. It can also be accomplished by using vegetation as a visual barrier, exhibit design or distance.

Flocks of flamingos will sometimes select their own nest site. It is important to observe the flock during the spring and summer and if birds are seen attempting to nest build in an area other than the carefully designed nest site it is probably wise to let them get on with it and only provide extra mud if necessary. Careful observations may help to decide how best to develop this area for the following season. Small modifications rather than wholesale redesigning of enclosures tend to bring the best results; however, it has proved possible to persuade colonies to breed on the keeper's preferred site by denying access to the site they had chosen the previous season.

Once an established flock has begun breeding, indicating their choice of nest site, they will remain faithful to that site from season to season. A new flock, or one that hasn't nested yet, may choose sites that are inappropriate or difficult to manage. However, they may need to be encouraged at those sites to get them started. Careful observations may indicate the reasons for choosing those sites, such as the need for privacy and lack of disturbance (very important for novice flocks and/or new imports), and the suitability of the nesting substrate (its moisture level and manipulative qualities). As an example, when the San Antonio Zoo's flock of breeding American flamingos was moved to their new exhibit in 1988, they made initial attempts at nest building on the pool edges and along the rear walls where the pool and watering of the plants kept the substrate wet. Next season they moved over to a more suitable and manageable nest area set up for them.

Nest Site Preparations

The important criteria for flamingos to build nests are a suitable substrate and an appropriate moisture level. Where there are no suitable natural nesting sites concrete lined pits filled with mud and clay can be created as nest islands. The concrete lip of each nest site should be lower than the edges of ponds. This allows the nest sites to be regularly flooded by raising and lowering the water level in the pond; however, this may also bring risks in sites susceptible to Botulism. An alternative method is to have a separate clean water supply to the nest so it can be flooded without the need to change the level of the water in the pond. Experiments have shown that rising water levels result in greater nest building activity than simple wetting of the nest site (Pickering 1989).

The best substrate should be easily manipulated by the flamingos to build and maintain a nest mound. The flamingos will stand or sit and pull nesting material to their feet and body using the bill like a backhoe. Eventually a mound is built, surrounded by a trench. At the San Antonio Zoo a sand/clay mix is used. This is the material used for baseball/softball diamonds, a 50% sand 50% clay mix. When this material is brought into the nest area, it is worked into the existing soil and any old, remaining nest material along with some timothy hay, by digging and turning over with shovels. Then it is thoroughly wetted with water. We find this mix, when formed into mounds, holds its structure well, even with heavy rains. Other institutions use the existing soils, adding potting soils or fine bark mulch as necessary but also turning over the soil, mixing in the mulch and wetting the area.

The nature of the substrate and the moisture level go hand in hand. The nesting material must be kept wet enough to enable the flamingos to dig with their bills. This can be accomplished in several ways. One is to raise the water level and flood the area. If one has a nesting island, especially one designed for this purpose, this can be very effective. Secondly, one can have a hose(s) set up to allow the area to be flooded on a controlled basis. The control (on/off and volume) of the hose needs to be somewhat remote from the nest area to prevent disturbance. A disadvantage of this method is that once the flamingos start digging and mound building, dams, dikes and low spots may be created generating problems in getting even coverage of water. Thirdly, sprinklers can be used. With proper placement on the ground or overhead, the coverage can be effective, even and controllable. At the San Antonio Zoo, two flamingo exhibits use the flooding technique, and the main flock uses a combination of a hose and sprinklers.

Providing Nest Starts

Most managers will provide “starter” nest mounds to help stimulate the birds. Providing a nest start may be more important for young or newly formed flocks. It appears to act as a stimulus to entice first-time breeders into nest building. This has also been tried with free-ranging birds in the Camargue, increasing numbers of breeding pairs and establishing a regular nest site (A. Johnson, pers. comm.) In captivity, established breeding flocks may not require “starter” nests. At the San Antonio Zoo in 1995, no nest starts were given to the well-established breeding flock of Caribbean flamingos. The birds built good nest mounds entirely on their own and had an excellent breeding year. However, providing nest starts is an effective stimulatory tool and ideally providing nest material to the nest site should be done just prior to the nesting period or even the week the first sign of nest building activity is observed. Using about a half or more of a wheelbarrow load of material, suitably wetted, one can form a mound measuring about 0.6 meters (2') in diameter at the base, 0.45 meters (1 ½') in diameter at the top, and 0.38 meters (1 ½') tall. The mound should be packed together to insure its survival, even during rains. A shallow depression should be formed on the top. A 18.9 liter (5-gallon) bucket can be packed with the nest material and inverted over to aid in the formation of a nest start. Flamingos tend to build their nest mounds as close together as possible. Therefore, the bases of any nest starts can be as close as 0.45 meters (1 ½') to each other. An excess of nest starts should be provided to allow the flamingos to select their own nests. Spare nest sites are often occupied by young birds practicing nest building. The nest site should be kept damp. If the flock does not lay within three to four weeks of the extra mud being added the nest site should be reworked to ensure there is sufficient freshly turned mud for nest building. This practice should be continued at intervals throughout the summer until the flock breeds or autumn arrives.

Permanent nests built out of fiberglass or concrete are not recommended. The hard surface can result in broken eggs and broken legs. Nests left intact throughout the year lose their stimulatory effect. If any birds are reproductively active, and they like the location, they may choose to adopt a pre-made mound or nest start, add to it and finish it off.

Nest Building Behavior

Paired flamingos start nest building by standing at the site and begin pulling material to that site using their bills and reaching out with their long necks to extend the range of nest material gathering. The mated pairs work together. As the materials start to accumulate and pile up, the birds will alternately adopt a standing and a sternal-recumbancy position on top of the pile and

continue pulling materials to them. With their breasts on the middle of the top, a shallow depression is formed with a lip. The mound will grow in diameter and height until the egg is laid. Nest building will continue after the egg is laid. The mound is constantly maintained by pulling wet material to it and dribbling it down the sides. Sometimes the nest mounds can reach a remarkable height of 2 3/4 feet (0.76 meter) tall.

Space Requirements for Nest Area

The recommended space for each individual nest site is 12.25 square feet, or 3.5 x 3.5 feet (1.15 square meter, or 1.07 x 1.07 meter). The size of the nesting area will be determined by the size of your flock. The main breeding flock of Caribbean flamingos at the San Antonio Zoo numbers approximately 60 birds. In our experience, about one-half of the flock will be taking part in nesting activity at any one time. This gives us 15 pairs, or 183 square feet (16.8 square meters) of nest area used. Approximately 500 square feet (46 square meters) is set-aside as a nesting area. This seems to adequately accommodate the amount of area used by the nesting birds. This also seems to correlate with other institutions published figures (Johann 1998; Studer-Thiersch 2000).

Post Hatching Nest Maintenance

Once chicks start hatching and leaving the nests, the hazards they may encounter if there is too much standing water around the nests becomes a concern. Most institutions cease or reduce the watering necessary for nest maintenance, in order to insure the survival of the chicks. However, the disadvantage is impairment to nest maintenance and any further nest building and egg laying. Does this reduction or lack of watering curtail some of the potential breeding that could occur? In small flocks (20-40) this may not be a major concern, but in larger flocks (50+) it probably is. Larger flocks do seem to have a more extended breeding season. This requires extra duties to enhance chick survival, continued breeding and nest building. Careful water management is necessary to keep the substrate suitable for nest building without endangering chicks leaving the nests. Adding nest material if necessary, egg manipulation and management, chick management, and pinioning of chicks all require considerable skill and experience to perform without undue disturbance of the colony. This disruption can cause egg breakage, injury to chicks, and potential abandonment of nests. Inexperienced flamingo managers are urged to contact institutions with the necessary experience and knowledge. See also the Egg and Chick Management sections.

Pinioning and Fertility

Pinioning flamingos definitely impacts fertility of eggs (King, 1994). The degree of reduction in the percentage of fertility in eggs can be quite variable, ranging from only 25% fertility in San Antonio Zoo's pinioned male Caribbean flamingos (Perry & Atkins 1997) to higher percentages, like 100% fertility in the 14 eggs produced by the pinioned male Chilean flamingos at the San Antonio Zoo in 1997. The impact of pinioning is also variable amongst the other species of flamingos (Pickering 1992, King 1994, King 1997). Even amongst individuals of the same species, the effect of pinioning is variable. Some individuals have "the knack" to achieve proper copulation and produce fertile eggs, while others never seem to get it. The exact reason for this reduction of fertility is not clear. Probably the mechanical act of copulation is impaired, as all the long-legged birds seem susceptible to it (Pickering, 1992). The impact on reproduction in captive pinioned flamingo flocks is considerable. Large flocks can make up for it in sheer number of eggs and still achieve

considerable hatching success. However, in smaller flocks, where the number of birds coming into breeding condition is low and egg production is low, considerable time is wasted brooding infertile eggs. Careful egg management, such as egg pulling, dummies, recycling, egg substitution, candling and artificial incubation, can help but won't solve the ultimate problem of low fertility.

One solution is the "long pinion" proposed by Peter Shannon in 1991. This pinioning method leaves a greater portion of the flight surface. It is hoped this will increase balance during copulation and increase fertility. The Audubon Zoo in New Orleans has been "long pinioning" since 1991 and the San Antonio Zoo since 1997. However, the data to support this is still pending. (Figure 5) The other solution is to leave your flamingos full-winged. In enclosed exhibits, indoors or outdoors, this can be done without fears of the flamingos flying away. The full-winged breeding flamingos at the San Antonio Zoo were housed in an enclosed exhibit from before 1950 to 1988. Since 1988, the San Antonio Zoo's newer Caribbean flamingo exhibit is enclosed but has an open front with curtains that can be lowered at night or whenever work has to be done in the exhibit. The birds, in general, have shown no inclination to fly out. Only five birds have flown out of the exhibit. All of these were one or two-year-olds and were recovered. The pay-off is nearly 100% fertility in the eggs.

At the Basel Zoo in Switzerland, no chicks have been pinioned in many years so now the majority of the flock is full-winged. The exhibit is outdoors and not enclosed. While an occasional flamingo has left, the losses have been very acceptable (Studer-Thiersch, personal communication). There are also a number of examples of flocks that have or had a full-winged bird or two in them that don't fly off. The San Antonio Zoo has a smaller, outdoor, open exhibit where a full-winged bird has shown no inclination to fly off for two years. Another male has been left full-winged for six months without flying off. The San Antonio Zoo's goal is to have a few full-winged males amongst the flock of 20-25 birds to up the percentage of fertility.

It should be pointed out that leaving flamingos full-winged is not a guarantee of 100% fertility. Nomadic flamingos depend on synchronous breeding in their reproductive cycle. Any asynchrony that exists between males and females, whether it be from weather variations such as sudden drop in temperature or other reasons, could result in infertile eggs, even though the copulations may be technically perfect (Studer-Thiersch, personal communication).

With newer sexing techniques, it should be possible to sex chicks quickly, before they need to be pinioned. Females could be pinioned and males left full-winged. Newer ideas, management techniques, exhibit designs, and exhibit construction materials may allow for more full-winged birds to maximize egg fertility.

Egg Production and Incubation

Record Keeping and Observations

Good record keeping and observations, combined with colored, numbered plastic banding can help with reproductive management, including egg management and chick management. Knowing the reproductive history of your individual flamingos allows you to anticipate fertility/infertility in eggs and make informed decisions as to whether to pull, allow recycling, substitute a dummy, or allow continued incubation. Good records will also alert one to adept parents, ones with a history of chicks with problems, and any of the anomalous social units (trios, quartets, same-sex pairings).

Figure 6 is an example record sheet used at the San Antonio Zoo to keep track of eggs, chicks and parents during nesting season.

Clutch Size

All of the six flamingo species lay single-egg clutches. Multiple-egg clutches are rare and are discussed under Anomalies.

Incubation Period

Table 3 lists incubation periods for all the species, compiled from various sources.

Species	Mean Incubation Period	Incubation Period Range	Source
Caribbean	28.9	27-30	Pickering, 1992
Greater	29.7	26-32	Pickering, 1992
Chilean	29.1	28-31	Pickering, 1992
Lesser		28	Sea World San Diego, pers. comm.
Andean		27-31	del Hoyo, et al, 1992
James'		27-31	del Hoyo, et al, 1992

Table 3. Incubation Periods of Flamingos

Anomalies

Multiple-Egg Nests

Multiple-egg nests have been reported but are rare (King, 1994, Shannon, 2000, Studer-Thiersch, personal communication). The San Antonio Zoo has had only four cases of multiple-egg nests during the years 1984-2000. Shannon (2000) reports one female regularly laying two eggs in one nest at 5-9 days apart at the Audubon Park Zoo. Multiple-egg nests can also result from some of the trios, quartets and same-sex pairings, which occur amongst flamingo colonies (Shannon, 2000). In multiple-egg nests, the survival of the eggs is reduced. When the same female lays a second egg, the first egg will probably be buried with continued nest building prior to the laying of the second egg. With the social dynamics of the various trios, quartets and same-sex pairings, the first egg is generally lost, and the chances of the second egg surviving are also reduced. In other words, the chances of both eggs surviving in a multiple-egg clutch are nil, and the chances of the remaining egg are also reduced. Due to the unlikely success of multiple-egg clutches, consideration should be given to managing the eggs by pulling one or both, and/or using dummies (see also the Trios, Quartets and Same-sex Pairings section).

Uneven Sex Ratio

When there is a significant variance from an even sex ratio, observers find there are problems with nesting and egg breakage. This is probably a result of unpaired birds trying to pair up with or take

part in the breeding activities of paired birds. The most easily observed is a flock of Caribbean or greater flamingos skewed towards males. The larger males can be seen trying to pair and copulate with the shorter females of a bonded pair. This interrupts the normal activities and can result in nest abandonment and egg breakage. If a manager has the facilities, the troublesome birds can be removed from the flock for the duration of the breeding season. This would be more difficult to observe in the less sexually dimorphic flamingo species.

Even though a more or less-balanced sex ratio is desirable, it still does not prevent the formation of trios, quartets and same-sex pairings, which can cause more disturbances than heterosexual pairs (Studer-Thiersch, personal communication).

Egg Breakage

It seems to be a normal phenomenon for some egg breakage to occur in the gregarious, colonial nesting flamingo. The normal acceptable level needs to be defined. At the San Antonio Zoo, the successful Caribbean flamingo flock has suffered from 10 to 50% egg breakage each year. King (1994) reports egg losses of 28% in 1992 and 48% in 1993 for the Caribbean and greater flamingo flock at the Rotterdam Zoo. Pickering (1992) reports egg losses ranging from 13 to 37% for Slimbridge's greater, Caribbean and Chilean flamingos. Is this normal? How does it compare to colonies in the wild? Can some of it be prevented or managed?

Adelheid Studer-Thiersch's paper, "Behavioral Demands on a New Exhibit for greater flamingos at the Basel Zoo, Switzerland (2000)", offered some well-studied answers and solutions to egg breakage. The increased size of the new Basel Zoo exhibit allowed for greater separation of various activities, such as feeding, resting, exploring, and displaying. The higher vegetation barriers allowed for visual separation. The new wintering quarters resulted in fewer disturbances to preparations for breeding. This made for calmer flamingos, higher breeding motivation and increased synchronization of egg laying, thus reducing egg breakage. Fewer females had to recycle and lay additional eggs. The number of eggs laid by the females was reduced from 2.5/female per season to 1.6/female to achieve the same degree of breeding success.

Trios, Quartets and Same-Sex Pairings

Even though heterosexual pairings and fidelity are more common in flamingo social relationships, other relationships do exist. In captive populations, homosexual pairs may comprise five to six percent of the couples (Bagemihl, 1999). Same-sex pairs will feed, call, sleep and deal with aggression by other birds together. Mountings and copulations may also take place. When nesting, these couples act the same as heterosexual pairs and have been known to successfully hatch and raise foster chicks (King, 1994). Peter Shannon's paper, "Social and Reproductive Relationships of Captive Caribbean Flamingos" (2000), details homosexuality and multiple-partner relationships and their impact on reproductive activities. Table 6 from that paper summarizes these relationships (see also King, 1993b, 1994). These other relationships can impact egg laying and chick rearing, not only in that particular relationship, but on those nesting around them. This can impact egg management. For example, in relationships involving two females, two eggs and the possibility of the eggs being fertile, one or both of the eggs are more vulnerable to being lost. If a manager is aware of the situation, those eggs could be saved through careful egg management (see also Multiple Egg Nests and Egg Management sections). To detect and monitor for these trios, quartets and same-sex pairings requires an investment of observation time. Beginners may

require considerable time to gain these observations, but experienced observers and careful record keeping can reduce, significantly, the time necessary to gain this knowledge and insight.

Extended Monogamy

- * A single male and a single female
- * Multi-year monogamous relationship
- * Little or no promiscuous behavior by either bird
- * Relationship usually ended only with the death of one partner or if the female chose a new, exclusive partner

Serial Monogamy

- * A single male and a single female
- * Typically one or two-year monogamous relationship, lasting throughout the nesting season
- * Either bird more likely to have been promiscuous than birds in extended monogamous relationships

Trios (one male and two females)

- * Formed when a second female joined an established pair (usually the new female remained subordinate to the original female), or a female attracted a male from a established pair, and his previous mate remained attached to the male (the new female became the dominant female)
- * Typically did not last longer than one season
- * Associative – all three birds maintained the same nest
- * Disassociative – the second female maintained a separate nest without assistance from the male or the other female

Trios (two males and one female)

- * Usually formed when a female changed mates and the former mate remained attached to her, or the second male had a relationship with her sometime in the past and had no current mate, or the two males were paired with each other in previous years, and one of them then accepted a female mate
- * Once established, typically lasted for several seasons
- * Usually associative – all three birds maintained the nest, although depending on the group's history, sometimes the second male merely stayed close and helped defend the nest

Trios (other)

- * In two cases, the chick from the previous year participated in the parent's nesting activity, never incubating but sometimes feeding the current chick

Quartets (two male and two females)

- * Usually developed when a trio was formed from partners of two previously established pairs and the fourth bird remained attached to the group of four, or the birds routinely switched partners among the group of four
- * Typically a long-term relationship among the group

- * Other birds outside the group could be seasonal partners of one member of the quartet, but they did not remain a long-term member of the group

Same-sex pairs

- * Often seen among juvenile birds
- * Sometimes occurred when the female of a two male:one female trio died or chose a new partner
- * Adult female seemed more prone to same-sex pairings than adult males, although female:female pairings generally lasted only one season, whereas male:male pairings could continue over several seasons

Table 4. Characteristics of typical breeding relationships among captive Caribbean Flamingos at the Audubon Park Zoo, 1981-83. Used with permission of The Waterbird Society

Egg Size

Table 5 lists egg dimensions for all flamingo species. Table 6 focuses on egg dimensions of Caribbean and Chilean flamingos from two zoos.

Table 5

SPECIES	MEAN (mm)	n	RANGE
Caribbean	90.7 x 55.0	115	82.6-104.0 x 49.0-59.4
Greater	89.1 x 54.6	402	77.0-103.5 x 47.7-61.6
Chilean	92.0 x 53.1	51	82.7-106.0 x 49.8-59.7
Andean	86.6 x 55.0	27	80.9-94.0 x 52.0-60.0
James'	82.8 x 51.0	19	78.1-87.8 x 48.4-55.2
Lesser	82.3 x 49.9	124	52.0-94.0 x 38.0-56.0

Table 5. Egg dimensions for all species of flamingos. Data from a variety of wild and captive sources, adapted from Kear & Duplaix-Hall (1975, Appendix 5).

Table 6

CARIBBEAN FLAMINGO EGG MEASUREMENTS

Zoo	Seasons	# of eggs	Measurements (Mean)	Measurements (Range)	Weights (Mean)	Weights (Range)
			in millimeters	in millimeters	in grams	in grams
San Antonio	84-98	60	91.4 x 56.0	79.22-103.5 x 49.9-61.4	155.6	117.0 - 187.2
	85-98	27				
Audubon Park	81-92	250	90.25 x 57.0	79.5-101.0 x 56.0-58.0	153	123.8 - 183.4
	81-92	20				

CHILEAN FLAMINGO EGG MEASUREMENTS

Zoo	Seasons	# of eggs	Measurements	Measurements (Range)	Weights	Weights (Range)
			(Mean)		(Mean)	(Range)
			in millimeters	in millimeters	in grams	in grams
San Antonio	90-97	10	91.1 x 56.1	85.3-95.2 x 53.0-58.4		

Table 6. Caribbean and Chilean Flamingo Egg Dimensions and Weights from the San Antonio and Audubon Park Zoos

Hatching & Development

Parental Care

During the hatching process, the brooding parent will fidget and may rise (weather dependent) more often to check on the hatching chick, especially as the chick vocalizes. Here is where the chick-parental bond is cemented. While eggs may be freely substituted, chicks cannot, nor can pipping eggs be switched. Once vocalizations have started, whether from the internally pipped egg, the externally pipped egg or the newly hatched chick, no exchanges can be made. Eggs need to be switched or substituted before vocalizations have started. In Caribbean, greater, Chilean and lesser flamingos, the internal pip will be around day 26 or slightly before.

During the hatching process and once a chick hatches, good parents will sit tight to the nest, never leaving it unattended. They will be very solicitous of the chick, even when standing up. As the parent moves around on top of the nest, they step “gingerly” to avoid undue pressure on the hatching egg or chick. When standing, a good parent will be frequently and “solicitously” touching the bill to the hatching egg or chick. Observations have shown that a parent may actually help the hatching process. Parents can help the chick emerge from the egg by gently pulling on shell fragments or membranes with their bills. A parent may ingest some of the hatched shell fragments and materials.

An inexperienced parent may lack in some of these “solicitous” behaviors, actually appearing “alarmed” at the hatching events and easily displaced by curious or other aggressive flamingos. If an aggressive non-parent gets on the nest with the hatching egg or newly hatched chick, the response is usually immediate and fatal. They may attack the egg or chick by hitting it aggressively with their bill. In some of the rare anomalous social groupings (triads, quartets, same-sex pairs), the non-parent can be solicitous and exhibit good parental behaviors. However, the potential for competition and/or friction between that group’s members could lead to inappropriate results, such as the chick or egg being crushed or displaced out of the nest.

Immediately after hatching, an exhausted chick will look wet, very “flattened” and immobile. Inexperienced observers can be alarmed and think the chick is dead or crushed. However, the chick should begin trying to lift its head and vocalize within an hour.

The chick will fluff out and begin sticking its head up between the parent's body and wrist joint of the wing. This is usually how the chick will receive its first food, as the parent drools the red crop milk from its beak tip into the upraised bill of the chick. Both parents will normally feed, however, occasionally only one parent will do the feeding of the chick. A single parent is capable of rearing a chick if it is in good condition. Sometimes over zealous feeding will result in the red crop milk

getting all over the grayish chick's down. This blood-like crop milk may alarm zoo visitors (and staff also), who are convinced that there is blood everywhere.

While the chick is on the nest, one or both of the parents will always be in attendance, whether brooding, standing on the nest over the chick, or standing at the side of the nest when the parents are relieving one another.

Leaving the Nest

Chicks will leave the nest as early as three days and as late as eleven, with five to seven days old the most common. When the chick is ready to leave the nest, there will be a few days when the chick will leave or fall off the nest and clamber back up. The chick's ability to do this is amazing, even when they leave as early as three days, or when it involves a nest as high as 2.8 feet (0.76 meter) tall. The parents and chick will use a nest other than their own, if one is available. A chick trying to climb back up an occupied nest will be re-buffed by the adults. Considerable bickering and fighting can occur between the parents trying to defend their chick and the nest occupants defending their nest site.

When the chick leaves the nest, the parents will stand over it, or just to the side of it, and guard it from all other flamingos. They will brood and feed the chick off the nest just like they did on it. At this point, it is important to discontinue the water that has been supplied for nest building. A chick that leaves early is less able to walk to drier ground and may be vulnerable to drowning or being trampled. Aggression from other flamingos is another obstacle. A parent that is brooding its chick off the nest may even engage in nest building while brooding.

This is a vulnerable time for the chick and where parental experience plays a big factor. Veteran or adept parents that have a record of success will ably brood, feed, lead and protect the chick. First-time or novice parents may not be as adept or confident in caring for their chick and may suffer losses. Good record keeping, banding, and observations are valuable assets in monitoring a chick's progress. Once leaving the nest, over the next few days, a chick will expand its boundaries by exploring the water area around the nest, all under the watchful eyes of the parents. The chick and parents may temporarily adopt a different, abandoned nest mound. The parents will gradually become more tolerant of the distance they allow the chick to wander away from the nest but will always be nearby and responsive to the chick's vocalizations. These wandering chicks may approach other adult flamingos and even beg to be fed. However, only the chick's parents will feed it; it will be rebuffed by other adults.

Weaning

It has been demonstrated that hand-reared flamingos can be weaned in as few as 23 days, but 30 days or longer is more typical (Perry & Atkins, 1997). When being parentally reared in captivity, this process can take much longer, in fact, almost a year. In other words, some parents can still be feeding their young as the next breeding season approaches. Some parents and juveniles break off the feeding in about four months while others do not. This prolonged feeding may relate to captivity, where the parents and juveniles are always in close proximity to each other. In the wild, the parents can fly off and, therefore, encourage weaning in the non-flighted juveniles. At the San Antonio Zoo, concerns have grown that this prolonged feeding of the juveniles may have negative effects on the health of the parent(s). The San Antonio Zoo's exhibit is a small one, 40 x 170 feet

(12.23 x 52 meters). This may contribute to this phenomenon more so than a larger, more spacious exhibit. The Basel Zoo reports that they regularly separate their greater flamingo parents and juveniles in the autumn. It is felt that when the juvenile stays too long with the parents (especially the male), it may adversely effect breeding in the following season (Studer-Thiersch, pers. comm.).

Adult Caribbean flamingos will loose their color while feeding their chick. One can detect the parents who are still feeding and the ones who are not, by the color in their plumage. The feeding parents will be pale, while the non-feeders will have more normal coloration. This is a gradual process as the rearing process progresses. This loss of color in the feeding parents is probably the result of a depleted blood supply of the pigment necessary for feather coloration. As the properly pigmented feathers are molted, they are replaced by feathers that lack the pigment. It gives the feeding parents a “mottled” appearance.

At the San Antonio Zoo, some three-month-old parentally reared young were pulled from the flock to keep some hand-reared flamingos company and aid in their socialization and weaning. They were separated from their parents for 1.5 months. Within a day of their return to the flock, the juveniles were being fed by their respective parents.

Fledging

When the feathers harden and the birds have the ability to fly, flamingo chicks are considered fledged. (They attain flight stage in 90 to 120 days (Allen, 1956)). For Caribbean flamingos, fledging is 70 to 75 days (Shannon, pers. comm.). In the Camargue, greater flamingo chicks have been know to fledge as early as 62 days. If pressed, wild lesser flamingo chicks can fly at 65 days (Brown, et al, 1982). In areas where adult lessers have to travel long distances to feed, the chicks develop slower and flight can be delayed as long as 90 days.

Sexual Maturity

Greater, Caribbean and Chilean flamingos are capable of breeding in their second year. In other words, a 1996 hatch bird can breed in 1998. However, the majority of those birds wait until later. Young, juvenile flamingos will participate in ritual displays and nest building. This practice probably “hones” these skills and prepares them for the future.

Bonding and Pair Formation

Observations and records with the San Antonio Zoo's Caribbean flamingo flock show that the initial pair bond of young flamingos is almost always with a peer, when peers are available. In other words, a 1996 hatch bird will pair with a 1996 bird. After the initial bonding, if a mate dies or if a new mate is acquired, then the age of a new mate is much more variable.

Reproductive/Egg Management

General Record Keeping

Egg and chick management depends on good record keeping and observations, as well as banding the birds with colored, numbered plastic bands. Knowing the reproductive history of your individual flamingos allows anticipating fertility in the eggs and making informed decisions as to whether to pull, recycle, substitute a dummy egg or allow continued incubation. Good records also help alert one to non-adept parents or parents with a history of chicks with medical problems.

Removing Eggs From the Colony

If one must remove eggs, for whatever reason, to minimize disturbance to the flock and other incubating birds, it helps to take the shortest route to the particular egg. Allow time, by moving slowly, for the flamingos to know you are entering and to get off their nests with the least amount of panic. In other words, allow enough time to allow the birds to rise up slowly, in a controlled way from their eggs and walk away from the nest(s). This will hopefully prevent any egg breakage or eggs falling out of the nests. If the birds won't walk away when given the opportunity, get low by going on your hands and knees, or duck walk for the final approach to the nest. If the birds stubbornly refuse to vacate the nest for the final grab, extend your hand, palm down over the egg as quickly as you can without totally spooking the bird. That way, if the parents strike out with their bill, it will hit your hand and not the egg. Most normal flamingos should leave the nest, but long-term captives, and especially hand-reared birds may be inclined to defend the nest from a human intruder to the end. It also pays to watch, or have an assistant to watch the return of the flamingos to the nests and make sure all returns to normal. The brooding parents should be highly motivated to return first and are easily identifiable by their bands and solicitous behavior to the egg. Non-parent birds returning to the nest will be aggressive to the egg.

Sometimes problems, such as egg breakage, disease, or predation, will require the removal of eggs. Eggs should be removed as soon after laying to ensure their safety and the pair given a dummy egg as a replacement. The handler should wear disposable gloves to reduce the transmission of germs to the egg, and the egg should be placed in a bowl lined with a paper towel and immediately transported to the incubator room where any excess dirt on the egg can be gently wiped off with a paper towel. To denote parentage, the egg is marked with a number or letter using a pencil or felt tip pen. The egg should be weighed and measured and all information entered into a data book. The egg should then be immediately placed in an incubator (37.5 C, 55% relative humidity). The entire process of egg removal and data collection should take no more than five minutes.

A cautionary note on removing eggs when dealing with small flocks with only a few pairs nesting: more care is necessary. Keep your visits as brief as possible and do not make wholesale changes, only small limited changes. At the San Antonio Zoo our small auxiliary group of 20 Caribbean flamingos had three nests with eggs. It was determined all three eggs were infertile. All eggs were pulled at one time with intentions of getting the birds to recycle. However, doing it all at once caused abandonment of the nest site. The infertile eggs should have been removed one at a time (see other note under recycling pairs).

Candling

If the egg is clean and free of dirt, determination of fertility may be made as early as four days following laying. At this stage, fertile eggs have a uniform "rosy glow" about them. After seven days of incubation, eggs free of dirt may be discarded if they are candled infertile, as by this time fertility, or lack thereof, is quite evident. Eggs that are particularly dirty may not be easy to candle and, therefore, should not be discarded. (These eggs should be routinely smelled to ensure they are not becoming rotten. It is advisable to move these undetermined eggs to a second incubator if one is available). Candling should preferably be done by personnel familiar with the composition of flamingo eggs, as the strikingly orange yolk could be mistaken as a sign of fertility. The candling process should be done as quickly as possible so the egg does not cool off too much. The candler should ensure that the egg is not jarred during the process or does not become too hot from the light source. Eggs are candled once a week to monitor development. Any fertile eggs that die during incubation can be necropsied to determine cause of death.

Returning Eggs to the Colony

As the time of hatching approaches, eggs should be carefully monitored. If the egg is to be returned to the parents (and not hand-reared from day one), the optimal time is when the chick is just beginning to internally pip or just before. By returning the egg to its parents at this time, the egg is maintained in the safe environment of the incubator that much longer. However, circumstances may dictate that the egg may need to be returned when the chick is in the air cell. This method is used when hatch dates for several chicks are one to two days apart. This will help reduce the amount of stress placed on the nesting birds by minimizing the times one has to venture into the nesting colony.

When returning eggs to parents for hatching, it is important to remember the pipping egg does not need to be returned to its biological parents. To increase the odds of survival for the chick, the egg should be placed under a pair that has demonstrated good parental skills in the past. In the case of new breeding flocks, eggs are best placed under parents that have demonstrated good incubation techniques with their dummy egg. After the egg is placed back under the parent, it is critical that the pair be monitored to ensure that the egg remains on the nest and is not kicked off in the uproar and scuttle that occurs during the switching period. The same techniques used in returning eggs should be used in removing eggs.

Also, see the Parental Care section of this chapter.

Recycling Pairs

To increase the number of fertile eggs produced in one season, females can be encouraged to lay again. This is accomplished either by removing a dummy egg from the pair any time during the incubation period or by removing the nesting pair's egg for artificial incubation and not replacing it with a dummy egg. Although the production of a second egg will not always occur, if it is early enough in the nesting season, most pairs will lay a second egg, and even a third egg is possible. When using this technique to increase the number of eggs laid, it is important to remember to keep an appropriate number of pairs sitting on dummy eggs so that there are enough parents to raise all the chicks. Otherwise, one will be forced into hand-rearing a chick. If an institution has the skill and means to hand-rear chicks, this can be an effective way to maximize production. Properly hand-

raised flamingo chicks are fully capable of integrating into the flock and are reproductively viable (Perry and Atkins, 1997). The San Antonio Zoo has had a hand-reared pair successfully rear chicks.

This can be an effective tool in a pinioned flock with a history of producing more infertile eggs than fertile ones. An egg can be pulled and replaced with a dummy while the egg is artificially incubated. If after seven days an egg is determined to be infertile, the dummy egg can be pulled and the nesting pair will hopefully recycle and possibly lay a fertile egg. This can significantly reduce the time wasted on incubating infertile eggs. If the egg proves to be fertile, it can be returned to the parents at the appropriate time or be a potential candidate for hand rearing.

At the San Antonio Zoo the small flock of 11 Chilean flamingos were breeding, with three pairs nesting. The conditions they were nesting in required hand rearing of any chicks produced. They were able to keep those three pairs nesting and recycling from July 1st until the end of November. The three pairs of flamingos produced a total of 13 eggs. They were able to do that by pulling one egg at a time, thereby leaving two pairs to continue brooding until the third pair recycled and laid their next egg. Then one of the eggs was pulled from the next longest sitting pair, allowing them to recycle, and so on. By keeping at least two pairs brooding, they were able to maintain nesting and recycling. Of the 13 eggs, 11 hatched, and nine were successfully reared.

Dummy Eggs

Flamingos will readily accept a substitute or "dummy" egg as a replacement for their real egg. The egg should be white and approximately the same shape, size and weight of a real flamingo egg (see Egg Size section). A chalky surface is not necessary. Dummy eggs made of plaster or wood will work well. Another way of creating dummy eggs is to save infertile eggs. The infertile egg can be blown out and refilled with sand or other suitable material. Also, if an infertile egg is not compromised with a crack or torn membrane, it will not become rotten too early, and may last long enough to function as a dummy. Infertile eggs can be refrigerated until needed.

End of Season Management

When the breeding season is near the end, there may still be one or more pairs still incubating eggs. However, the colonial nature of flamingos and the desire to join the flock may be strong enough to cause abandonment of the remaining egg(s). At this time, dummy substitution or just plain removal of the egg(s) for evaluation and potential hand rearing may be in order to prevent their loss.

Parent/Chick Management

Chicks may also require hand rearing when the chick itself is sick and needs veterinary attention or when the parents are neglectful or inept/inexperienced.

With an inexperienced pair, the chick will not be defended, brooded or fed like normal. One will see the chick more than momentarily alone and being abused by other flamingos. Long term, even a healthy chick will weaken, chill, and appear dirty from lack of parental preening and protection. If the chick lacks a feeding response and interest in attentive, solicitous parents, it may necessitate

removal from the colony for veterinary attention and potential hand rearing. Please refer to the Chick Management section for further details.

Summary

Since zoos can no longer freely remove flamingos from the wild, captive propagation has become a high priority. Zoos should be able to achieve captive, self-sustaining populations for all flamingo species. Hopefully, the information provided in this chapter, and the entire Flamingo Husbandry Manual, will help the zoos not currently breeding their flamingos to do so and enhance the success of the zoos that are already breeding flamingos.

If your flock is not breeding, try something different. Separating a portion of the flock and re-introducing them later is being investigated as a stimulus for breeding. Introduction of nests and eggs can be tried. Use of mirrors to fool flamingos into thinking the flock is bigger has been used in the past. Moving the flock to a new location or setting up a new flock in a new exhibit can also be an effective stimulus. Introducing new birds to the flock can trigger reproduction. Never assume breeding cannot occur! For flamingos, change itself can be a stimulus.

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Bibliography

- Allen, R. P. 1956. *The Flamingos: Their Life History and Survival*. National Audubon Society Research Reports.
- Bagemihl, B. 1999. *Biological exuberance: Animal Homosexuality and Natural Diversity*. St. Martin's Press, N.Y.
- Brown, L. H., Urban, E. K., and Newman, K. 1982. *The Birds of Africa, Vol. 1: Phoenicopteriformes*. Academic Press, N.Y.
- Hawk, V. 1999a. North American Regional Studbook for Chilean Flamingo (*Phoenicopterus chilensis*).
- Hawk, V. 1999b. North American Regional Studbook for Lesser Flamingo (*Phoeniconaias minor*).
- Johann, A. 1998. Maintenance of the Chilean flamingo at Rheine Zoo. *Int. Zoo News*. 45(7): 406-413.
- Kahl, M. P. 1975. Ritualized displays in Flamingos (eds. J. Kear and H. Duplaix-Hall): 142-149.
- King, C. E. 1993a. Ondergeschoven Kinderen- Flamingo Eieren Van Artis Naar Blijdorp [Foster Children- Flamingos from Amsterdam to Rotterdam]. *Dieren* 10(4): 116-19.
- King, C. E. 1993b. Ongelukkige Flamingo Liefdes [Tales of Flamingo-Love Gone Awry]. *Dieren* 10(2): 36-39.
- King, C. E. 1994. Maintenance and research implications of selected behaviors in a mixed colony of flamingos at Rotterdam Zoo. *Int. Zoo Yearbook*. 33: 103-113.
- King, C. E. 1997. Pinioning: does it effect copulation. *Harpij*. 16(3): 2-3.
- Ogilvie, M. and Ogilvie, C. 1986. *Flamingos*. Alan Sutton, Gloucester, England. 121 pp.
- Perry, J. and Atkins, V. 1997. The weaning, socialization and breeding history of hand-reared Caribbean flamingos, *Phoenicopterus ruber ruber*, at the San Antonio Zoo. *Proceedings of the 24th National Conference of the American Association of Zoo Keepers*. 15-23.
- Pickering, S. P. C. 1992. The comparative breeding biology of flamingos Phoenicopteridae at the Wildfowl and Wetlands Trust Centre, Slimbridge, Gloucester, England. *International Zoo Yearbook* 31: 139-146.
- Shannon, P. W. 1996a. North American Regional Studbook for Caribbean Flamingo (*Phoenicopterus ruber ruber*).
- Shannon, P. W. 1996b. North American Regional Studbook for Greater Flamingo (*Phoenicopterus ruber roseus*).
- Shannon, P. W. 2000. Social and reproductive relationships of captive Caribbean flamingos. *Waterbirds*. 23(1): 173-178.
- Studer-Thiersch, A. 1975. Group display in *Phoenicopterus*. in *Flamingos* (eds. J. Kear and N. Duplaix-Hall): 150-158.
- Studer-Thiersch, A. 2000. Behavioral demands on a new exhibit for Greater flamingos at the Basle Zoo, Switzerland. *Waterbirds*. 23(1): 185-192.

Chick Management

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Introduction

This chapter covers the special aspects of chick management. There are some general management guidelines that have been covered earlier in the Management Chapter. Please also see the chapters on Reproduction, Health and Housing for more information.

Chick management can be broken down into two main types: management of chicks being parent-reared or as part of a colony or flock, and management of chicks being hand-reared.

Colony Management

Managing flamingo chicks that are part of a colony presents unique challenges. Generally, chicks should only need to be manipulated if they are ill, abandoned, or regularly being picked on by other birds. In the event that it becomes necessary to manipulate a chick, the keeper should know that any intrusion will affect the dynamics of the entire colony and may increase the opportunity for injuries to occur.

In large colonies (50+ individuals) catching and restraining chicks is more risky than with smaller colonies. Flamingos panic easily, and it is wise to move slowly around them to avoid startling them, letting them move out of the way on their own. It is also important to use your most experienced staff when manipulating chicks within a colony. If the chick needs daily attention, it is recommended that it be removed until it is back to normal, rather than to attempt entering the colony and restraining the chick frequently.

Primary Concerns

Parental acceptance of the chicks is a primary concern (see Chick Abandonment). From hatching you should see both parents (in some cases you may only have one parent) feeding, brooding and protecting the chick. Most adults will vigorously defend the chick from other adults and other chicks. Some adults defend better than others, and you will need to make sure other adults aren't constantly harassing the chick. You may even see aggression between the pair who are feeding and brooding the chick. The chick should be very vocal from day one, and parents usually respond only to their own chick's vocalizations. Chicks can swim from the first day, although they can't swim for long periods. A general visual assessment of the chick should show you an active, vocal, healthy-looking chick that is being brooded, fed and defended by at least one parent.

Secondary Concerns

Other things to watch for with a newly hatched chick would be nest conditions and weather conditions. Nest conditions may include the level of the water around the nest and the height of the

nest itself. If the nest is too high and the chick falls out, it may not be able to get back up into the nest. Sometimes a chick will use a nearby nest if it is unable to get back up into its own. Weather can be a problem too. If it rains continuously chicks can get wet and be unable to thermoregulate. Too much rain can also contribute to high water levels around the nest. Water that is deep around the nests may cause nest erosion, loss of eggs and even loss of chicks if they are unable to get out of the water.

Chicks may also eat dirt substrate from around the nest, which can lead to impaction.

You should step-up your predator control during this time, as gulls, herons, and other animals will predate the youngsters.

Pinioning

If your management program calls for pinioning, this is something you can do during a catch-up to assess the chicks. (See the Health and Medicine Chapter for pinioning techniques). One thing to consider when pinioning chicks is that it is better to do it when the chicks are younger (two to ten days old). You may need a general anesthesia if you do it when the birds are older. If you pinion at less than five days of age, the chick is usually still in the nest. You want to be very careful if there are other birds on eggs, as eggs may be smashed when catching up the chicks. Even young chicks can be very mobile and may prove difficult to catch. Novices may want to contact people from other zoos who have experience in doing this. (For restraint techniques see the Capture, Handling and Restraint section in the Flamingo Management Chapter or the Physical Restraint section in the Health and Medicine Chapter.)

During this catch-up you may also want to conduct other procedures such as weighing, taking blood for genetic sexing, tarsus measurement, banding, adding a transponder chip, egg candling of other eggs and nest management. Be aware of how long you are in the colony and try to keep all handling and disturbance to a minimum. This is a judgment call that should only be made by experienced staff.

If done properly, flamingos quickly adapt to the regular handling of young chicks and other nest management activities. A brooding parent may not even stand up when an egg or chick is removed from under him or her.

Banding and Chick Identification

You can permanently band a chick at 60 days, but some people prefer to use temporary bands before that. Plastic poultry bands work well temporarily. These must be checked for tightness often as the chick grows. A color dye works well if you have only a few chicks. Keep in mind that dyes may fade and wash off so frequent reapplication may be necessary.

Various flamingo holders solve their identification problems in different ways (input from the Web). San Diego Zoo, as well as Rotterdam Zoo staff place transponders in the chicks when they are pinioned. The birds are recaptured at a later date for final banding. Disney's Animal Kingdom places plastic bandettes on their Greater flamingo chicks when they do the neonatal exam. Pinioning and drawing blood for sexing are done at the same time. The bandettes have to be changed to a larger size at about one month of age. At two months old the chicks receive their adult bands. Past experience has shown the bandettes fall off before they become too tight. Many

years ago, Audubon Park Zoo would alternate a chick's pinion site, depending on the order of hatching. Height and other definitive physical characteristics, such as color, were noted for each chick as it developed. This enabled the staff to definitively identify the chick when it was finally banded. This method has also worked well for older, parent-raised chicks, which can be further identified when their parent(s) feed(s) them. At the Wetlands and Wildfowl Trust in Slimbridge, England, they fit their five-day-old chicks with web tags until it is time to band and/or microchip them (see Marking Flamingos in the Management Chapter),

When permanently banding a bird at 60 days, if this is your first hands-on, you can sometimes do a physical exam at the same time. This can be used as a training opportunity for vets and keepers (see the Health and Medicine Chapter for sample collection information). Since there is some correlation between tarsus measurement and sex (see the Addendum to the Flamingo Management Chapter), you can also do a tarsus measurement (i.e. a larger tarsus = a male). If you have a lot of chicks, you may want to do just a brief visual check, weigh, pinion and return the birds.

Chick Issues

Chick Abandonment

The decision to pull a chick that has been abandoned is a difficult one. Sometimes chicks can be left alone for several hours but may not be abandoned. It depends on a lot of variables and should not be done without a great deal of consideration. It may also depend on your institution's policy on hand rearing. The decision to pull a chick should only be made by an experienced person who has spent a lot of time observing the situation. Things to look for include: chick is isolated, getting dirty, not being fed by either parent, shivering, lethargic, unable to stand, lack of good vocalizations and no contact with either parent. Other considerations may be approaching darkness, threat of predation, and continuous aggression from other flamingos. No other flamingo will accept any chick but its own so fostering to another pair is not possible.

If you must pull a chick you should immediately provide supportive care, i.e. heat, food, and/or fluids. Do this until you can stabilize the chick and then return it to its parents as soon as possible. Try to return it in the early a.m. so you have all day to watch. Chicks have been pulled for as long as two weeks and returned to the flock, and the parents have accepted them back. Your first choice should always be to return the chick to its parents.

Another option, if you are able to, may be to offer supplemental feedings to the chick while it is still in the colony (see the hand-rearing section of this chapter for diet). This option will work in some cases, but it requires thought on how to get the chick alone without too much disturbance to the rest of the flock.

As the chick gets older and starts eating food on its own, you should add extra pans of food so the chicks don't have to compete with the adults. Also, if the adults are fed a dry pelleted food, providing pans of food with water in them can help encourage feeding.

Hand-rearing

Sometimes it becomes necessary to hand-rear a chick for medical reasons or for reasons mentioned under chick abandonment. The concerns of hand-reared chicks becoming imprinted on humans have been raised, however, it has been proven that they slowly lose this dependence after being assimilated into the flock. San Antonio Zoo personnel were instrumental in formulating the early guidelines for hand-rearing flamingo chicks, and more recently the National Zoo staff has redefined the protocols for a more expedient, less labor-intensive process.

Care and Feeding

Early Chick Handling and Brooder Requirements

Once a chick has hatched and dried, the umbilicus is swabbed with a dilute betadine solution, and it is placed in a brooder with a clean towel substrate, with an initial temperature setting of 99° F (37.22° C). During the first two weeks after hatching, the brooder temperature is critical for a chick. If a chick is too cool or too warm, this in turn will affect proper food passage and, thus, the well being of the bird. Temperature guidelines must be utilized as just that, guidelines, as each bird is slightly different. The temperature is gradually lowered over an approximate two-week period until it is at room temperature. Heat can be provided by a forced-air brooder or a brooder with a 100-watt flood lamp that warms the surrounding air. If a chick is shivering, the temperature should be slightly increased. If a chick is panting or is lethargic, perhaps the temperature is too high. Also critical during the first two weeks after hatching is the chick's hydration. This can be controlled by dilution of the formula. If the chick's feces are thick and pasty or it seems to have trouble defecating, adding more water to the formula when feeding can increase the hydration, which in turn allows for better food passage. However, you don't want the formula to be so diluted that the chick is not receiving enough calories to gain weight. [Note: During the first couple of days it is not unusual for a chick to lose weight and then begin gaining weight under the formula dilution guideline.] Strengthening the formula too soon will lead to impaction and dehydration. Weighing the chick after hatching or retrieval from the colony gives you an important benchmark to work from. Thereafter, a morning weight, prior to the first feeding of the day, allows you to follow the developmental progress of the chick.

Feeding the Chick

1. Feed under a heat lamp on a clean towel to keep the chick warm. After warming the formula, stir well to avoid hotspots, then test it on your wrist. Keep the formula container in a bowl of warm water to prevent cooling off during feeding. The chick may refuse formula that has cooled.
2. Place index finger under lower mandible to cradle head and encircle the neck with the thumb to control head movement (forming a semi-circle). Once the chick is conditioned to feeding, it may sway its head side to side slightly. Cradling the head will offer better control (see photo).
3. When the chick elicits a feeding response, dribble formula slowly into the tip of the lower mandible with a syringe, either with a catheter tip syringe (diagram A) or with a luer lock

syringe with the lock cut off (diagram B). It is very important to feed slowly, making sure the chick is swallowing while you slowly push the plunger on the syringe. It is easy to aspirate a flamingo chick if you feed too fast. The chick will stop when full.

4. Wait approximately 8-10 hours after hatching before offering the first feeding. Thereafter, feedings should be 2-3 hours apart, between the hours of 6:00 AM and 10:00 PM. The amount given is gradually increased at each feeding, if the chick will take it. Start with an initial amount of 3-4 cc of lactated ringers or unflavored children's electrolyte-type product for a newly hatched chick. At the second feeding, formula is introduced at a 75% water/25% formula dilution initially. The formula is gradually strengthened over the next week or two (depending on the chick's hydration and feces consistency) to 100% formula (see Figure 1). **IMPORTANT:** Most problems observed with hand-rearing flamingos are seen in the first two weeks and are caused by feeding formula that is too thick, thus impacting the chick.
5. As the chick grows, the frequency at which the chick is fed decreases to three times per day (at approximately 30-40 days of age, depending on the bird), while the amount at each feeding is increased to a maximum of 60 cc. Larger syringes can be used as the amount fed increases.

Under the traditional hand-feeding method, as formulated by the San Antonio Zoo (Kunneman and Perry, 1992), amounts fed were gradually increased as the chicks were fed ad lib prior to weaning, up to as much as 180-200 cc each feeding, with the frequency fed reduced to three times per day (see Figures 2 and 3). This was continued until the chicks were 1 1/2 - 3 months of age, then the middle feeding was dropped. After a few days the morning feeding was dropped, then finally the evening feeding was dropped, as the chick increased foraging on its own to maintain its weight. This method kept the chicks full of formula but decreased self-feeding from the food pan, hence delaying the weaning process.

The accelerated method protocol defined by the National Zoo (Hallager, 1996; Bishop, 1998) limited the amount of formula fed to a maximum of 60 cc at each feeding. Formula was offered only three times per day by around day 12-15 (depending on the bird).

The five stages of this accelerated method are:

1. Stage One: The first feeding consists of lactated ringers or water. At the second feeding the birds are fed a diluted formula consisting of 75% water and 25% formula. The first 2-3 days they are fed every 2-3 hours, between 6:00 AM and 10:00 PM. The first stage is to gradually strengthen the formula to 100% over the next week, though this stage has ranged from 2-15 days, depending on the chick.
2. Stage Two: Gradually increase the volume to 60 cc, while decreasing the feeding frequency to three times per day. At the same time, gradually lower the temperature so that by around day 12 the chick is maintained at room temperature. A 100-watt amber flood lamp hung at one end of an open-air brooder provides a heat source. Solid food, a complete flamingo pelleted diet, broken into small pieces, is offered on day seven, served both dry and soaked in water. The chicks will instinctively begin picking at the pieces, however, initially, they will not be ingesting too much.
3. Stage Three: Maintain feeding the volume of 60 cc of formula three times per day until the chick is over 400 grams. This averages about 24 days old.

4. Stage Four: The weaning process involves reducing the volume of formula to 30 cc at one feeding and then discontinuing it. First, reduce the noon feeding and then discontinue it, then repeat the procedure with the afternoon and morning feedings. The reduction of formula in the weaning process is in direct proportion to the chick's ability to maintain or gain weight by self-feeding. Weaning should take an average of 10 days.
5. Stage Five: Post weaning, chicks are maintained in a back area away from flock competition until they are approximately 30 days old. Body weight is monitored daily until the chicks are introduced to the colony. After that, the chick's interactions with the flock should be watched as well as continuing to monitor its weight. The chick should be removed from the group in the evenings until you are certain it has adjusted well to the colony.

Chicks have been weaned between 29-42 days under this 30-day wean objective. Flexibility of process and individual evaluation of each chick, with changes based on differences in development, make this accelerated method successful, saving both time and labor.

Notes:

- * Until the chick demonstrates a strong swallowing response the formula should be fed much diluted. The chick should be encouraged to stand while feeding. The continuous vocalizations during feeding are a good indication that all is proceeding well. All hand reared chicks should be weighed regularly. To ensure proper growth a weight gain in the region of 8% per day (Chilean Flamingo; Liggett 1989) to 10% per day (Caribbean; Kunneman & Perry 1990) should be expected. If weight gains exceed this the amount of food should be reduced. Chicks are normally fed five times a day, every two hours for the first ten days, four times per day up to ten weeks of age and twice a day from ten weeks until weaning. Unless the chick is showing a particularly slow growth rate, night feeds are not necessary. Hand reared chicks wean between 80 and 130 days.
- * Flamingos chicks which have been abandoned by their parents may refuse to accept food from a syringe and may have to be fed via a catheter tube. When tube fed the formula must be liquidated to prevent clogging. All feeding equipment must be scrupulously cleaned and disinfected after each feed. Exercise is very important for young flamingos to reduce the risk of abnormal leg or wing development. Imprinting does not always occur in hand reared flamingo chicks but to reduce the risk of imprinting contact between human attendant and chicks should be minimized. Rearing chicks of a similar age together also avoids imprinting.
- * Some chicks raised under the accelerated weaning process have experienced leg problems at fledging age. Captive hatched and reared flamingos are prone to developing "bow legged syndrome" found in other long legged birds (see the Metabolic Bone Disease section in the Health and Medicine, Chapter 6). This condition has been associated with nutritional factors in conjunction with growth rate (Brunning 1973, Humphreys 1985, Fowler et al 1987). Exercise and supplements of calcium and vitamins have shown some success in preventing these problems in other long legged birds (Brunning & Dolensek 1986, Duignan 1987).

Exercising the Chick

In a colony environment, the chicks would naturally exercise as they follow their parents around. In a brooder environment, chicks should be taken out on warm days for short walks to strengthen their legs after two weeks of age. A natural substrate is preferred. It is best not to walk the chick immediately after feeding. The chick will follow you closely, listening to your voice, so care should be taken not to accidentally trample it. A behavior that has been noted is that chicks will excitedly walk up to your feet and sit down suddenly.

Multiple Chicks

If it is necessary to rear multiple chicks, they may be introduced to one another as early as two weeks of age. Earlier introduction will not allow you to monitor the feces of the chick during that critical first two weeks when hydration is so important. Multiple chicks may reduce imprinting somewhat as the chicks have one another to focus on. Prior to introduction, the birds need to be identified in some manner. Various methods have proved useful and are listed near the start of this chapter (Banding and Chick Identification). Care must be taken upon introduction, as even a small chick can be aggressive to another. If aggression does occur, wait and try introducing at a later date. Placing the birds next to one another so they can see, or at least hear each other should ease the transition. Having a brooder mate will often times encourage picking at the solid food as they follow the leader.

Introduction of Chicks to the Flock

Once the chicks are weaned and have fledged, weigh more than two kilograms, are more than 100 days old, and are self-feeding well (as determined by maintaining or gaining weight), they may be introduced to the flock. This is best accomplished on a day when the chicks can be put out in the morning (in good weather) so observations can be made all day and when staffing allows for intermittent observations. Prior to introduction, using the same or similar food pans in the back area as the colony feeds from will benefit the chicks, as they may be hesitant about eating from an unfamiliar food pan. There may be some initial aggression by the flock, and the chicks may remain on the outside fringe until the group accepts them. If more than one chick has been hand-reared, waiting to put them out in small groups is preferred and beneficial over single introductions, as the chicks will have familiar “buddies” to mingle with until they acclimate to the flock. Minimal interaction with the chicks by aviculturists servicing the area will help as well. The chicks will gravitate towards the aviculturists when they enter the area, but this should not be reinforced through interaction. This gradual transition could take as long as a year. Monitoring the weight one week after introduction will indicate if the birds are utilizing the food pans and acclimating well.

References

- Bishop, M. 1998. Accelerated weaning of Chilean flamingos at Seaworld Orlando. Presented at the Wetlands International/IUCN-SSC Flamingo Specialist Group Meeting, Miami, FL.
- Hallager, S. 1996. Early Weaning of Hand-reared Flamingo Chicks at the National Zoological Park. *Avicultural Magazine* 102(1): 15-17.
- Kunneman, F. and Perry, J. 1992. Hand-rearing the Caribbean flamingo *Phoenicopterus r. ruber* at the San Antonio Zoo. *Proceedings of the 1990 Flamingo Workshop*, pp30-40 (also published in the 1990 AAZPA Regional Conference Proceedings, pp225-231).

Figures

Figure 1 – Examples of hand raised flaming feeding records.

SPECIES: Chilean flamingo feeding record

D.O.H. 11/2/93

WEIGHT: 80 grams

TIME

Date	Day	Temp	Wt.	Time	Amount	Diet	Remarks	Morbidity
11/2/93	1	99°F	80 g.	1000a	3 cc	Lactated ringers only	Incubator hatched	
				1230p	3 cc	75% H2O/25% Formula	Fecal since being fed	
				300p	3.5 cc	75% H2O/25% Formula	Feces green. Bird is giving good feeding response (F.R.)	
		99°F		515p	3.5 cc	75%H2O/25% Formula		
				715p	3.5 cc	75%H2O/25% Formula	Good F.R.	
				920p	4 cc	75%H2O/25% Formula	Good F.R.	
11/3/93	2	99°F	77 g.	400a	4 cc	75%H2O/25% Formula		
				700a	5 cc	75%H2O/25% Formula		
				930a	6 cc	75%H2O/25% Formula	Fecal consistency good	
				1130a	6 cc	75%H2O/25% Formula		
				130p	6 cc	75%H2O/25% Formula	Fecals look good. Good F.R.	
				430p	8cc	75%H2O/25% Formula		
				730p	8 cc	75%H2O/25% Formula	Eating well. Fecals look good.	
				1030p	8 cc	75%H2O/25% Formula		
11/4/93	3	99°F	76 g.	430a	8 cc	60%H2O/40% Formula	Started on 60%H2O/40% Formula. Good F.R.	

Date	Day	Temp	Wt.	Time	Amount	Diet	Remarks	Morbidity
				730a	8 cc	60%H2O/40% Formula	Stronger formula passed well.	
		98°F.		1030a	9 cc	60%H2O/40% Formula	Lowered temp. to 98°F.	
				130p	9 cc	60%H2O/40% Formula	Looks comfortable at new temp.	
				430p	9 cc	60%H2O/40% Formula		
				730p	10 cc	60%H2O/40% Formula		
				1030p	10 cc	60%H2O/40% Formula		
11/5/93	4	98°F.	80 g.	530a	10 cc	50% H2O/50% Formula	Started on 50%H2O/50% Formula.	
				830a	10 cc	50% H2O/50% Formula	Feces look good on 50/50 mix.	
		96°F.		1130a	10 cc	50% H2O/50% Formula	Lowered temp. to 96°F.	
				215p	19 cc	50% H2O/50% Formula	Good F.R. Very hungry.	
				530p	20 cc	50% H2O/50% Formula		
				800p	20 cc	50% H2O/50% Formula		
				1030p	20 cc	50% H2O/50% Formula		
11/6/93	5	94°F.	84 g.	600a	20 cc	50% H2O/50% Formula	Lowered temp. to 94°F.	
				900a	20 cc	50% H2O/50% Formula	Looks comfortable at new temp.	
				1230p	20 cc	50% H2O/50% Formula		
				330p	25 cc	50% H2O/50% Formula	Good F.R.	
				630p	20 cc	50% H2O/50% Formula	Eating well; vocal; good fecal discharge	
				945p	20 cc	50% H2O/50% Formula		
11/7/93	6	93°F.	89 g.	530a	20 cc	50% H2O/50% Formula	Lowered temp. to 93°F.	

Date	Day	Temp	Wt.	Time	Amount	Diet	Remarks	Morbidity
				845a	25 cc	50% H2O/50% Formula		
				1130a	20 cc	50% H2O/50% Formula		
				130p	20 cc	50% H2O/50% Formula		
				430p	30 cc	50% H2O/50% Formula		
				730p	25 cc	50% H2O/50% Formula		
				1030 p	25 cc	50% H2O/50% Formula	Feces look good.	
11/8/93	7	93°F	101 g.	530a	25 cc	25%H2O/75% Formula	Started on 25%H2O/75% Formula mix.	
				830a	25 cc	25%H2O/75% Formula	Feces look good on new mixture.	
		92°F.		1200p	25 cc	25%H2O/75% Formula	Lowered temp. to 92°F.	
				330p	25 cc	25%H2O/75% Formula	Great feeding response	
				730p	25 cc	25%H2O/75% Formula		
				1000p	25 cc	25%H2O/75% Formula		
11/9/93	8	90°F	110 g.	600a	25 cc	25%H2O/75% Formula	Lowered temp. to 90°F.	
				845a	25 cc	25%H2O/75% Formula	Looks comfortable at new temp.	
				1200p	30 cc	25%H2O/75% Formula		
				300p	35 cc	25%H2O/75% Formula		
				600p	35 cc	25%H2O/75% Formula	Fecals look good.	
				930p	35 cc	25%H2O/75% Formula		
11/10/93	9	90°F	119 g.	530a	35 cc	100% Formula	Started on 100% Formula.	
				845a	35 cc	100% Formula	Fecals look good on full strength formula.	

Date	Day	Temp	Wt.	Time	Amount	Diet	Remarks	Morbidity
				1130a	35 cc	100% Formula		
				300p	35 cc	100% Formula	Very vocal & active.	
				715p	35 cc	100% Formula		
				1030p	35 cc	100% Formula		11/11/93
	10	90°F	137 g.	600a	35 cc	100% Formula	Fecals look good.	
				915a	35 cc	100% Formula		
				1230p	35 cc	100% Formula		
				345p	40 cc	100% Formula		
				630p	45 cc	100% Formula		
				1000p	45 cc	100% Formula	Fecals look good.	
11/12/93	11	88°F	162 g.	615a	50 cc	100% Formula	Lowered temp. to 88°F.	
				1030a	40 cc	100% Formula		
				300p	40 cc	100% Formula		
				630p	45 cc	100% Formula		
				1030p	40 cc	100% Formula		
11/13/93	12	86°F	181 g.	600a	35 cc	100% Formula	Lowered temp. to 86°F.	
				1000a	40 cc	100% Formula		
				230p	40 cc	100% Formula	Eating well. Vocal & active.	
				630p	40 cc	100% Formula		
				1015p	40 cc	100% Formula		
11/14/93	13	86°F	206 g.	545a	45 cc	100% Formula	Very vocal. Good F.R.	

Date	Day	Temp	Wt.	Time	Amount	Diet	Remarks	Morbidity
				930a	50 cc	100% Formula		
				120p	50 cc	100% Formula		
				530p	50 cc	100% Formula	Good F.R.	
				1000p	50 cc	100% Formula		
11/15/93	14	86°F	235 g.	600a	50 cc	100% Formula		
				1030a	55 cc	100% Formula	Eating well	
				230p	55 cc	100% Formula		
				630p	60 cc	100% Formula		
				1030	60 cc	100% Formula		

Figure 1. Example of a typical chick feeding data sheet.

75 grams krill
75 grams capelin (heads, tails, & fins removed)
75 grams hard-boiled egg yolk
2 cups Gerber Oatmeal Baby Cereal (dry)
1 teaspoon Vionate
1/2 teaspoon calcium carbonate
1200 cc water

Blend well

Figure 2. Flamingo hand-rearing formula for chicks ranging from 1-30 days of age (Kunneman and Perry, 1992).

75 grams krill
75 grams capelin (heads, tails & fins removed)
75 grams hard-boiled egg yolk
1 cup Gerber Oatmeal Baby Cereal (dry)
1 cup Mazuri Flamingo Complete Maintenance pellets (soaked)
1 teaspoon Vionate
1/2 teaspoon calcium carbonate
1200 cc water

Blend well

Figure 3. Flamingo hand-rearing formula for chicks over 30 days of Age (Bishop, 1998).