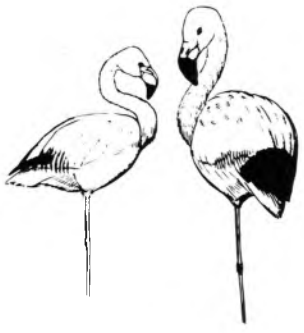
The mortality of captive flamingos at Slimbridge 1975-89



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Generally, captive flamingos appear to be relatively healthy in comparison with other captive wildfowl at Slimbridge. During the period 1975-89, a total of 131 dead flamingos was examined. Renal failure (21.3%) and cardiac failure (16.8%) were the most common causes of death followed by trauma (10.6%) and foot infections (10.6%). The pattern was generally similar between species. James' and Lesser Flamingos had significantly higher mortality rates than Greater, Chilean and Andean Flamingos. The majority (75%) of flamingo deaths occurred during the winter and spring when birds spend more time in their winter housing. Although the houses are heated, the lower temperature may be a contributory factor; the level of stress within the flock may also be higher when the birds are in an enclosed house.

In 1961, the Wildfowl Trust enlarged its collection by adding three species of flamingo at Slimbridge. Since then the number of flamingos has gradually increased and by 1989 a total of 144 Chilean Flamingos *Phoenicopterus chilensis*, 114 Caribbean Flamingos *P. ruber ruber*, 89 Greater Flamingos *P. ruber roseus*, 30 Lesser Flamingos *Phoeniconaias minor*, 52 Andean Flamingos *Phoenicoparrus andinus*, 6 James' (Puna) Flamingos *P. jamesi* was held.

Their health and mortality were reviewed by Humphreys (1975) and Wood (1975). During this period (1961-73), most of the adult mortality appeared to be stress-related in newly arrived imported birds. Twenty-eight percent of the deaths were directly attributed to stress of capture and travel. A further 24% were due to aspergillosis *Aspergillosis fumigatus* which is frequently related to stress (Humphreys 1975). In this paper we present an analysis of the *post mortem* findings of birds examined during the period 1975 to 1989 (called the "later period") and compare these with mortality in the early period (1961-73).

Methods

All birds found soon after death were subjected to a standard *post mortem* examination (Harrison & Harrison 1986). Samples for bacteriology, virology, toxicology and histopathology were taken where necessary to confirm initial diagnosis. For the purposes of this analysis, cardiac diseases included both cardiac failure (which was often associated with atherosclerosis, myocarditis or myocardial infarction) and also pericarditis due to bacterial infection of the pericardial sac around the heart. Renal diseases were also grouped for analysis to include visceral gout, renal failure due to nephritis and renal impaction. Visceral gout is caused by failure to eliminate nitrogenous waste products from the kidneys; as a consequence, urates are deposited on other organs of the body cavity including the liver, kidney, heart and air sacs. Creamy-white deposits are seen on the serous surfaces, but may sometimes infiltrate the organs themselves. Mortality rates were calculated as both an annual percentage mortality and, to avoid biases due to small flock sizes in some years, as a total of deaths per total number of live flamingo years.

Results

During the period 1975-89, a total of 131 dead flamingos was examined at Slimbridge. All six species of flamingo were

represented in this sample (Table 1). Renal failure (21.3%) and cardiac failure (16.8%) were the most common causes of death during this period. Trauma (10.6%) and foot infection (10.6%) also accounted for a considerable number of deaths. The pattern was generally similar between species, although proportionally more Greater Flamingos (23%) died from capture myopathy than others. Also, only one Greater Flamingo suffered cardiac failure. Seven of the Lesser Flamingo deaths (21%) were due to oesophageal impaction; these occurred during the cold winter 1977/78 and were a result of the soya protein in the diet congealing at low temperatures and obstructing the oesophagus. This problem was solved by using an alternative protein source.

to 1946 to the surface of the mud where the birds pick up the pellets when feeding at the water silt-interface. Deaths through trauma were all cases of compound fractures of tarsus or tibia or dislocation of inter-tarsal joints. These broken bones typically occur when the flock panics or stampedes, one or two birds falling over and being trampled by the others.

Foot infections were the primary cause of death in 10.6% of cases. Of the 477 flamingos caught and examined in 1989 and 1990, 21% had cuts or lesions on their feet (Table 2). Caribbean and Greater Flamingos seem to suffer most from these problems although the highest proportion of deaths attributed to this cause was in the Andean Flamingos. Cracked feet and minor cuts allow invasion by *Staphylococcus* and

Table 1. Autopsy findings of flamingos examined at Slimbridge, 1975-89. Figures in brackets are comparative figures for the period 1961-73 taken from Table 18 in Kear & Duplaix-Hall (1975).

	Primary cause of death															
	Trauma	Foot Infection	Renal Failure	Cardiac Failure	Lead Poisoning	Tuberculosis	Pneumonia	Tumours	Egg Peritonitis	Oesophageal Impaction	Enteritis	Aspergillosis	Wetfeather	Capture Myopathy	Other	Examined *n*
Caribbean	3	4	9	7	1	-	-	-	-	-	1	1	-	-	1	27
	(3)	(6)	(2)	(1)	(0)	-	-	-	-	-	(1)	(1)	-	-	(1)	
Greater	3	2	-	1	-	-	-	-	-	-	-	-	-	3	4	13
	(3)	-	-	(1)	-	(1)	-	(1)	-	-	-	-	-	(2)	(3)	
Chilean	2	2	5	7	7	2	1	1	1	-	-	-	1	-	3	32
	(6)	(3)	(4)	(3)	(1)	-	(3)	-	-	(1)	(1)	(4)	-	-	(3)	
Lesser	4	4	6	4	1	-	2	3	-	7	1	-	-	-	1	33
	(5)	1	-	-	-	(2)	(1)	-	-	-	(1)	(2)	-	(17)	(10)	
Andean	-	2	1	1	-	-	-	1	-	-	-	-	-	-	1	6
	(4)	(1)	-	-	-	-	(2)	-	-	-	-	(3)	-	(5)	-	
James'	2	-	7	2	-	1	2	-	-	-	2	-	3	1	-	20
	(5)	-	(1)	(3)	(1)	-	(4)	-	-	-	-	(21)	-	(15)	-	
All species	14	14	28	22	9	3	5	5	1	7	4	4	2	3	10	
1975-89 % incidence	10.6	10.6	21.3	16.8	6.8	2.2	3.8	3.8	0.7	5.3	3.1	3.1	1.5	2.2	8.4	
1961-73 % incidence	16.8	7.1	5.2	5.2	1.3	2.6	7.1	0.6	1.3	1.3	3.2	23.9	-	28.4	10.3	

Seven Chilean Flamingos (21%) died as a result of lead poisoning. Lead poisoning typically occurs after mud and silt in the enclosure have been disturbed; this brings lead shot from wildfowling activities prior

other bacteria causing septicaemia infections to become deep-seated within joints and thus very difficult to treat.

Tuberculosis (*Myobacterium avium* serotype 1), although the most common

Table 2. Number of flamingos with lesions or cut feet when captured to be re-ringed in 1989 or 1990 and the number in which the primary cause of death was due to foot infections.

	Re-ringed	Birds with lesions or cut feet		Deaths 1975-87	Birds in which primary cause of death diagnosed as a foot infection 1975-89	
	n	*n*	%	*n*	*n*	%
Caribbean	112	50	45	27	4	14
Greater	89	26	29	13	2	15
Chilean	151	6	4	32	2	6
Lesser	31	2	6	33	6	12
Andean	51	6	12	8	2	25
James'	6	0	0	20	0	0
n all species	440	90	21	133	16	12

cause of death in waterfowl at Slimbridge (Cromie 1991), was found in only three flamingos (2.2%). The only parasites found were one *Tetrameres* and a small number of tapeworms (sp. unknown). Both waterfowl and flamingos feed on the intermediate host of *Acuaria* (*Daphnia*), but the disease, although common in collection waterfowl, was not found at any flamingo *post mortem* examination.

Table 3. Seasonal distribution of flamingo deaths.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Caribbean	2	2	3	2	3	5	3	1	0	0	2	4
Greater	1	2	5	1	1	0	0	0	0	1	1	1
Chilean	6	5	2	5	2	2	1	2	1	2	1	3
Lesser	4	4	4	6	4	0	0	0	0	0	4	7
Andean	2	1	0	0	0	1	0	0	1	1	2	0
James'	5	1	3	2	3	0	1	0	0	1	0	4
n all species	20	15	17	16	13	8	5	3	2	5	10	19
% all species	15.0	11.3	12.7	12.0	9.7	6.7	3.7	2.3	1.5	3.7	7.5	14.3
% incidence of renal failure	6.0	6.0	9.1	21.2	15.2	3.0	6.0	0	3.0	6.0	9.1	15.2

Temporal variation in mortality

Most deaths occurred during winter and spring; mortality was greatest in January and December with fewest deaths occurring during August and September (Table 3). This annual pattern was similar in James', Lesser, Greater and Chilean Flamingos, but there were too few Andean deaths to detect any annual pattern. Most of the deaths in Caribbean Flamingos occurred from December through to July with fewest deaths occurring in September and October. Most of the deaths from lead poisoning and oesophageal impaction occurred during January, while the number of birds succumbing to renal failure seemed to peak in April and May. Only seven more females than males died during the period 1975-89, and the distribution of death throughout the year and proportion of deaths from each cause was similar for the sexes.

Mortality rates

Overall mortality ranged from 0.012 deaths per live flamingo years (1.1% per annum) in the Greater flock to 0.132 deaths per live flamingo years (9.3% per annum) in the James' Flamingo flock (Table 4). James' and Lesser Flamingos had significantly higher mortality rates than Greater, Chilean and Andean Flamingos (Table 4).

Comparison with 1961-73

There was a significant change in the major causes of mortality between the early and later periods. Stress-related problems accounted for the majority of deaths in the early years. Stress was associated with wild caught birds dying soon after arrival at Slimbridge. Cardiac and renal failure, diseases of old age or possibly diet accounted for the largest proportion of the deaths in the later period. There was also a small increase in the

Table 4. Flock size (fs.), number of deaths (d.) and annual mortality rate (%) of Slimbridge flamingos 1975-89. The mortality rate of James' and Lesser Flamingos is significantly greater than that of Greater, Chilean and Andean Flamingos P 0.05 (Mann Whitney U-test). Flock sizes are listed in the Avicultural Report in WILDFOWL (1975-89).

	Caribbean			Greater			Chilean			Lesser			Andean			James'		
	fs.	d.	%	fs.	d.	%	fs.	d.	%	fs.	d.	%	fs.	d.	%	fs.	d.	%
1975	60	2	3.3	20	0	0	130	2	1.5	42	2	4.7	26	0	0	18	2	11.0
1976	60	2	3.3	18	0	0	140	4	2.5	40	2	5.0	25	0	0	15	1	5.5
1977	68	0	0	57	2	3.5	130	1	0.8	32	8	25.0	29	0	0	12	1	6.6
1978	57	1	1.7	61	0	0	129	3	2.3	34	6	17.6	34	0	0	17	0	0
1979	57	2	3.5	66	1	1.5	191	2	1.1	44	0	0	38	2	5.8	17	1	5.8
1980	70	0	0	72	1	1.4	191	2	1.1	50	3	6.0	42	2	5.3	20	1	5.8
1981	60	2	3.3	80	0	0	194	2	1.0	50	1	2.0	44	0	0	12	7	35.0
1982	62	2	3.2	65	3	4.6	141	2	1.4	48	1	2.1	46	0	0	9	4	33.3
1983	87	0	0	77	0	0	141	0	0	54	5	9.3	46	1	2.1	8	1	11.0
1984	88	2	2.3	86	1	1.2	142	1	0.7	55	1	1.8	46	0	0	8	0	0
1985	98	1	1.1	80	0	0	144	5	3.5	32	1	3.2	46	1	2.1	7	1	12.3
1986	103	4	3.8	79	1	1.3	127	2	1.4	32	0	0	49	0	0	7	0	0
1987	106	2	1.8	78	1	1.3	139	1	0.8	32	1	3.1	52	0	0	6	1	14.5
1988	113	0	0	86	1	1.2	142	1	0.7	32	1	3.1	52	1	1.9	6	0	0
1989	114	4	3.5	89	1	1.2	144	4	2.8	30	1	3.1	52	1	1.9	6	0	0
Mean annual mortality rate (%)		2.1			1.1			1.4			5.7			0.5			9.3	
Deaths per live flamingo years		0.019			0.012			0.016			0.054			0.013			0.132	

number of deaths from tumours and from leg and foot infections between the two periods. The proportion of deaths due to trauma was lower between 1975-89 than 1961-73. The incidence of tuberculosis remained very low throughout both periods.

The figures for the total number of birds in each flock are unavailable for the early period, so that it is impossible to compare mortality rates from 1975-79 with 1961-73; however, one can compare the number of each species examined (Table 5). The proportion of Greater and Andean Flamingos examined in both periods was lower than Caribbean, James', Lesser or Chilean. This is consistent with mortality between 1975 and 1989.

Discussion

Generally, captive flamingos appear to be relatively healthy. The stress of capture and travel in the early years lead to a large number of deaths (52.3%) (Humphreys 1975). Capture myopathy is thought to be associated with elevated levels of lactic acid in the muscles, caused by fear and exertion. Birds suffering from this condition often become stiff, sometimes paralysed, and may die quickly. Stress can also aggravate other conditions: the susceptibility to aspergillosis seems to be much increased in stressed birds (Humphreys 1975). The drop in the number of stress-related deaths in the later years may be due to a reduction in the number of birds imported; it may also reflect acclimatization to captivity of wild-caught flamingos

Table 5. Number of flamingos examined during the periods 1961-73 and 1975-89.

	Number of birds examined				Mean annual mortality rates 1975-89
	1961-73		1975-89		
	n	%	*n*	%	
Caribbbean	28	18.2	27	20.3	2.05
Greater	11	7.1	13	9.7	1.2
Chilean	31	20.1	32	24.0	1.4
Lesser	26	16.8	33	24.8	5.8
Andean	13	8.4	8	6.0	1.3
James'	45	29.0	20	15.0	9.4
Total	154		133		

so that captive-bred birds are less susceptible to stress. Improved techniques in catching and handling flamingos may also have reduced levels and duration of stress imposed during capture for ringing or movement between Trust Centres. Improved skill in catching flamingos and improved enclosure design are likely to be factors contributing to the reduction in the number of cases of trauma-related deaths in the later period.

The very low incidence of tuberculosis (2.4%) in flamingos suggests that they may have some natural immunity to the disease. This view is reinforced when one considers that over a third of adult waterfowl at Slimbridge die from tuberculosis (Cromie *et al.* 1991) and that flamingos feed in the mud and shallow water at the edges of pools where Tubercle bacilli are probably most abundant (Schaefer *et al.* 1973). Cromie (1991) also suggested that the high protein diet on which the flamingos are fed may reduce their susceptibility to tuberculosis.

Cardiac and renal failure, the most common causes of death in the later period, are typically diseases of old age, but the aetiology may also have a dietary component. Unfortunately, only a few flamingos brought into the collection were ringed so we cannot confirm that these are all old birds. However, renal failure may also result from a septicaemic infection caused by a localised foot or leg infection. Phelan, Ambrus & Graham (1990) showed that in their survey of avian autopsies of birds that demonstrated a multi-systematic bacterial infection 50% of cases showed renal involvement, i.e. the kidney is one of the commonest sites for the localisation of bacteraemias. A further 45% of birds suffering from such bacterial infections demonstrated interstitial nephritis which is though to have arisen as a result of antigen: antibody reaction (Phelan, Ambrus & Graham 1990). The same authors also demonstrated that toxic nephropathy was a common cause of death in birds maintained in captivity. The commonest pathogenesis arises as a result of *hypervitaminosis D* which in turn leads to hypercalcaemia, resulting in calcium deposition in renal tissue. Such changes are likely to occur as a result of excess vitamin D in the diet.

Foot and leg infections showed only a slight increase between the periods 1961-73 (7.1%) and 1975-89 (10.6%). These infections can be treated if caught at an early stage; however, when infections become deep-seated within joints, they tend to be difficult to treat. Intramuscular ampicillin injections (5 mg per kg body weight) combined with daily foot dipping in 2% formalin for five days has proved an effective treatment. These infections usually gain access through cracks and cuts in the feet. Clearly, improved substrates in flamingo houses may decrease the incidence of cracked feet. The high incidence of foot problems (45%) in the Caribbean flock suggests that the pool and loafing area used are much less suitable than those used by the Chilean flock, or that the latter species' feet are perhaps much harder and less prone to cracking in British conditions.

The majority (75%) of flamingo deaths occurred during the winter and spring when birds spend more time in their winter housing. Although the houses are heated, the lower temperature may be a contributory factor. The level of stress within the flock may also be higher when the birds are in an enclosed area. The extra energetic cost of development of reproductive organs and courtship display prior to the breeding season may have been contributing factors in the seasonal pattern of mortality. Although breeding-related mortality in wildfowl typically occurs after long incubation periods (Owen & Black 1989), there was no evidence for increased mortality after incubation in flamingos.

There were significantly different mortality rates between flamingo species: James' and Lesser Flamingos have significantly higher mortality rates than the other four species of flamingo (Table 4). With no data on the mortality rates of wild James' or Lesser Flamingos, it is impossible to assess whether these high rates of mortality are to be expected. However, the fact that some individual Lesser and James' Flamingos have survived in captivity for over 20 years indicates that the longevity of these species is similar to that of other flamingo species. Lesser and James' Flamingos are the only species that have yet to breed successfully at Slimbridge. This and their high mortality rate may indicate that all the requirements and climatic conditions for their well-being are not being met. Also, the lack of breeding success may be a result of subclinical ailments affecting

birds in this country. With hindsight, it is easy to detect these problems but, without accurate record-keeping over a number of years, such trends are difficult to detect in long-lived species.

Such data can show which species are well-suited to current captive conditions and which do not flourish. Clearly, from an avian-health point of view, Greater and Andean Flamingos seem best able to cope with captive conditions. However, the Greater Flamingos at Slimbridge have a much higher breeding success than Andean Flamingos (Pickering in press) suggesting that they are best adapted to the conditions at Slimbridge. Caribbean and Chilean Flamingos also breed successfully in captive flocks in Britain (Creighton & Stevens-Wood 1990) and survive well. Their poor survival rate and lack of breeding success suggest that Lesser and James' Flamingos do not cope well with conditions in this country. Until the problems of keeping these species have been resolved, further importations from the wild seem unwise.

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