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The effect of fine granular sand on pododermatitis in captive greater flamingos (Phoenicopterus roseus)

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Abstract

Pododermatitis is a worldwide health and animal welfare problem in captive flamingos (Phoenicopteridae). Since sub-optimal substrate or flooring has been described as a factor in the development of pododermatitis in poultry and raptors, it is also suspected to play a role in flamingo foot health. Small groups of flamingos were separated from the main group in an indoor enclosure with artificial grass carpet and, in earlier years, concrete flooring, with additional fine granular sand in the water basin for the study year. Feet were evaluated before and after the separation. Judged subjectively, foot lesions had shown a general increase in the indoor enclosure in earlier years. In contrast, lesion severity and prevalence, scored in accordance with a standardised protocol, decreased when fine granular sand was provided. Since flamingos were observed mostly standing on sand and as this represented the major differentiating factor between years, it is concluded that fine granular sand is a favourable substrate to maintain, and one that may even lead to an improvement in flamingo foot health.

Keywords: *animal welfare, flooring, foot problem, greater flamingo, pododermatitis, substrate*

Introduction

Approximately 5,200 greater flamingos (*Phoenicopterus roseus*) are kept in over 130 institutions worldwide, for the most part in Europe (ISIS 2011). A survey of 20 European and North American zoos showed that up to 100% of captive flamingos suffer a variety and degree of foot problems (Nielsen *et al* 2010). Among other birds, raptors, owls (Strigiformes), cockatiels (*Nymphicus hollandicus*) and penguins (Sphenisciformes) are most affected by pododermatitis (Halliwell 1975; Reidarson *et al* 1999; Harcourt-Brown 2008). In raptors, the type 1 to 4 classification for bumblefoot lesions describe nodular lesions of differing severity (Halliwell 1975). Since flamingos are afflicted by lesions other than the nodular variety, a different classification had to be devised to score the severity of hyperkeratosis (slight overgrowth/marked overgrowth), fissures (superficial/deep), nodular lesions (without ulceration/with ulceration) and papillomatous growths (finger-like/cauliflower-like) (Nielsen *et al* 2010). Foot lesions tend to occur in captivity, and foot problems in wild birds have been rarely reported (Herman *et al* 1962).

Substrate has been described as an important factor in the development of pododermatitis in poultry (Martrenchar *et al* 2002; Meluzzi *et al* 2008; Youssef *et al* 2010), and bumblefoot in birds of prey is associated with inadequate perching surfaces (Halliwell 1975). None of investigated substrates — bare concrete, vinyl or rubber lining, soil or grass — could be identified as particularly suitable for flamingo foot health, all having their respective disadvantages (Nielsen *et al* 2012). In flamingos, a positive correlation was found between climate as well as time spent indoors and the prevalence of fissures in a survey performed in 20 European and North American zoos (Nielsen *et al* 2012). This finding suggests that factors such as flooring, humidity of flooring, space levels or feeding regime — all of which differ between indoor and outdoor enclosures — are possibly associated with the prevalence of pododermatitis.

Basel Zoo, Switzerland has kept greater flamingos since 1932 and foot problems have been observed for a long time. The greater flamingo group in Basel Zoo consists of around 100 adult birds (with a balanced sex ratio) and 20 to 25 juveniles per year (22 in 2011). For a number of years, in the winter months, groups of juvenile flamingos were separated from the main group in order to spend some weeks in an indoor enclosure prior to leaving the zoo. Foot lesions always seemed to worsen during this time and it was decided to furnish this indoor enclosure with a new substrate, and monitor foot health after this husbandry change.

Table 1 Development of severity of foot lesions and prevalence of fissures (FSs), nodular lesions (NLs) and papillomatous growths (PGs) of captive flamingos from Basel Zoo in the three flamingo groups kept on fine granular sand (groups A, B and C).

		Group A: November–December 2010		
Number of birds		13		
Duration (days)		34		
	Before	**After**	**Difference†**	**Significance; *P*-value**
Severity	2.0 (± 0.7)	1.6 (± 0.7)	–0.4 (± 0.5)	0.03
Prevalence FSs score 1+2	100%	100%	0%	ns (1)
Prevalence FSs score 2	77%	100%	23%	ns (0.08)
Prevalence NLs score 1+2	92%	92%	0%	ns (1)
Prevalence NLs score 2	54%	69%	15%	ns (0.4)
Prevalence PGs score 1+2	23%	8%	–15%	ns (0.16)
Prevalence PGs score 2	15%	0%	–15%	ns (0.16)
		Group B: January–February 2011		
Number of birds		10		
Duration (days)		33		
	Before	**After**	**Difference†**	**Significance; *P*-value**
Severity	3.2 (± 0.4)	2.7 (± 0.5)	–0.5 (± 0.5)	0.03
Prevalence FSs score 1+2	100%	100%	0%	ns (1)
Prevalence FSs score 2	100%	90%	–10%	ns (0.32)
Prevalence NLs score 1+2	100%	100%	0%	ns (1)
Prevalence NLs score 2	60%	60%	0%	ns (1)
Prevalence PGs score 1+2	100%	90%	–10%	ns (0.32)
Prevalence PGs score 2	100%	60%	–40%	0.045
		Group C: January–March 2011		
Number of birds		11		
Duration (days)		83		
	Before	**After**	**Difference†**	**Significance; *P*-value**
Severity	2.7 (± 0.5)	2.0 (± 0.8)	–0.7 (± 0.9)	0.03
Prevalence FSs score 1+2	100%	100%	0%	ns (1)
Prevalence FSs score 2	100%	45%	–55%	0.014
Prevalence NLs score 1+2	100%	100%	0%	ns (1)
Prevalence NLs score 2	18%	100%	82%	0.003
Prevalence PGs score 1+2	100%	91%	–9%	ns (0.32)
Prevalence PGs score 2	91%	18%	–73%	0.005

† A negative difference stands for a reduction of foot lesions (an improvement); a positive difference stands for an increase of foot lesions (a worsening).
ns = not significant.

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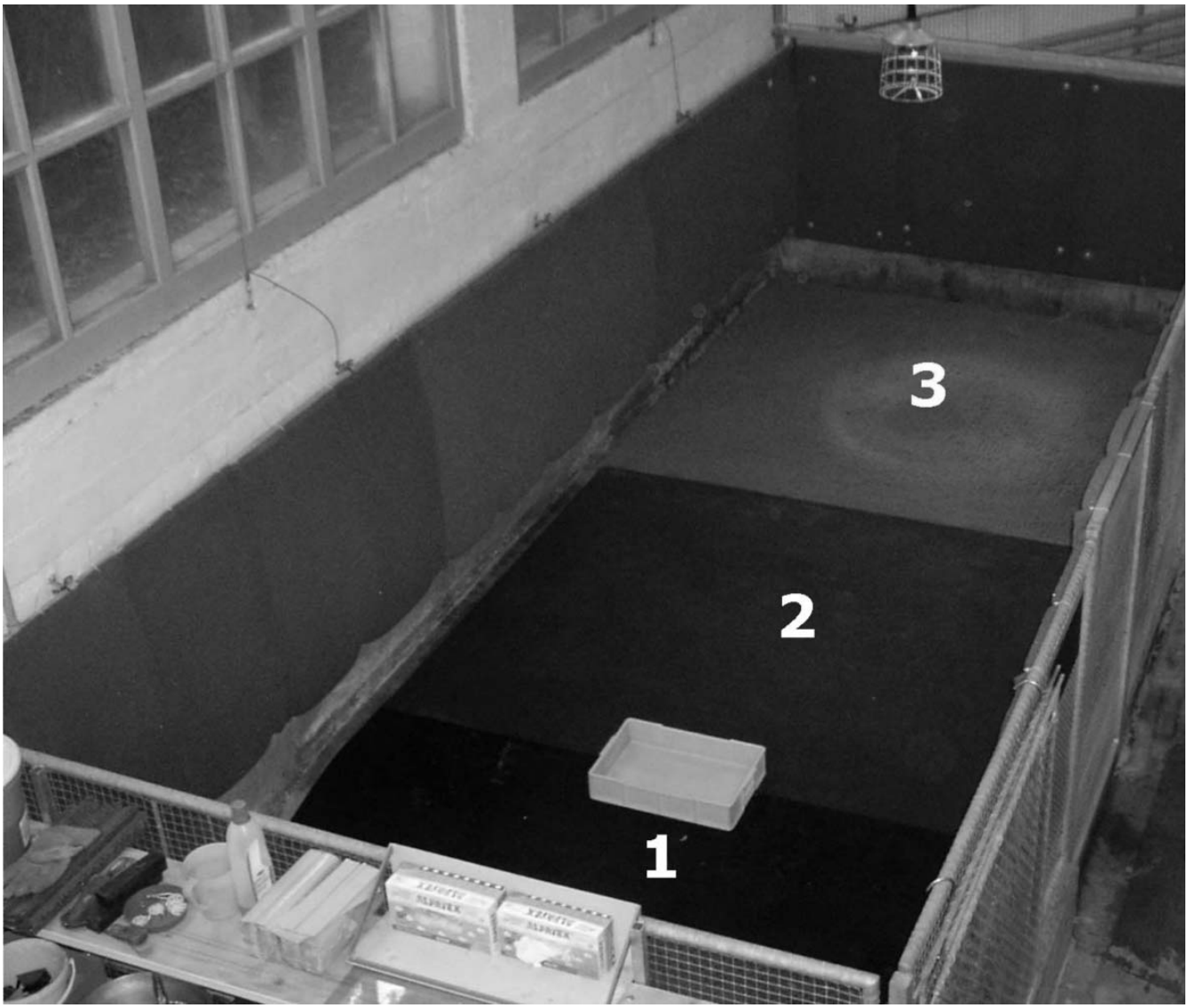
Figure 1

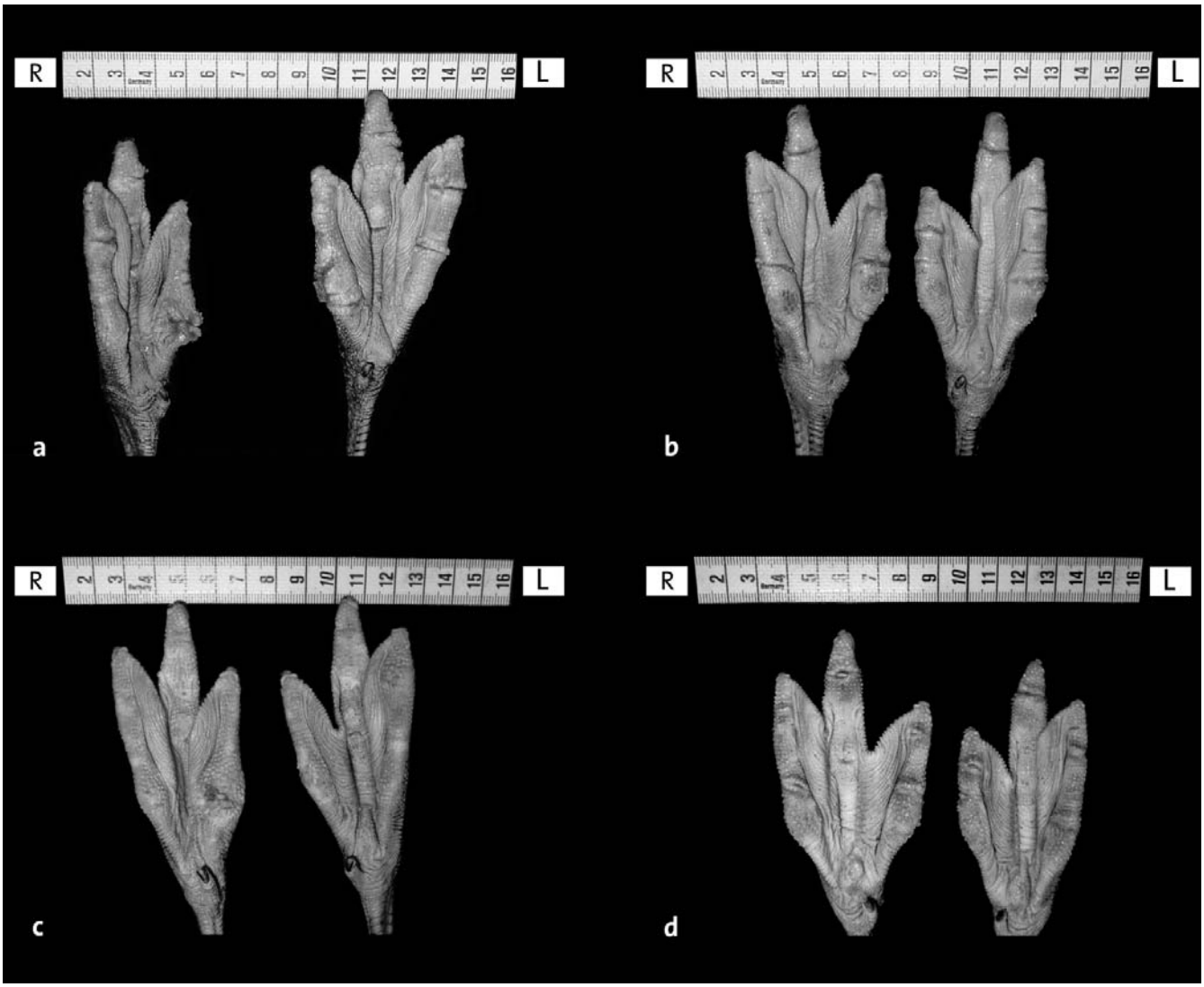


Indoor enclosure composed of (1) a sloped rubber-lined water pool, (2) an artificial grass carpet and (3) a shallow pond with fine granular sand covered with water.

Materials and methods

Three small flamingo groups (group A, B and C; Table 1) were separated from the main group in winter 2010/2011 and kept for differing time intervals in a separate, 22.5 m^2 indoor enclosure. This enclosure was composed of a 7.5 m^2 sloped, rubber-lined water pool (maximum depth: 20 cm), a 7.5 m^2 artificial grass carpet (Rasenteppich Patio Grün, Home Market, Inb GmbH, Lagerstrasse 7, CH-8600 Dübendorf, Switzerland) and a 7.5 m^2 shallow pond filled to a depth of 10 cm with fine granular sand (Flussschwemmsand, 0–1-mm grain size, Meyer-Spinnler AG, 3142 Muttenz, Switzerland) and covered with 5 cm of water (Figure 1; numbers 1, 2 and 3, respectively). The birds in the outdoor enclosure were fed *ad libitum* with an in-house mixed diet in a 2-m diameter feeding pond while those in the indoor enclosure were fed the same *ad libitum* in-house mixed diet in a plastic bucket with water (groups A and B). Group C were fed with artemia, chironomes or rice in the morning and with the same in-house mixed diet in the afternoon and evening. All groups were kept in the same house; group A alone (November–December 2010), and groups B (January–February 2011) and C (January–March 2011) together before group B left the zoo (Table 1). Prior to housing in the indoor enclosure, the flamingo group of approximately 120 animals was kept in the flamingo exhibit (around 2,000 m^2). When the weather was cold they would mostly remain inside (94 m^2) on concrete flooring and rubber mats used for cattle whereas during warmer periods they would be outside on grass with concrete water pools. No sand flooring was provided in the flamingo exhibit for the main flamingo group, in contrast to the indoor enclosure for the three small trial groups. Groups A and B consisted mainly

Figure 2



Examples of the feet of two female, sub-adult flamingos (a, c) at the beginning of the housing period and (b, d) at the end of the housing period. No 60714 on the left and 61011 on the right, respectively.

of juvenile birds (hatched in the same year, five to seven months old) whereas group C consisted of sub-adult (one- to three-years old) and adult (more than three-years old) flamingos. Severity and classification (Nielsen *et al* 2010) of foot lesions were determined before and after their respective stays in the smaller house (Table 1). In our study, the classification of hyperkeratosis was not used because there was no age-matched control of a normal foot, and because it was shown that the prevalence of hyperkeratosis is up to 100% (Nielsen *et al* 2010). The following lesions were classified: superficial fissures (FSs score 1), deep fissures (FSs score 2), nodular lesions without ulceration (NLs score 1), nodular lesions with ulceration (NLs score 2), finger-like papillomatous growths (PGs score 1) and cauliflower-like papillomatous growths (PGs score 2). Classification of lesions was performed on-site by the first author; during this procedure, digital photographs of all feet were taken. These photographs were later used to score the severity of the lesions (0–5; independent from the type of lesion; Wyss *et al* 2013), again performed by the first author. Changes between time-points (score deltas) were compared between specific groups using Kruskal-Wallis one-way ANOVA (analysis of variance) and the Kruskal-Wallis multiple-comparison *Z*-value test (Dunn's test); in order to test whether a score change between two time-points was significant, a Wilcoxon signed-rank test for difference in medians (with null hypothesis of no difference in scores between time-points) was used. Statistics were performed in NCSS 2007 (www.ncss.com). The level of statistical significance was 0.05.

Results

Lesions generally improved during the experimental time-period (Table 1). Two typical examples of animals from group C are shown in Figure 2 (a)–(d), where a severity

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score 3 (both animals) at the beginning of the housing period in two sub-adult (1.5 and 2.5 years of age) female flamingos can be seen to improve to a severity score 2 (both animals) at the end of the housing period. In both animals, mainly fissures, but also papillomatous growths developed to nodular lesions with ulceration. The severity of foot lesions decreased significantly (P = 0.029) in all three groups. For groups B and C, the prevalence of the majority of the different types of lesions, especially score 2, decreased significantly (group C), or at least numerically (group B). For group A, only a numerical decrease in papillomatous growths was noted. In group C, nodular lesions with ulceration (NLs score 2) increased significantly and tended to be most notable at those points of the feet classified with a having a fissure prior to the experiment.

Discussion

Even when three different surfaces were available in the house (fine granular sand, grass carpet, concrete), the keeper working in the indoor flamingo enclosure noted that flamingos appeared to spend most of their time on the sand. An additional incentive for this preference might have been the heating lamp that was positioned above this substrate (see Figure 1). Therefore, and due to the subjective impression that lesions had been worse in previous years when no sand had been provided in the same indoor house, the effect on foot lesions may be mostly attributable to this substrate. The fact that the most distinct differences were observed in the group kept in the indoor enclosure for the longest time-period (Table 1) suggests that with time positive substrate effects on foot health should be expected. The findings suggest that indoor housing in itself might not be harmful to flamingo foot health (Nielsen *et al* 2012), if the optimal substrate is chosen. Nodular lesions with ulceration were the only lesions seen to increase during animals' stay in the indoor house, and were mostly found where fissures had been previously classified as fissures (Figure 2[b], [d]). This can be explained by the healing process of fissures. Natural wound healing of a fissure occurs from all sides towards the middle (Ackermann 2011). A remnant from a fissure healing from both sides towards the middle resembles central ulceration, and the proliferating tissue around the fissure may appear as a small nodule; the lesions therefore had to be classified as nodular lesions with ulceration (NLs 2).

Conclusion

The present study indicates that flooring may be an important factor in the development of pododermatitis in captive greater flamingos. A covering of fine granular sand markedly improved the condition of flamingo feet. It may be that a covering of sand on concrete-floored ponds represents a simple and inexpensive way of promoting foot health in captive flamingos when the re-building of an existing flamingo enclosure is not feasible. For new flamingo enclosures, a natural base of mud or fine granular sand is recommended. Further studies are warranted in order to gain a better understanding of the aetiology of pododermatitis in flamingos. The results of this study may help to improve the foot health of captive flamingos.

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