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Author(s) :Elizabeth Chang Reissig, M.V., M.S., D.V.Sc., Daniel M. Tompkins, M.S., D.Phil., Richard F. Maloney, M.S., Emily Sancha, B.A., and David A. Wharton, Ph.D.

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PODODERMATITIS IN CAPTIVE-REARED BLACK STILTS (*HIMANTOPUS NOVAEZELANDIAE*)

Elizabeth Chang Reissig, M.V., M.S., D.V.Sc., Daniel M. Tompkins, M.S., D.Phil., Richard F. Maloney, M.S., Emily Sancha, B.A., and David A. Wharton, Ph.D.

Abstract: A potential cause of pododermatitis ("bumblefoot") was investigated in captive-reared juvenile black stilts at the Department of Conservation "Kaki Recovery Program" at Twizel, New Zealand. To address the importance of substrate, the development of clinical signs in individuals was compared among aviaries that contained rubber matting and/or salt footbaths, and controls. No effect of either experimental manipulation of the environment was apparent on pododermatitis development. With the substrate appearing not to be an initiating factor, and a previous study that indicated that the birds' diet fulfills the nutritional requirements for rearing black stilts in captivity, results of this study suggest that insufficient space for exercise may instead be the cause.

Key words: Black stilt, *Himantopus novaezelandiae,* pododermatitis, endangered bird, captivity, recovery program.

INTRODUCTION

The black stilt (*Himantopus novaezelandiae*), or "Kaki," is a critically endangered wading bird whose range is currently restricted to the braided rivers and wetlands of the Mackenzie Basin in South Canterbury, New Zealand.[7] Since 1981, the Department of Conservation's "Kaki Recovery Program" (based in Twizel, New Zealand) has maintained a captive breeding, releasing and monitoring regime, with the aim of preventing any further decrease of black stilt numbers in the wild and ultimately increasing population size.[7] However, the captive-reared birds had a range of clinical problems, including pododermatitis, or "bumblefoot."

Pododermatitis is a common husbandry condition of captive-reared birds characterized by local injury to the integument of the foot (usually the digital or plantar metatarsal pads).[1] Symptoms include scab formation, thickenings, swellings, inflammation, and ulcerative lesions of the subcutaneous tissues of the foot pads, and, in extreme cases, distortion of the digits and septic arthritis of the joints, and osteomyelitis.[1,4,14,16,17] The condition has been reported in falcons, owls, wild turkeys, waterfowl, cockatiels, penguins, and poultry.[1,3,6,8,9,14,15] However, there are differences in etiology among species, and pododermatitis has not previously been described in black stilts.

Although various microorganisms have been found in birds of prey with pododermatitis, it is not an infectious disease.[8,13,18] Rather, causative factors described mainly in falcons include obesity, inactivity (often because of insufficient space for birds to fly), housing problems (such as inadequate perches and unsuitable substrates), and vitamin deficiencies.[9,11,13,15] Trauma, poor litter condition, and devitalization of the weight-bearing plantar structures also have been suggested as causes of pododermatitis in poultry.[1]

Several husbandry measures have been recommended to prevent pododermatitis in raptors.[9,13] These include changes in diet (to both decrease the weight of birds and to ensure that all essential nutrients are provided) and substrate (particularly the perching and roosting sites), and the provision of more space to facilitate exercise.[9,10,13,15] This study describes the occurrence of pododermatitis in captive-reared black stilts and assesses the efficacy of different aviary substrates in reducing the progression of this condition.

MATERIAL AND METHODS

Substrate manipulations were conducted during January to August 2003 in 13 black stilt aviaries located at Twizel (44°17.02′S, 170°5.73′E), Mackenzie Basin, South Canterbury, New Zealand. Each aviary measured 212–252 m^2 and housed 2 to 5 juvenile black stilts. All the birds were raised from artificially incubated eggs that originated

From the Institute of Pathology, Faculty of Veterinary Sciences, National University of La Plata, P.O. Box 296, La Plata 1900, Argentina (Chang Reissig); New Zealand Centre for Conservation Medicine, Private Bag, Grey Lynn, Auckland 1022, New Zealand (Tompkins); Department of Conservation, Twizel Area Office, Private Bag, Twizel 7944, New Zealand (Maloney, Sancha); and Department of Zoology, University of Otago, P.O. Box 56, Dunedin 9054, New Zealand (Wharton). Present address (Chang Reissig): Juncal 3829, Barrio Las Victorias, San Carlos de Bariloche CP 8400, Río Negro, Argentina. Correspondence should be directed to Dr. Chang Reissig (eli.changreissig@gmail.com).

Table 1. Occurrence and severity of pododermatitis symptoms in captive-reared juvenile black stilts, in relation to experimental substrate manipulation. Data are presented as the number of individuals.

	Substrate manipulation				
Signs (rank)	Rubber matting	Salt footbath	Rubber matting and salt footbath	Control	Total no. birds (%)
No lesions (0)	0	1	0	2	3 (6)
Crack (1)	1	0	0	2	3 (6)
Callus (2)	9	7	7	8	31 (66)
Crack and callus (3)	2	2	2	4	10 (22)
Total birds	12	10	9	16	47 (100)

from wild birds. A mixed diet, composed of ox heart mince (89.1%), mealworms (10.3%), iodized salt (0.2%), and kiwi premix (0.4%) (Kiwi Premix®, Carlyle Veterinary Clinic, Napier 4110, New Zealand), was provided ad libitum at 09:00 and 16:00 hours each day of the week.[5] Fresh water was available continuously. All the birds were released at the Mackenzie Basin in September 2003 as part of the Kaki Recovery Program.

Because the black stilt is a wading bird, the substrate of the Twizel aviaries consists of rounded river stones and gravel, with water flowing in parts. As one manipulation, rubber matting was provided (120 × 60 cm, and 0.6-cm thick) in the area that birds used for perching and roosting in 3 aviaries that housed a total of 12 birds. In addition, salt footbaths was provided (1 footbath per aviary: 60 × 40 cm, filled to a height of 7 cm with 35 g/L of salt in distilled water) on the floor of 3 aviaries that housed a total of 10 birds. Three further aviaries, which housed a total of 9 birds, were provided with both rubber matting and salt footbaths, whereas the remaining 4 aviaries that house a total of 16 birds were left as controls. Both artificial substrates represented less than 0.5% of aviary total surface (matting and salt footbath surfaces represented 0.3% and 0.1%, respectively).

The birds were weighed and examined in January at the age of 1 mo, when they were moved from brooders to the aviaries, and again in September, at 9 mo of age before release. The presence of clinical signs was ranked in order of increasing severity for each individual according to the following categories: 0 (no lesions), 1 (crack present in the skin of at least 1 foot), 2 (1–6-mm-diameter callus present on at least 1 foot), 3 (callus present, with further cracking, on at least 1 foot).[15]

All the birds were observed fortnightly during the course of the trial to record both activity and the time spent when using one of the following 4 substrates: water, gravel, rubber matting, or salt footbath. Bird behavior was classified and recorded in the following 8 activities: walking, gathering, feeding from food plates or from the water, roosting, preening, sitting, interacting, and others, which was a combination of 2 activities (roosting and preening, and sitting and preening), or when the bird was standing up and alert. The individual activity was registered every 5 min during 30 min per aviary, between 08:00 and 18:00 hours during 2 consecutive days for 6 periods: early morning, middle morning, late morning, early afternoon, middle afternoon, and late afternoon.

Bird weights before release, time allocation to different activities, and the time spent on different substrates were all analyzed by using 1-way analysis of variance (ANOVA), both among treatments and lesion categories. Because observations during the different daytime periods were evenly distributed among treatments, this factor was not included in activity analyses. Because individual birds were observed repeatedly during the study and the number of records differed among birds, comparisons of the different activities among treatments were performed by 1-way ANOVA on the mean times that every bird allocated on each activity. Data were log-transformed to improve normality and variance homogeneity if needed, and the Tukey honestly significant difference (HSD) post hoc tests were performed for multiple comparisons when required (Statistica 1998 Edition®, StatSoft, Inc., Tulsa, Oklahoma 74104, USA).[12]

RESULTS

On initial examination in January, 45 of the 47 black stilt chicks (96%) already exhibited symptoms of pododermatitis; 41 had small cracks, and 4 exhibited swelling, on the digits of at least 1 foot. Before release in September, most juveniles (>87.5%) in all experimental groups still had symptoms, including further hyperkeratinization (callus development) (Table 1). There was no

Figure 1. Ulceration of the plantar metatarsal pad and peripheral callus (hyperkeratosis) of the plantar surface of the feet of a captive-reared black stilt. Label tag height = 1 cm.

detectable effect of either the rubber matting or salt footbath treatments on either the proportion of birds affected or the severity of symptoms; the majority of individuals exhibited discrete lesions that involved hyperkeratinization in the metatarsal pad (Fig. 1), some localized swelling and reddening of the tissues that surrounds the defect or some cracks in the second, third (Fig. 2), and fourth digits. There were no significant differences among the groups in bird weight among treatments (1-way ANOVA; $F = 0.217$; $df = 3, 43$; $P = 0.884$) nor among symptom development ($F = 0.849$; $df = 3, 43$; $P = 0.475$).

A total of 576 observations were carried out, distributed fairly evenly among treatments: rubber matting, 165; salt footbaths, 143; rubber matting and salt footbath, 149; control, 119 (Kruskal-Wallis test; $H = 4.369$; $P = 0.224$). Time spent walking was significantly different among treatments (1-way ANOVA; $F = 5.866$; $df = 3, 34$; $P = 0.002$), with birds in aviaries provided with both rubber matting and salt footbaths walking significantly more than birds in rubber matting and control aviaries (Tukey HSD, $P < 0.05$) but not when compared with birds provided just with salt footbath (Tukey HSD, $P > 0.05$) (Fig. 3a). In contrast, the remaining bird activities did not show differences among treatments (1-way ANOVA, $P > 0.05$; Fig. 3a). The time that individuals spent on different activities did not vary with pododermatitis symptoms (1-way ANOVA, $P > 0.05$; Fig. 3b). In aviaries provided with artificial substrates, the birds spent substantial time using both the rubber matting and salt footbaths (averages of 30% and 3.5%, respectively; Fig. 4). When time spent per substrate type was corrected by its total surface, the birds in the control aviaries spent equivalent time in water and on gravel (Table 2). However, in treatments provided with artificial substrates, birds spent significantly more time (per m^2) in any artificial substrate than in water and gravel (Table 2).

Figure 2. Swelling and cracks on the third digits of a captive-reared black stilt. Label tag height = 1 cm.

DISCUSSION

Pododermatitis is generally considered a disease of inactive and overweight birds housed in poorly designed aviaries.[9,11] As such, recommended preventative measures include changes in diet and substrate, and the provision of more space to facilitate exercise.[9,10,13,15] This study addressed the substrate issue for black stilts reared in captivity as part of the Department of Conservation's "Kaki Recovery Program," for which pododermatitis is a reoccurring disease condition.

Neither the provision of rubber matting nor salt footbaths made any difference to the occurrence and the severity of pododermatitis in reared birds. The lack of an effect of either treatment on pododermatitis development cannot be attributed to the birds that did not use either the rubber matting or the salt footbaths. Artificial substrate surfaces were relatively small compared with aviary surface; matting and salt footbath surfaces represented 0.3 and 0.1%, respectively. During the observation periods, birds in aviaries with rubber mats present were recorded as spending an average of 30% of their time actually on the rubber matting, whereas birds in aviaries with salt footbaths present spent an average of 3.5% of their time actually in the footbaths. Such time periods were considered sufficient for the matting and salt footbaths for any potential effects of the treatments to be realized, which implies that the substrate used in the Twizel aviaries (rounded river stones and gravel, with water flowing in

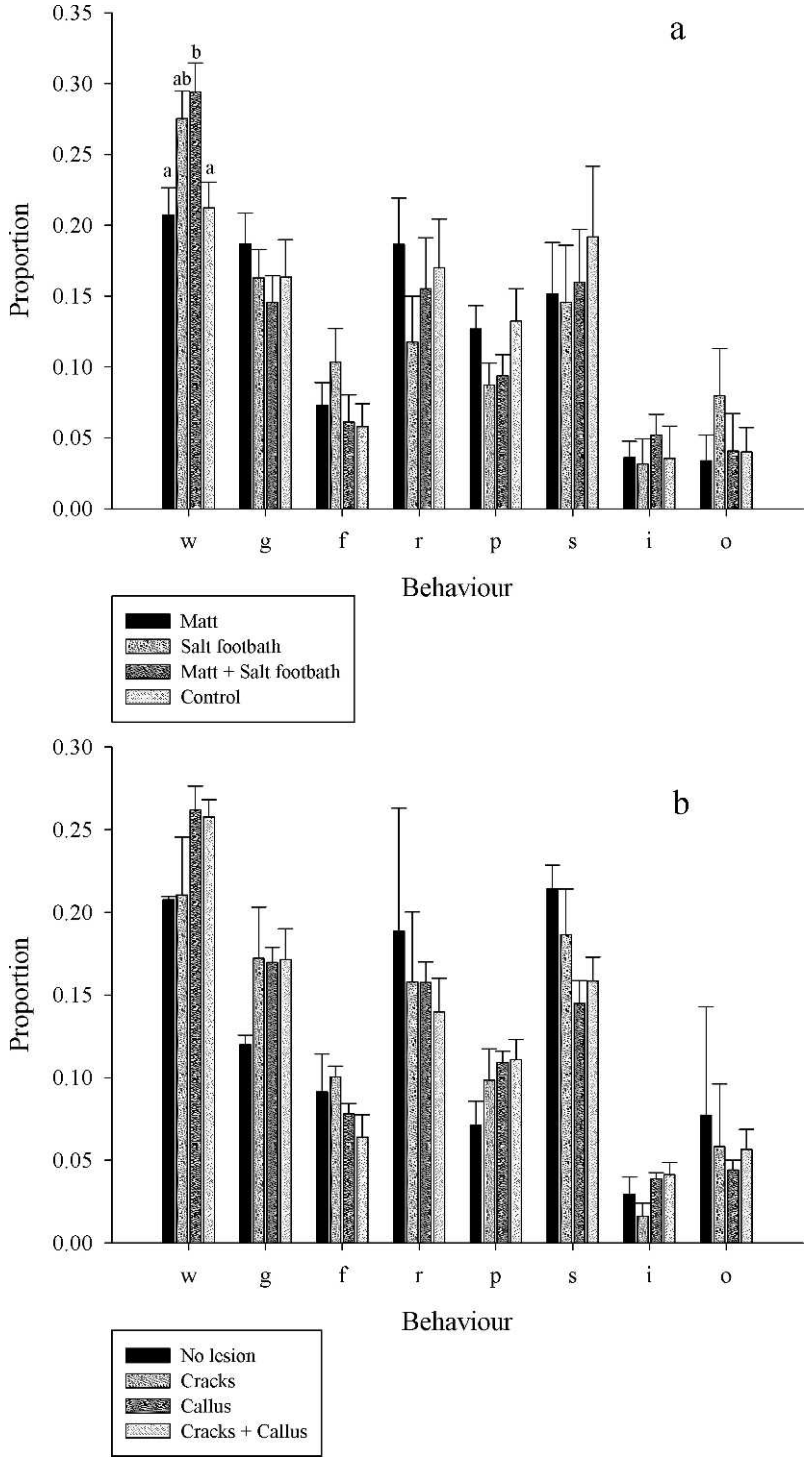

Figure 3. Juvenile black stilt activity in relation to experimental substrate manipulation. **a.** The effect of treatment on behavior. **b.** The effect of pododermatitis symptoms on behavior. Bird activities: walking (w), gathering (g), feeding from food plates or from the water (f), roosting (r), preening (p), sitting (s), interacting (i) and others (o). Different letters on the top of the columns indicate significant differences (Tukey honestly significant difference test, $P < 0.05$).

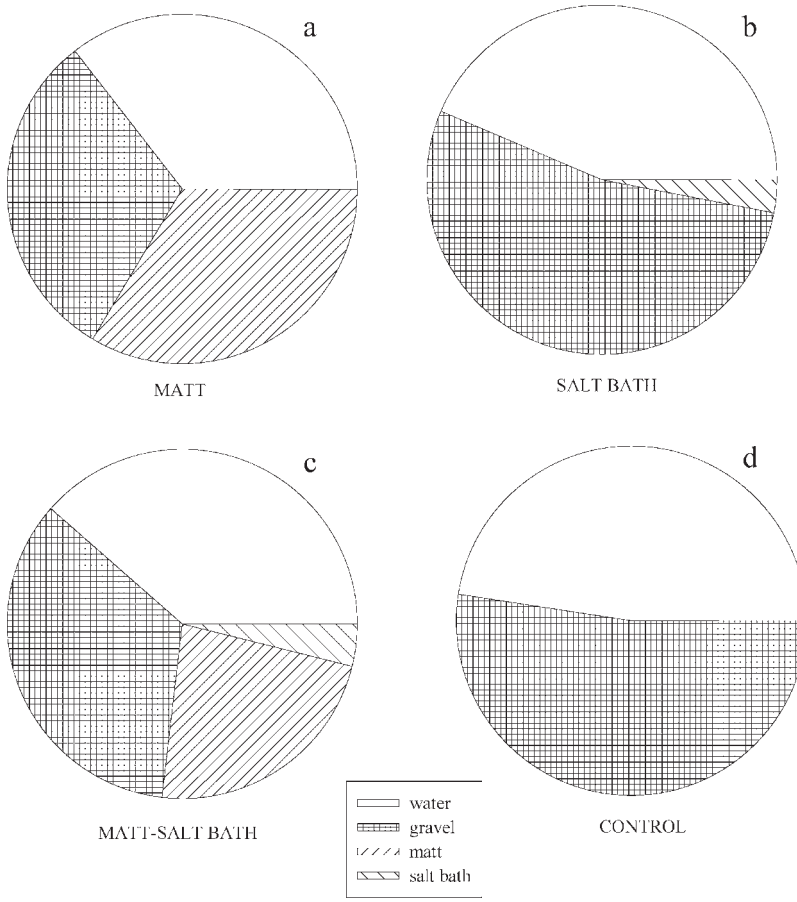

Figure 4. Time spent by black stilts on different substrates in the 4 treatment groups.

parts) is not a cause of the pododermatitis observed.

During this study, clinical signs of black stilts with pododermatitis included cracking or peeling of the skin on the digits, swelling, ulcers, and development of callus on the plantar feet surface. Swelling or ulcerative lesions may become infected and could be life threatening if infectious agents invade associated tendon sheaths and bones.[15] Although bacteremia is common in birds with the lesions mentioned above, signs of infection were not apparent in this study. It has been reported that advanced cases of pododermatitis can be infected with a *Staphylococcus* sp., and routinely sanitary measures, such as substrate disinfections and regular stone changing, are needed.[9,13,15,18] Before this trial, it was considered that the inability to effectively change and/or disinfect the substrate in the aviaries may be encouraging secondary infections and, hence, be

Table 2. Results of 1-way analyses of variance of the time spent by black stilt on natural and artificial substrates (corrected by substrate surface availability) present in aviaries in the 3 treatments and control.[a]

Substrate manipulation	df	F	*P*	Tukey HSD test[b]
Control	1,12	1.973	0.186	—
M	2,33	162.148	<0.001	M > G = W
SFB	2,27	11.966	<0.001	SFB > G = W
M and SFB	3,32	15.802	<0.001	M = SFB > G = W

[a] HSD, honestly significant difference; M, matting; G, gravel; W, water; SFB, salt footbath.
[b] Shows differences among substrates at $P < 0.05$.

contributing to the problem.[2] However, the fact that secondary infections were not observed in this study further implies that the observed pododermatitis is not a hygiene issue.

With no indication that substrate is playing a role in the pododermatitis observed, diet and exercise space are other factors that need to be considered. Deficiencies of single vitamins (principally vitamin A and biotin) have been reported as predisposing factors to pododermatitis in birds.[1,11] However, the diet used at the "Kaki Recovery Program" has been analyzed before this study and seems to fulfill the nutritional requirements for rearing black stilts in captivity.[5] Thus, the remaining question is whether or not the birds reared at Twizel have sufficient space to facilitate exercise, which could be investigated readily by using aviaries of different size.

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