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Efficacy of seawater for washing oiled birds during an oil spill response

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ABSTRACT

Aquatic pollution events can be detrimental to the survival of wildlife, particularly birds. To decontaminate affected birds, large quantities of fresh water are required. A recent study using seabird feathers, demonstrated that seawater wash/rinse can effectively remove oil from feathers. However to determine whether seawater was effective for live birds, we used 36 mallard ducks to replicate the oiled feather wash/rinse study. We investigated the time and volume of water used, bird water-proofing scores after daily swims and a barbule amalgamation index (BAI), for feathers collected at stages throughout the process. Results indicate that for oiled mallard ducks, the use of seawater for decontamination wash/rinse was effective. Seawater wash however, took longer and used a greater quantity of water. Time to birds being waterproof, was not significantly different between groups. The use of seawater has worldwide application for oiled wildlife response activities particularly in areas where freshwater supplies are limited.

1. Introduction

During an aquatic pollution event, birds are at the highest risk of becoming contaminated with hydrocarbon products which severely affect the insulation and water repellency of their plumage (Clark, 2001). Contaminated individuals quickly become water-logged and lose the ability to thermoregulate leading to either hypothermia or hyperthermia and/or drowning (Clark, 2001; Jessup and Leighton, 1996).

Oiled wildlife response is globally recognized as an important component to the clean up of oil after a spill and has received increased exposure since the *Exxon Valdez* oil spill in 1989, when thousands of birds and other wildlife died from oil related health problems (Piatt et al., 1990; Piatt and Lensink, 1989). Remoteness of the site of a spill has been identified as a major constraint in wildlife response (Ruoppolo et al., 2013) with access to large volumes of fresh water for the decontamination process just one of the many logistical challenges associated with a remote response (Callahan and Clumpner, 2005). Washing oiled wildlife uses a significant quantity of freshwater (up to 1200 l per 1 kg bird) and in remote areas, this could potentially be problematic where freshwater is limited.

A key component of an oiled wildlife response for birds is the decontamination or cleaning process, during which the hydrocarbon oil product is removed from plumage. Various cleaning agents have been trialled with varying results including: cornstarch; sawdust; iron filings; organic solvents; mineral oils; and bilge cleaners (Bryndza et al., 1995; Orbell et al., 1999). Currently, the international best practice for decontaminating oiled avifauna involves a succession of washes through baths of warm (41 °C), softened freshwater and Dawn™ detergent (1–2%), followed by a rinsing process whereby all detergent residues are removed (Massey, 2006). The removal of all traces of both oil and detergent are fundamental for the restoration of the water repellency and insulating properties of feathers (Bryndza et al., 1995). Following cleaning, oil-affected avifauna need to be rehabilitated in pools where swimming and preening are encouraged, whereby individuals can work to realign clean feathers and restore waterproofing. A recent study demonstrated that seabird feathers washed with seawater generally had lower scores for waterproofing compared with freshwater (McConnell et al., 2015), however when examined during microscopy there was evidence to suggest that sea water washing may provide a reasonable alternative. McConnell et al. (2015) also suggested that the experimental application of these methods to live birds could confirm the relationship between feather integrity, measured using a barbule amalgamation index (BAI), and preening behavior on waterproofing. The aim of this study was to investigate the effect of seawater washing on the waterproofing of an aquatic bird by assessing, i) waterproofing scores of whole birds used in oiled wildlife response, and ii) assessing feather clumping (BAI) under light microscopy at various stages throughout the washing and waterproofing procedure.

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2. Material and methods

Forty-four hand-reared mallards (*Anas platyrhynchos*), obtained from a wildlife rehabilitator, were used for this study. Four experimental groups included: i) seawater wash/seawater rinse, ii) freshwater wash/freshwater rinse, iii) seawater wash/freshwater rinse, iv) freshwater wash, seawater rinse. Ducks were tube fed 20 ml Vytrate® solution at least an hour prior to oiling. For oiling, each duck was submersed in a solution of 1 l heavy fuel oil to 40 l warm water (giving an approximate 1 cm of heavy fuel oil on surface of tub for all birds) for 1 min and transferred straight away to the wash station to which it was allocated (1 of the 4 treatment groups). All ducks were washed and rinsed by experienced wash personnel with water and 2% Dawn® (Procter and Gamble). The time (mins) and quantity (litres) of water were recorded for wash period. Each duck was then transferred to a rinse station and assigned to the selected rinse medium. Total time (mins) for rinsing was recorded. Ducks were then transferred to a drying room where they were monitored until dry. Fluids and food were provided as per standard oiled wildlife protocols (Mazet et al., 2002). Two feathers (one contour feather and one down feather) were collected at set time points; 1) pre-wash, 2) post-wash, 3) pre-swim, and 4) post swim (Table 1), to assess under light microscopy using a Barbule Amalgamation Index (BAI) that was used for a pilot study on feathers (McConnell et al., 2015). After the wash day (i.e. on day 2), ducks were put into large swimming pools to commence the waterproofing process in freshwater. The ducks were swum daily and assessed by experienced personnel as to their waterproofness (scored between 1 and 5), as per in-house oiled wildlife waterproof assessment protocols, where a score above 4.5 is suitably waterproof. All ducks were swum for three days. Ducks were observed continuously during the swimming process to monitor on-water preening and haul-out behavior, and if they were notably stressed and required removal from the pools.

For this study, seawater was collected directly from the intertidal zone at Plimmerton, New Zealand (41°5.06′S; 174°51.99′E) with a hardness > 6000 mg/l $CaCO_3$ and salinity of 3.5%. Fresh water was tap water run through a water softening device with a hardness of < 60 mg/l $CaCO_3$. For all washing and rinsing water temperature was constant (40–41 °C).

For each feather collected, four 800 μm sections were selected from each feather were assessed using light microscopy. Sections were selected semi-randomly, from either side of the feathers rachis, but avoiding the very tip and looser bottom feathers to avoid areas that may have contain pre-oiling splits in ramus because of general feather structure (O'Hara and Morandin, 2010). Following O'Hara and Morandin, 2010, a BAI was determined for each section: which consisted of creating a numerical series, where ‘unclumped’ barbules were scored ‘1’ and ‘clumped’ barbules were scored equivalent to the number of barbules in the clump. An average was calculated for each series to produce the section amalgamation index. Section results were then collated to give a mean amalgamation index for each feather. Mean BAI for each treatment group were then compared to assess waterproofing at each of four stages; 1) pre-wash, 2) post wash, 3) pre-swim, 4) post swim (Table 1).

The difference in water used for washing (time and quantity) and rinsing (time) were compared between groups using non-parametric “Kruskal-Wallis tests”. Waterproofing scores were compared using repeated measures ANOVA with post-hoc pairwise comparisons. Feather BAI scores were compared with a 2-way ANOVA using corrected marginal means due to uneven sample sizes. Alpha level for significance was set at 0.001 due to violation of Levene's test for variance. All statistical analyses were undertaken in IBM SPSS Statistics, version 23.

Table 1
Mean barbule amalgamation index (BAI) scores (± S.E.) of feathers collected from mallards at time 1 (pre-wash), 2 (post-wash), 3 (pre-swim), 4 (post-swim) and from four groups; 1 (freshwater wash, freshwater rinse), 2 (freshwater wash, saltwater rinse), 3 (saltwater wash, freshwater rinse), 4 (saltwater wash, saltwater rinse). There was no significant difference between groups ($p = 0.028$) or for the time that feathers were collected ($p = 0.098$) and no significant interaction ($p = 0.185$).

Group	Time of feather collection	Mean BAI score	Std. error	95% Confidence interval	
				Lower bound	Upper bound
1	1	3.031	0.202	2.634	3.428
	2	2.616	0.202	2.219	3.013
	3	2.516	0.202	2.119	2.913
	4	2.717	0.213	2.299	3.136
2	1	2.359	0.219	1.928	2.790
	2	2.653	0.260	2.141	3.166
	3	2.323	0.213	1.905	2.742
	4	2.051	0.225	1.607	2.495
3	1	2.592	0.213	2.173	3.010
	2	2.336	0.241	1.862	2.811
	3	2.707	0.213	2.289	3.126
	4	2.687	0.225	2.243	3.131
4	1	2.789	0.233	2.331	3.248
	2	2.556	0.285	1.994	3.117
	3	1.876	0.225	1.432	2.320
	4	2.036	0.225	1.593	2.480

3. Results

Eight ducks were removed from the study due to complications arising from salt toxicity thought to be caused by these hand raised freshwater ducks swallowing the salt water during the rinse process (Finlayson et al., 2015). The remaining ducks were assessed as adequately cleaned straight after wash in both fresh water and salt water (i.e. all oil was removed as per typical assessment for an oiled wildlife response). Washing took significantly longer in salt water ($F_{1,36} = 16.998$, $p < 0.001$) with significantly more water ($F_{1,36} = 13.365$, $p = 0.001$) (Fig. 1). On average, it took 13.4 min to wash in freshwater compared to 19.1 min with salt water. There was a significant difference in the rinse time between groups ($F_{3,36} = 11.206$, $p < 0.001$), with the treatment seawater wash/freshwater rinse taking the longest mean time of 21 min and freshwater wash/seawater rinse treatment the shortest mean time of 11 min (Fig. 2). There was a significant time difference to waterproofing across the three days that the ducks were swum ($F_{2,35} = 43.017$, $p < 0.001$), with ducks from the seawater wash/freshwater rinse treatment considered ‘waterproof’ (WP score > 4.5) from day 1 (Fig. 3.). Ducks in the freshwater wash/freshwater rinse group also appeared to be mostly waterproof after one day of swimming. With alpha level set to 0.001 for feather analysis due to unequal variances, there was no significant difference between groups ($p = 0.028$) or for the time that feathers were collected ($p = 0.098$) and no significant interaction ($p = 0.185$). There was generally high variation for all feathers analysed (Table 1), with

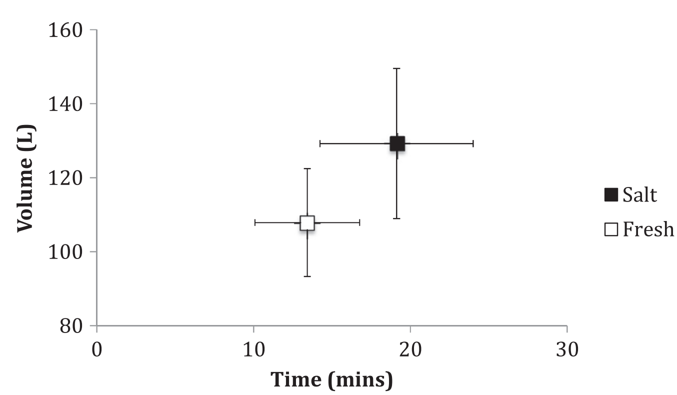

Fig. 1. Mean wash time and water volume (± SE) for oiled mallards washed in either seawater (salt) or freshwater (fresh). Washing took longer in salt water ($F_{1,36} = 16.998$, $p < 0.001$) with significantly more water ($F_{1,36} = 13.365$, $p = 0.001$).