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EXPERIMENTAL OILING OF SANDERLINGS (*CALIDRIS ALBA*): BEHAVIOR AND WEIGHT CHANGES

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Abstract—We applied fresh and weathered oil from the *Anitra* oil spill to the belly feathers of experimental sanderlings (*Calidris alba*) to simulate 20% plumage oiling, whereas controls were stroked with clean swabs only. We tested the null hypotheses that there were no differences in behavior following oiling and that there were no differences in weight gain or loss in control and experimental birds. Control sanderlings showed no differences in behavior before and after oiling, but oiled birds spent significantly less time resting and more time bathing and preening. Significant differences in weight and behavior were observed between the control and oiled birds. Following oiling, the sanderlings preened vigorously, spreading the oil so that they appeared to have oiling rates of 30%. Thereafter, the percentage of their plumage that was oiled decreased steadily over the next 2 weeks, but the birds never appeared completely free of oil.

Keywords—Oil Oil spill Birds Behavior Weight changes

INTRODUCTION

Oil production and consumption continue to increase globally, within both developed and developing countries. Many countries import crude oil and export oil products. This results in increased transportation of oil over the oceans, with an increased potential for oil spills. From 1978 until 1994, there were as many as 205 oil spills of more than 10 million gallons each year, not to mention other smaller spills [1]. The amount of oil entering the oceans from oil spills alone averages 40 to 325 million gallons/year worldwide [1]. As oil tankers have increased in size, so have oil spills [2]. The potential ecological damage to the organisms that live in the oceans and along the shore is large because so many organisms (or their early life stages) are concentrated along the coasts. It is along the coasts that most major oil spills occur, both because of offshore drilling and because of lighting and oil transfer operations [3]. Birds are often the most visibly affected because they concentrate and forage along the ocean [4,5].

In the wake of oil spills, hundreds of birds can wash ashore [6]. Seabirds and shorebirds are more at risk from oil spills than other birds because they spend the most time in marine environments. Birds can be harmed when they are covered with oil [7,8], when they ingest it [9], and when they bring it back on their plumage and accidentally oil their eggs [10,11] or offspring [12,13]. Estimates based on studying oiled birds in captivity suggest that birds ingest 50% of the oil on their feathers within 1 week of exposure, but others have suggested that ingestion occurs much more rapidly [14].

For people involved in cleanup decisions, it is critical to understand whether the birds are being oiled every day or whether the oil on their plumage still remains from the initial oiling. One other key question for oil spill response teams is whether the weathered oil on the beaches is as harmful to birds and other beach organisms as the fresh oil. This is critical because managers must decide whether to continue picking up the oil or to rake the oil into the sand to keep beach-goers from direct oiling. However, this procedure ensures that the oil remains in the sand, where it can affect soil invertebrates. Few experimental data are available for making an informed decision, and our experiments were designed to answer these questions using oil from an actual oil spill.

Other research has shown that oiling of seabirds increases metabolic rate [15], changes the thermal neutral zone [16], and decreases growth [17]. Oiling can also result in changes in the levels of pituitary hormones, estrogen, androgen, and corticosterone [18]. Both physical and physiological effects can occur at low levels of oiling [19,20].

In this study, we examined the effect of oiling the plumage of sanderlings (*Calidris alba*) on their subsequent behavior and weight. We tested the null hypothesis that there were no differences in behavior or weight as a function of oiling. We were also interested in how long it took the sanderlings to preen their plumage so that no oil was visible and in whether there were differences between fresh and weathered oil. We used oil from the *Anitra* oil spill that occurred in Delaware Bay and along the New Jersey (USA) shore in May and early June 1996. Delaware Bay is one of the top three ports of the United States in terms of both oil tanker calls and amount of oil moved through the port [2]. Delaware Bay is the major continental stopover point for shorebirds in the spring [4–6].

MATERIALS AND METHODS

Our experimental sanderlings were collected along the coast of Texas in the winter of 1995 under appropriate permits from the Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service [21]. The birds were used for other behavioral observations, and our permit stipulated that they not be returned to the wild. Our protocol was approved by the Animal Review Board of Rutgers University. The sanderlings

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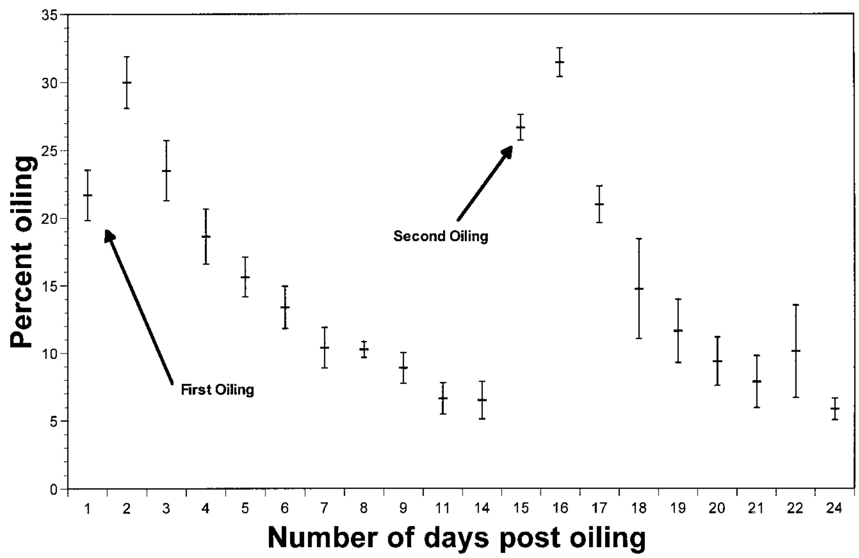

Fig. 1. Percentage of plumage that was oiled by visual estimate on the Sanderlings following oiling ($n = 8$).

were not subjected to as much oil as sanderlings foraging along the Ocean City, New Jersey, shore during the *Anitra* oil spill, nor were they oiled as frequently.

Ten sanderlings were part of the oiling experiment. Of the 10 sanderlings, two were controls, and four each were assigned to receive fresh oil or weathered oil. The additional controls were used to understand changes in weight of the sanderlings in the experiment.

Birds were housed under a light : dark cycle of 13:11 h in 3m × 3m enclosures where they could move and fly freely. They were provided with food and water ad libitum, and at least one container had running water.

We observed the birds before oiling, extensively during the following 48 h, and less extensively until 2 weeks after oiling. Visual estimates of oiling, measurements of extent of oiling, and weights were obtained daily for 2 weeks following oiling.

Before oiling all birds were weighed and given bands with a unique color combination. Birds were assigned to a group on the basis of weight; that is, all three groups had birds that were similar in weight. Birds were allowed to reacclimate for 1 h in their cage before behavioral observations were started. Behavioral observations were then made 1 h before oiling.

All birds were then captured, and two birds were oiled at a time (one with fresh oil and one with weathered oil). We did not have truly fresh oil available but used oil that had been released in the water for about 14 d (until it reached shore). Weathered oil was taken from the beaches 28 d after the initial spill and had been only recently washed in by high tides. Because the oil was removed from the beaches each day by cleanup crews, the weathered oil had been weathered in the water rather than by lying on the beach.

We applied the oil with a cotton swab and weighed the swab when it was full of oil and after we had oiled the bird. A different swab was used for each bird, and birds were oiled on their undersurface. This allowed us to calculate the amount of oil that was applied. We applied oil so that the bird appeared 20% oiled, the most common oiling category following the *Anitra* oil spill [21]. The birds were initially exposed to 20% oiling and 2 weeks later were again given oil equal to 20% oiling of their plumage.

Sanderlings then were placed in the pen, and behavioral observations were made with binoculars on each bird for five 1-min samples by two observers. We could not oil all birds at once because it would then be impossible to obtain behavioral data immediately following oiling. Using stop watches, we recorded the amount of time devoted to resting, feeding, running or walking, preening, bathing, or in aggression. We continued this protocol until all birds had been oiled or stroked with a clean swab (control birds).

Observations were made immediately after oiling and 1, 3, 5, and 7 h after oiling on the first day (1 h before lights were turned out) and again 21 h (1 h after lights were turned on), 24 h, and 30 h after oiling. On the third day after oiling, observations were made 45 and 49 h after oiling. Thereafter, behavioral observations were made at 24-h intervals.

Visual estimates of oiling were made following every behavioral observation period and at 24-h intervals during the following 2 weeks. Birds were captured every 24 h to obtain weights and to measure the extent of visible oiling on the plumage. This estimate of oiling was more precise than the visual estimates but cannot normally be performed in the field because birds are not captured. Estimates of oiling were made to assess how long oil remains on the plumage and to understand the oiling patterns observed in the field.

We present means and standard errors in the text and figures and used a two-way analysis of variance (which gives χ^2 statistics) with repeated measures to determine whether there were differences as a function of treatment and the interaction of treatment and time since oiling [22]. We present statistical information whenever p was less than 0.1 to prevent type II errors (due to small sample sizes).

RESULTS

Degree of oiling and weight differences

The second day after oiling, the percentage oiled that we could observe with binoculars increased to about 30% as they spread the oil over their undersurface and sometimes onto their heads (Fig. 1). The percentage of oiling then decreased but reached a plateau at about 6 to 7% (Fig. 1). The measured oil showed a similar increase followed by a decrease (Fig. 2). The

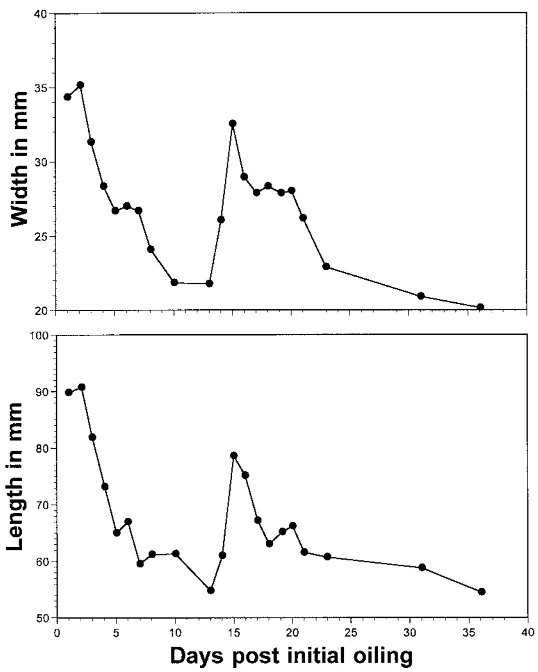

Fig. 2. Length and width of oil on underside of Sanderlings as measured during weighing.

fresh oil spread more than the weathered oil, covering more of the plumage.

The oiled birds experienced a decline in weight during the period following oiling, from an average of about 70 g to an average of about 63 g 10 d later (Fig. 3). For the 10 birds in the experiment, food consumption decreased from 93.1 g/24 h in the week before oiling to 58.5 g/24 h the week following oiling.

Behavioral observations

The behaviors of interest were preening, bathing, and resting because the birds were expected to try to remove the oil immediately after exposure, leaving less time for resting. Bathing increased immediately after exposure to oiling for both oilings and was slightly higher during the rest of the experiment (Fig. 4; $\chi^2 = 3.8$, $p < 0.09$). Preening also increased immediately after exposure and remained high for several days (Fig. 4; $\chi^2 = 11.7$, $p < 0.01$; treatment type $\times$ hours since oiling, $\chi^2 = 4.7$, $p < 0.07$). Resting time, however, was lower in oiled birds (Fig. 4; hours since oiling, $\chi^2 = 33.8$, $p < 0.007$; treatment type $\times$ hours since oiling, $\chi^2 = 16.3$, $p < 0.005$). Thus, oiled birds spent more time preening and bathing and less time resting than control birds.

Aggression also increased overall in oiled compared with control birds. We compared the number of aggressive encounters in the first three observation periods following oiling ($\chi^2 = 9.2$, $p < 0.002$). The mean number of aggressive encounters per session during the first oiling experiment for oiled birds was 1.8 $\pm$ 0.6 and for the control birds was 0.3 $\pm$ 0.2; during the second experiment, it was 5.1 $\pm$ 0.9 for oiled birds and 0.2 $\pm$ 0.2 for control birds.

DISCUSSION

Comparison of oiled and control birds

The following main differences were observed: (1) oiled birds spent more time preening and bathing than control birds, (2) oiled birds spent less time resting than control birds, (3) oiled birds were more aggressive than unoiled birds, (4) weight decreased in oiled compared with control birds, and (5) the oil that was visible on the plumage increased in the day following oiling and decreased thereafter.

It is not surprising that the oiled birds spent more time preening immediately after exposure or that they bathed more

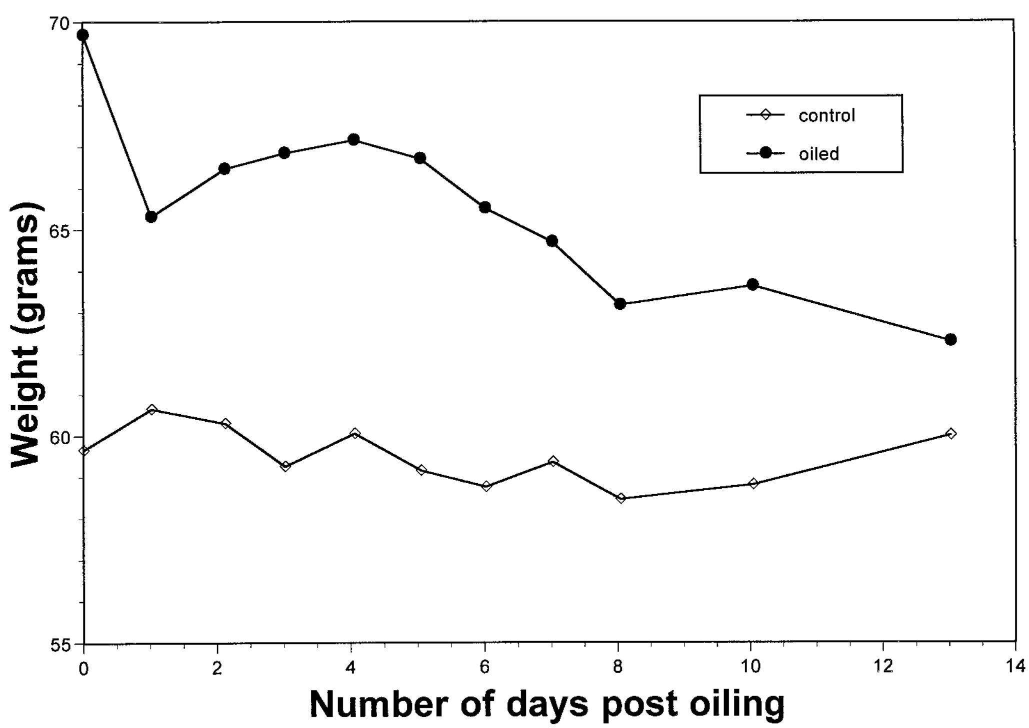

Fig. 3. Average weight of oiled and control Sanderlings during the first oiling experiment.

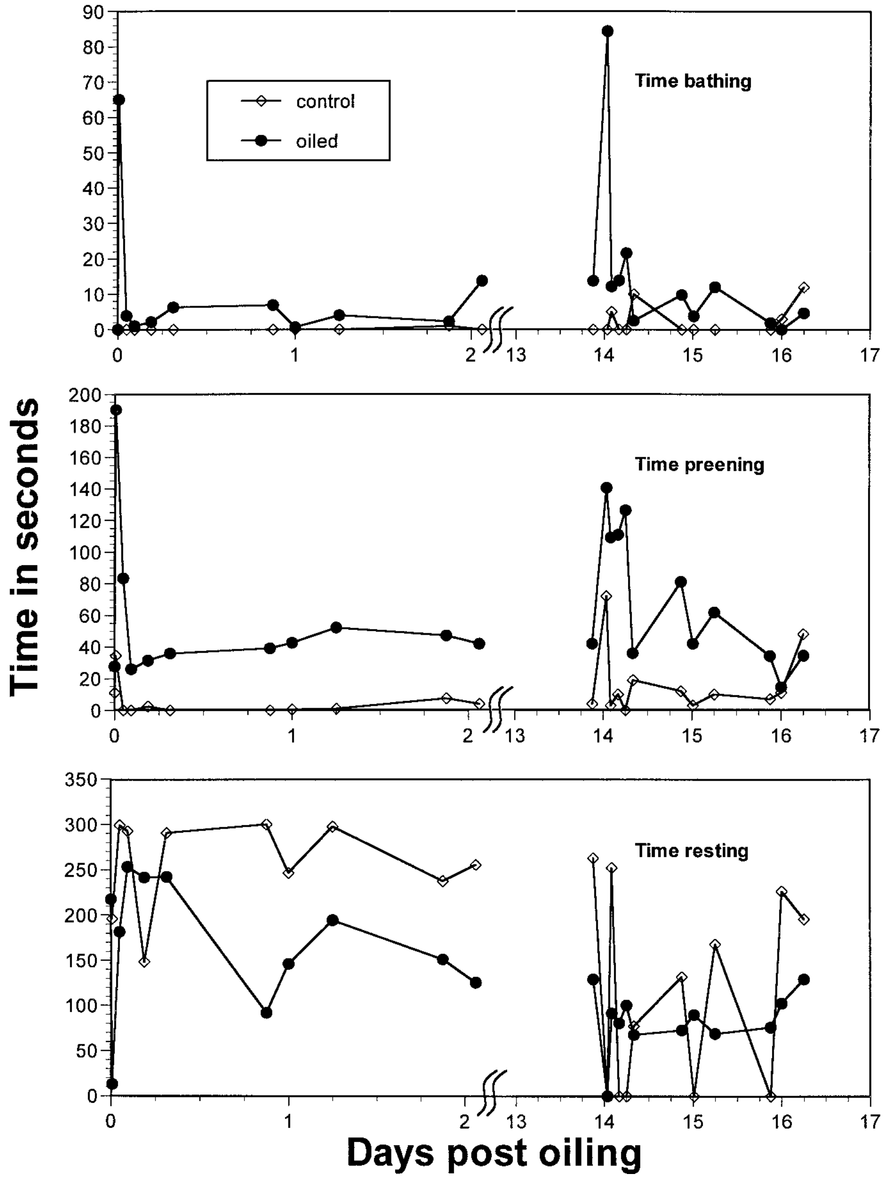

Fig. 4. Time devoted to different behaviors for oiled (solid circles) and unoiled (open circles) Sanderlings during the first and second experiments.

than the control birds. The increase in aggression was of interest because it was associated not only with protecting the water source (the pans with running water that they used for bathing) but with space in general. It almost seemed as if the oil made them more irritable, which would also detract from foraging time in the wild.

The pattern of oiling on the plumage was curvilinear with time; the percent of their plumage that was oiled increased over the first day and then began to decrease. It appeared that when the oil was first applied, the birds were spreading it by their preening action and, thereafter, began to remove it. It was somewhat surprising that some oil remained on their bellies for 2 weeks. Larson and Richardson [23] found that the percentage of oiled shorebirds observed during counts at Grays Harbor decreased significantly 10 d after oiling with high-grade (no. 6) fuel oil. We expected that the birds would be able to preen all the oil off their plumage within 3 to 4 d based on the fact that some unoiled birds were observed on the Delaware Bay beaches 3 to 4 d after the oil from the spill reached the shore. It now appears that these birds may have been migrants that had just arrived rather than oiled birds that had cleaned their plumage completely by preening. Some could have been birds that were never oiled.

Significance for migrating birds

We initiated this project largely because it was important to provide data that would allow us to understand the potential long-term effects of moderate oiling on migrating shorebirds. The shorebirds that stopped in Delaware Bay and along the southern New Jersey coast during their spring migration in 1996 encountered tidal waters and beaches with moderate oiling [21]. Even though cleanup crews removed the oil each day, with every new tide there was a film of oil or tar balls. Except in the case of some piping plovers (*Charadrius melodus*), most shorebirds were not completely covered with oil, and few dead carcasses were found. If a significant effect occurred, it was most likely in foraging behavior, weight gain, and length of stopover, which may have affected subsequent survival during migration or reproductive success in the Canadian Arctic.

Stopover areas are extremely important to migrating shorebirds [24], particularly because some species travel as much as 30,000 km each year. Many species stop only once or twice during migration, and the places they do stop must provide sufficient resources for continued flight [24]. Delaware Bay and the southern New Jersey Atlantic coast host the largest concentration of spring migrating shorebirds in North America [5]. The environmental conditions and food resources shorebirds encounter in migration at stopover areas are important for survival and later reproduction. Most of the shorebirds that pass through Delaware Bay are on their way to the Canadian Arctic, and they must arrive on the breeding grounds with sufficient fat reserves for reproduction. Timing is critical because of the short breeding season. Protection and management of stopover areas is necessary for conservation of food and habitat resources [25], and this management includes providing foraging habitat that is free from contaminants such as oil.

Shorebirds that foraged in the surf following the *Anitra* oil spill were particularly vulnerable because the oil continued to drift in with every high tide during most of May and into June. Sanderlings that run in and out with the tide to probe for invertebrates expose their bellies to any oil slick, providing the opportunity for continual oiling with each new wave of oil [21,26]. Our data indicate that even moderately oiled shorebirds alter their behavior and lose weight immediately after oiling. Given that this occurred after only one oiling and that the sanderlings that fed along the southern New Jersey coast were oiled anew each day, it is possible that they did not gain the weight they should have. This may have resulted in either continuing migration at suboptimal weights or prolonging their stopover time.

The length of stay of shorebirds on a spring stopover area may depend partly on body condition [27]. Length of stay may then be a result of body fat status when they first arrive on the stopover grounds, food resources and foraging conditions on the stopover area, and their foraging behavior. If food is plentiful and shorebirds can forage undisturbed, then presumable stopover time is less than if these conditions are less optimal. Oiling may decrease their attentiveness to foraging, providing an added stress for migrating shorebirds.

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