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Effect of Oil and Oil Dispersant Mixtures on the Basal Metabolic Rate of Ducks

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Although some studies have been carried out on the effects of crude oil on the basic metabolic rate (BMR) of ducks (HARTUNG 1967; McEWAN AND KOELINK 1973) none have assessed the combination of oil plus dispersant. Since the use of dispersants is a potentially major tool in the handling of oil spills, it seems advisable to study this problem so as to be able to make a rational decision whether or not to use dispersants when there is a threat to seabirds.

MATERIALS AND METHODS

Wild strain adult mallards (Anas platyrhynchos) were kept in groups of 3 or 4 with a thick bedding of dry hay. They had free access to a wading pool of fresh water and were fed commercial breeder's poultry pellets ad libitum throughout the experiment. The temperature in the animal room was kept around 15°C year-round but the light periodicity was not controlled.

Treatment for each bird included two exposures to seawater alone, a few days apart, to establish the basal metabolic rate of each individual bird, then a one-time exposure to either Prudhoe Bay Crude Oil (PBCO), Corexit 9527 or PBCO + Corexit 9527. After exposure to one of the pollutants, the bird was exposed two more times to seawater alone, 4 to 8 days and 8 to 14 days after, to follow the effect of the pollutant over a two-week period. For the seawater swimming part of the treatment, plastic tanks measuring 50 cm x 52 cm x 30 cm were used. Each tank was surrounded and covered by metal fencing, forcing the bird to remain on the water during the whole one-hour exposure period.

A 50-um thick oil slick was simulated by spreading 12 ml of PBCO on the water surface and stirring with a glass rod to obtain as homogeneous a layer as possible. It was then left to evaporate under a fan for a period of one hour. The preparation of the dispersant Corexit 9527 involved first a 1:2 (Corexit: seawater) dilution and then the addition of 1.2 ml of this solution to the seawater in the swimming tank (≃60 L). The dispersant was also stirred in with a glass rod.

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For the oil + dispersant mixture, the PBCO was first prepared exactly as described above, and after the one-hour evaporation period, 1.2 ml of the 1:2 (Corexit:seawater) mixture was added to it and stirred in until the surface oil was broken into small droplets and almost completely disappeared from the surface. This proportion of 10:1 (oil:dispersant) corresponds to the application procedure recommended for use in the case of an oil spill.

The birds were randomly assigned to one of the three treatment groups (PBCO, Corexit or PBCO + Corexit) with a minimum of 10 birds per treatment group. Each bird was fasted for 12 to 24 h before the experiment and so was expected to be in a post-absorptive state by the time of metabolic measurements. The exposure period to either seawater alone or seawater pollutant lasted one hour, during which time the bird had to remain in the water. After exposure, the bird was immediately transferred to the metabolic chamber, contained inside a thermostatically controlled incubator. The average temperature in the chamber was -12°C to simulate the cold stress to which a bird could be exposed when returning to shore during winter or almost all year in an arctic environment.

The metabolic chamber itself consisted of a 40 cm x 30 cm x 20 cm clear plexiglass box with an air-tight side door. The bird sat in the box on a grid raised 2 cm above the bottom of the box. The air inlet into the chamber was located under this grid with the outlet in the upper corner of the box, thus allowing a more diffused flow pattern around the bird. A low power light (7.5 watt) was left on at all times inside the incubator, so as to reduce the stress on the bird of being placed in a totally dark environment. The air leaving the metabolic chamber was dried and analyzed for its oxygen and carbon dioxide content. A Beckman Model 864 Infrared analyzer was used for CO_2 analysis and a Beckman Model 755 Paramagnetic analyzer for O_2 analysis.

The metabolic rates of the ducks were obtained by measuring the exchange of respiratory gases. Oxygen consumption and CO_2 production measurements were taken every 5 min over a $2\frac{1}{2}$ to 3 h period and were used to calculate the respiratory quotient ($RQ = CO_2/O_2$). Metabolic rate was computed using the formula of ROMIJN AND LOKHORST (1966):

$$Kcal = 3.871\ (L\ O_2) + 1.194\ (L\ CO_2)$$

These results were then calculated in kilocalories per kilogram of body weight per day (Kcal/kg day). The average metabolic rate for each experiment was calculated from 20 to 30 readings.

The normality of the distribution of each group of data was verified using the Kolmogorov-Smirnov statistical test. The paired t-test was used to compare the significance of the differences between the results of each exposure using the same bird, and unpaired t-test to compare the results of the different treatment groups.

RESULTS AND DISCUSSION

Visual observations

It only took a few minutes for the ducks to pick up almost all of the oil from the water surface, staining mostly the breast and wing feathers. After exposure to oil the birds were frequently observed shivering suggesting that the insulating properties of their plumage had been damaged. The barbules of these feathers were matted into clumps, allowing water to infiltrate the plumage and disrupting the smooth "layering" arrangement of the feathers. These observations parallel those made by HARTUNG (1967).

The birds swimming in water contaminated with dispersant sank to a much lower level than normal. It is assumed that this reduction in buoyancy was caused by the surfactant which rendered the feathers hydrophilic and therefore broke the water-repellent barrier that normally allows the birds to swim on the water while remaining completely dry. It was also noticeable that the birds could not shake or preen the water off their plumage as usual. In spite of their efforts to preen, they remained wet for much longer than birds exposed to only water or even to oil.

Despite the fact that the oil was effectively dispersed by the Corexit, after a few minutes birds exposed to the mixture were indistinguishable from birds exposed to oil alone. By the end of the one-hour exposure period, they were just as soaked and waterlogged as birds exposed to dispersant alone and their plumage was as stained and matted as those exposed to oil alone.

Changes in metabolic rate

The average values of the metabolic rates for each treatment are given in Table 1.

Table 1. Metabolic Rates of Mallards Exposed to Oil and/or Dispersant (kcal/kg day)

	OIL	OIL + DISPERSANT	DISPERSANT
CONTROL	206.8± 6.5 (15)	195.6± 4.0 (12)	195.5± 9.5 (10)
EXPOSURE	*222.7± 9.5 (15)	***241.5±10.3 (11)	204.7± 6.0 (10)
1° POST-EXPOSURE	***232.6± 6.8 (15)	***231.9±12.0 (12)	193.0±10.8 (10)
2° POST-EXPOSURE	**232.0±10.2 (15)	***237.7± 9.1 (12)	201.2±11.5 (9)

Figures are arithmetic means with standard error and sample size

*** significantly different from the CONTROL value with P > 99%
** significantly different from the CONTROL value with P > 95%
* significantly different from the CONTROL value with P > 90%

The control values were consistent within groups and were similar to previously reported data (HARTUNG 1967; McEWAN AND KOELINK 1973). Although the basal metabolic rate (BMR) is significantly increased by oil, it is markedly less than that found by earlier works. HARTUNG's measurements on a single mallard showed close to a doubling of the BMR (measured at -10°C) caused by 15 g of fuel oil and in the closely related black duck (Anas rubripes) 10 g of oil caused a 60% increase. McEWAN AND KOELINK's data cannot be compared directly as they worked at higher temperatures, but their results indicate greater changes of BMR than noted here. While it is not possible to compare the degree of damage caused by oil using different oils and under somewhat different conditions, the difference between our findings and those reported earlier are difficult to explain. There is a further difference between our findings and those of HARTUNG (1967) in that he found a marked decrease of BMR back towards control values 3-7 days after exposure to oil, whereas we found a slight increase over the period 4-14 days after exposure.

Although birds swimming in seawater + Corexit 9527 showed signs of loss of buoyancy, there was no significant increase in the BMR. This lack of effect of the dispersant observed on the day of exposure continues over the post-exposure period, as seen by the metabolic rates calculated 4 to 8 days and 8 to 14 days after exposure.

This lack of response may be due to the fact that the air entrapped between the feathers was still intact and only the surface feathers were soaked, therefore not causing as big a stress as oil alone which opens the plumage to the infiltration of water and to the escape of metabolic heat. The metabolism was measured after a one-hour exposure period and would have probably been very different after a few hours if we consider the progressive wetting and waterlogging which resulted from exposure to dispersant.

The exposure to oil + dispersant has resulted in a clear increase in their BMR. This increase, seen on the day of exposure, extends to both the 1st and 2nd post-exposure measurements, 4 to 8 days and 8 to 14 days after exposure. The metabolic rate of ducks exposed to oil + dispersant was not significantly different from that of ducks exposed to oil alone.

Our experiments showed that the degree of oiling to which we exposed our ducks caused a modest but significant increase in the metabolic rate. Under the experimental conditions (one-hour exposure, small volume swimming tanks, measuring of metabolism after the removal of the bird from the water), the dispersant (at 30:1 ratio) does not appreciably increase the effects caused by the crude oil on the metabolic rate, although it seems to increase the damage to plumage which leads to progressive waterlogging.

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