Bull. Environ. Contam. Toxicol. (1985) 35:9–14

Bulletin of Environmental Contamination and Toxicology

Thermoregulation in a Naturally Oil-Contaminated Black-Billed Murre *Uria aalge*

Bjørn M. Jenssen, Morten Ekker, and Claus Bech

Department of Zoology, University of Trondheim, N-7055 Dragvoll, Norway

The effect of oiled plumages on seabirds is considered to be reduced thermal insulation, with a resultant increase in metabolic rate. This conclusion is based on results from ducks with experimentally oil-contaminated plumages (Hartung 1967; McEwan and Koelink 1973, Lambert *et al.* *1982*). In these studies, oil-contamination caused an increase in the metabolic rate of between 15 and 50% in various species of ducks. However, there seem to be no similar studies involving naturally oiled birds. The only study providing data on thermoregulatory ability in such birds, is that of Erasmus *et al.* (1981), who measured body temperature in the Jackass penguin (*Spheniscus demersus*) with 75% oil-contaminated body surface.

In the present paper, data on body temperature, metabolic rate, and insulation in a Black-billed Murre (*Uria aalge*) contaminated during an oil-spill at sea are presented.

MATERIAL AND METHODS

The Murre was captured north-west of Runde ($62^{\circ}24'$N, $5^{\circ}37'$E) on the central west-coast of Norway on the 4th of April 1984. The bird was air-frighted to Trondheim the following day and was used in experiments until the 8th of April. The Murre was heavily oiled on the right ventral side of the body, whereas there was only little oil elsewhere on the body. About 15% of the body surface was covered with oil. The body weight at arrival was 680 g. During the experiments the mean body weight was 660 g.

The metabolic rate (MR) was calculated from continous recordings of oxygen consumption (VO_2) in an open-circuit system. The bird was placed in a 16.5 L plexiglass respiration-chamber in a Foster constant temperature cabinet. Dry air entered the chamber at a rate of about 6.0 L/min, causing an oxygen extraction of less than 1%. Air flow rates were measured with a calibrated spirometer. The outcoming air was dried with silicagel and the CO_2 removed with ascarite before a fraction of the air was passed into an oxygen analyser (S-3A, Applied Electrochemistry, Inc.) for continous analyses of the O_2 content. Prior to each experiment the oxygen analyser was calibrated, using athmospheric air. The oxygen consumption was calculated according to the equations given by Depocas and

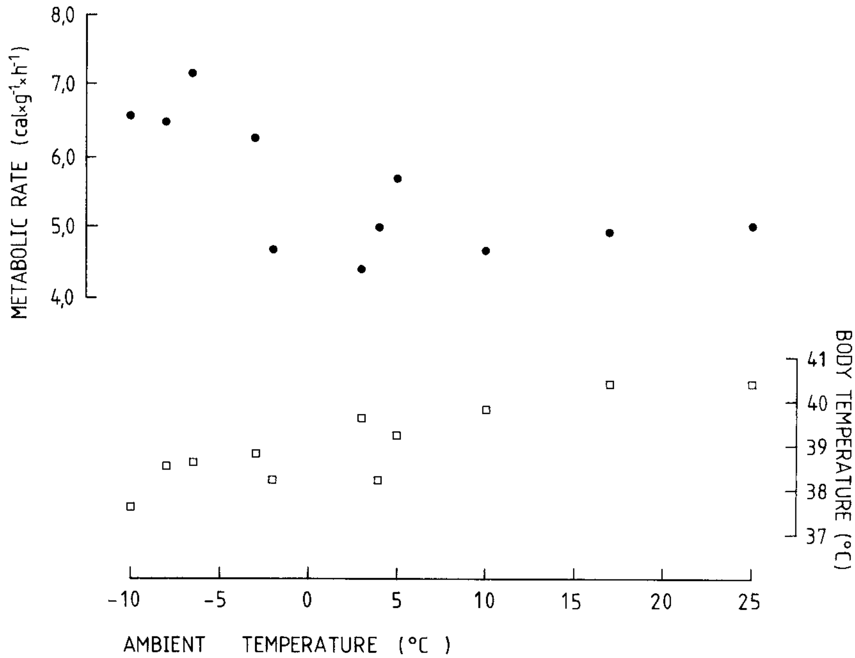

Figure 1. Metabolic rate and body temperature in an oiled Black-billed Murre (*Uria aalge*) as a function of ambient temperature. Points represents values obtained after at least 20 min exposure to each ambient temperature.

Hart (1957) and converted to STPD conditions. The metabolic rate was calculated from the oxygen consumption using 1 ml O_2 equal to 4.8 cal. Body temperature (T_B) was measured with a small radiotelemetry transmitter (Reinertsen 1982) placed in the stamach of the bird. The ambient temperature (T_A) was changed several times during an experimental day, but the bird was allowed to acclimate for at least 20 min before any recordings were obtained at each new T_A. The insulation (I) was calculated according to the equation $I = 1/C$, where $C = MR/(T_B-T_A)$ (Aschoff 1981)

RESULTS AND DISCUSSION

Figure 1 shows the effect of ambient temperature changes on metabolic rate and body temperature in the Murre. In the thermoneutral zone (TNZ), which extended from about 2.5 to at least 25.0°C, the metabolic rate was at its lowest level (basal metabolic rate) and averaged 4.94 cal g^{-1} h^{-1} (n=6, SD=0.42). This value is lower than those found by Johnson and West (1975) and McEwan (1975), who reported values for basal metabolic rate of 6.26 and 5.21 cal g^{-1} h^{-1}, respectively. However, even though the oil-contaminated Murre had a low metabolic rate, the body temperature was kept stable at an apparently normal level. In a separate experiment, in which the body temperature was measured continously for 6 hours in the undisturbed Murre, T_B averaged 39.5°C. In comparison, Iversen and Krog

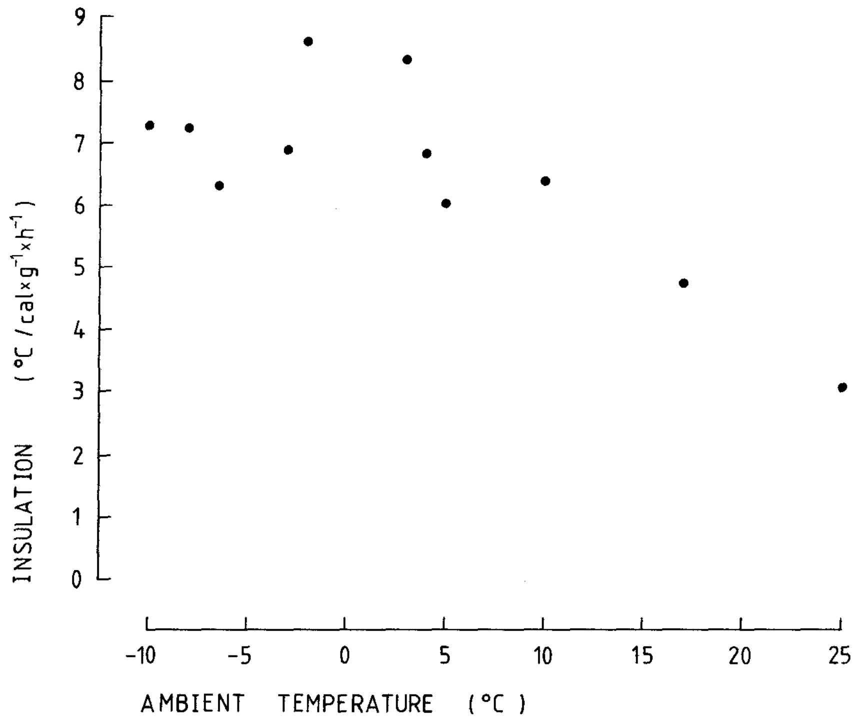

Figure 2. Insulation in an oiled Black-Billed Murre (*Uria aalge*).

(1972) and Johnson and West (1975) found T_B in the Black-Billed Murre to be 38.9°C and 39.0°C, respectively. At the lower critical temperature (2.5°C) the insulation had increased to its maximal level (7.26 °C/cal g^{-1} h^{-1}, fig. 2) and exposing the Murre to ambient temperatures below TNZ thus resulted in an increased metabolic rate. The increased heat production, however, was not adequate to sustain a normal body temperature (fig. 1). This is further emphasised by the data depicted in fig. 3, in which the Murre was gradually exposed to a decreasing ambient temperature. In spite of an increased metabolic rate at low ambient temperatures, the body temperature was gradually lowered. This points to a reduced metabolic capacity in the oiled Murre, and agrees with the data from the Jackass penguin, in which a fall of 2.5°C in T_B was found in oil-contaminated specimens (Erasmus *et al.* 1981).

The low metabolic rate reported in the present study seems to contradict earlier studies, in which an increased metabolic rate has been found in ducks with experimentally oil-contaminated plumages (Hartung 1967; McEwan and Koelink 1973; Lambert *et al.* 1982). At least three factors should be taken into consideration in explaining this discrepancy. Firstly, the Murre used in the present study weighted only 660 g (mean value), which is considerably below the normal weight for this species (957 g, Johnson and West 1975). The reduced metabolic rate could thus be the result of the Murre being

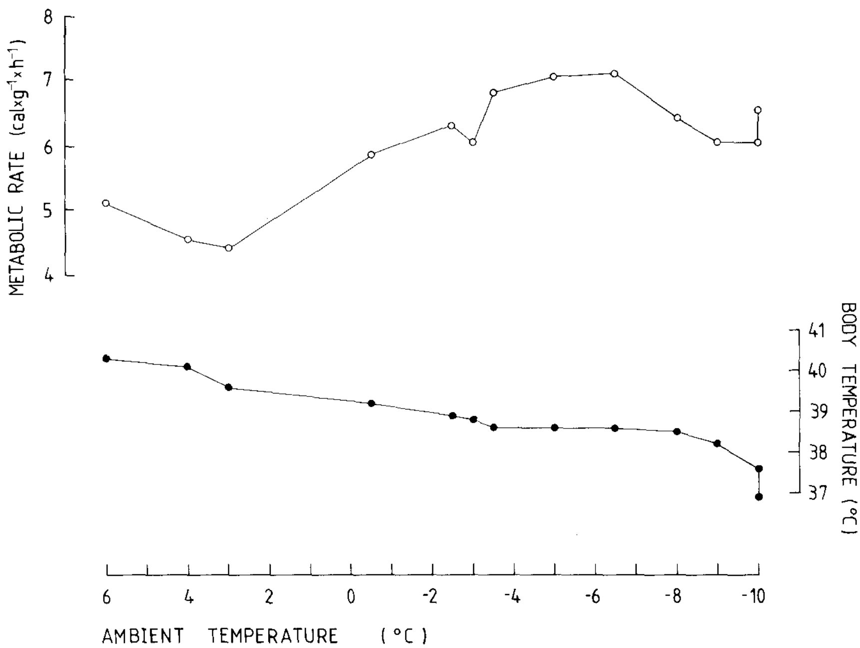

Figure 3. Metabolic rate and body temperature in an oiled Black-billed Murre (*Uria aalge*) during a gradual decrease in ambient temperature. Points represents measurements obtained each 15 min.

starved, which in other species of birds has been found to cause a reduced metabolism (Shapiro and Weathers 1981; Le Maho 1983). In the earlier studies involving experimentally induced oil-contamination in a laboratory, it is unlikely that the birds used were starved.

Secondly, the Murre could be suffering from toxic effects of ingested oil. It is known that externally oiled ducks can consume as much as 7 ml oil/kg/day by preening (hartung and Hunt 1966). Indeed, autopsy of the Murre revealed large amounts of oil in the intestine. Ingestion of oil in birds is known to induce malfunction of the kidney, the endocrine system and membrane transport system (Hartung and Hunt 1966; Crocker *et al.* 1974). Of special interest are the results showing a reduced level of thyroxin following oil-ingestion (Rattner and Eastin 1981). As the metabolic rate is in part dependent on the level of thyroxin, the observed low MR found in the present study could be caused by a low thyroxin level induced by oil-ingestion.

Finally, recent experiments on Eider ducks (*Somateria mollissima*) have shown that specimens with a wet and oiled plumage have a higher metabolic rate than specimens with a dry and oiled plumage (own unpublished observations). Earlier studies on metabolism in oiled ducks have involved procedures, which undoubtly would result in wet plumages in addition to the oiling. The Murre in the present study had a dry plumage (as when captured) and would subsequently not have suffered from an additional decreased insulation and increased metabolism due to the wetting of the feathers.

The results indicate that one should be very careful when extrapolating from laboratory-obtained data to field conditions. Thus, the high metabolic rate found in oiled birds during laboratory experiments (Hartung 1967; McEwan and Koelink 1973; Lambert *et al.* 1982) do not necessarily apply to field conditions. In order to describe the physiological responses of birds to an oil-spill at sea, all factors involved should be taken into consideration.

Acknowledgements. This study was financially supported by Norsk Hydro A/S. The authors also wish to thank Alf Ottar Folkestad for assistance and Randi Eidsmo Reinertsen for the loan of the telemetry equipment.

REFERENCES

Aschoff J (1981) The thermal conductance in mammals and birds: its dependence on body temperature and circadian phase. Comp Biochem Physiol 69A: 611-619.

Crocker AD, Cronshaw J, Holmes WN (1974) The effect of a crude oil on intestinal absorbtion in ducklings (*Anas platyrhynchos*). Environ Pollut 7: 165-177.

Depocas F, Hart JS (1957) Use of the Pauling oxygen analyser for measurements of oxygen consumption of animals in open-circuit systems and in a short-lag, closed circuit apparatus. J Appl Physiol 10: 388-392.

Erasmus T, Randall RM, Rand all BM (1981) Oil pollution, insulation and body temperature in the Jackass Penguin *Spheniscus demersus*. Comp Biochem Physiol 69A: 169-171.

Hartung R, Hunt GS (1966) Toxicity of some oils to waterfowl. J Wildl Manag 30: 564-570.

Hartung R (1967) Energy metabolism in oil-covered ducks. J Wildl Manag 31: 798-804.

Iversen JA, Krog J (1972) Body temperature in active and resting *charadriiforme* birds (murre, puffin and auklets) at different ambient temperatures. Norw J Zool 20: 145-148.

Johnson SR, West GC (1975) Growth and development of heat regulation in nestlings and metabolism of adult Common and Thick-billed Murres. Ornis Scand 6: 109-115.

Lambert G, Peakall DB, Philogene BJR, Engelhart FR (1982) Effect of oil and oil dispersant mixtures on the basal metabolic rate of ducks. Bull Environ Contam Toxicol 29: 520-524.

Le Maho Y (1983) Metabolic adaptations to long-term fasting in antarctic penguins and domestic geese. J Therm Biol 8: 91-96.

McEwan EH, Koelink (1973) The heat production of oiled mallards and scaup. Can J Zool 51: 27-31.

McEwan EH (1975) Pers. comm. in Johnson and West (1975).

Rattner BA, Eastin WC (1981) Plasma corticosterone and thyroxin concentrations during chronic ingestion of crude oil in mallard ducks (*Anas platyrhynchos*). Comp Biochem Physiol 68C: 103-107.

Reinertsen RE (1982) Radio telemetry measurements of deep body temperature of small birds. Ornis Scand 13: 11-16.
Shapiro CJ, Weathers WW (1981) Metabolic and behavioral responses of americal kestrels to food deprivation. Comp Biochem Physiol 68A: 11-14.

Received August 2, 1984; accepted August 9, 1984.