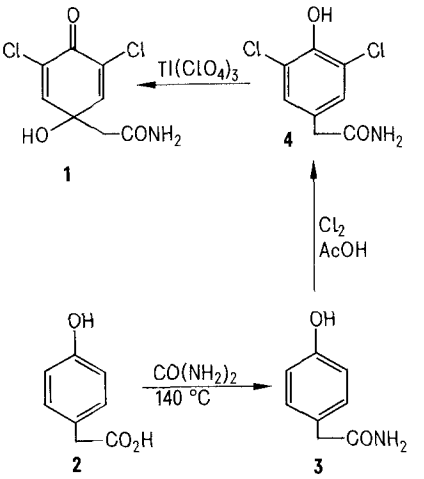
ter-methanol, 5 ml min^{-1}. The eluate at 8.3 min (single peak) gave **1**, colorless crystals, m.p. 162–163 C° (0.002% on dry sponge weight). Under these conditions, dichloroverongiaquinol was eluted before cavernicolin-1 and after cavernicolin-2. **1** proved, by the Petri disc zonal inhibition technique, to inhibit *Bacillus subtilis* and *Proteus vulgaris*.

The UV spectrum, λ_{max}^{MeOH} 245 nm, $\varepsilon = 9000$, revealed the dienone chromophore, whereas the IR spectrum showed hydrogens on oxygen or/and nitrogen, besides amide and enone carbonyl and olefinic bonds (ν_{max}^{nujol} 3450, 3420, 3150, 1700, 1675, 1590 cm^{-1}). The mass spectrum (EI, 70 eV) was indicative of 2 chlorine atoms and a primary amide group: m/e (%) = 237(2.6) 235(4)(M) 221(3) 219(4.5)(M-16) 220(10) 218(15)(M-17) 192(21) 190(32) (218-CO) 175(8) (219-$CONH_2$) 164(15) 162(20) (190-CO) 59(76) 53(44) 44(100). Finally, the ^{1}H-NMR spectrum revealed a proton situation similar to that for the dibromo-analogue of **1**[7]: $\delta_{TMS}((CD_3)_2CO)$ 7.35 (s, 2H, olefinic potons), 5.9 (br s, 1H, OH), 2.9 (br s, 2H, NH_2), 2.77 (s, 2H, CH_2).

The structural assignment was confirmed by synthesis starting from the readily available p-hydroxyphenylacetic acid (**2**). Thus, heating of **2** with urea at 140 C° under nitrogen overnight gave **3**, m.p. 175 C° (175 C°)[8] in a 85% yield. Treatment of **3** with chlorine in acetic acid at room temperature in the dark gave **4**, m.p. 193 C° (elemental analysis and spectra were satisfactory) in a 20% yield[9]. Finally, oxidation of **4** with thallium perchlorate[10] in perchloric acid at 10 C° for 5 min gave a product in a 50% yield, which proved to be identical in all respects with natural **1**.



It has been proved that *Aplysina fistularis* is able, owing to a bromoperoxidase, to convert tyrosine into 3,5-dibromotyrosine, and then the latter into the dibromo-analogue of **1** (dibromoverongiaquinol)[5,11]. It is then attractive to speculate about a similar biosynthetic route for **1** via 3,5-dichlorotyrosine[12]. In this connection, it is relevant to mention that free 3,5-dichlorotyrosine has been detected in the cuticle of the marine arthropod *Limulus polyphemus*[13].

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Temperature dependence of ventilation and O_2-extraction in the Kittiwake, *Rissa tridactyla*[1]

R. Brent, J.G. Rasmussen, C. Bech and S. Martini

Department of Zoophysiology, University of Aarhus, DK-8000 Aarhus C. (Denmark), and Department of Zoology, University of Trondheim, N-7055 Dragvoll (Norway), November 8, 1982

Summary. At low ambient temperature the Kittiwake, *Rissa tridactyla,* increased its oxygen consumption, while lung ventilation remained unchanged. A changed breathing pattern (lower frequency and higher tidal volumes) and an increase in the lung O_2-extraction was responsible for the observed decrease in the ventilatory requirement, which may be important because it reduces the respiratory heat loss during cold exposure.

Respiratory heat and water loss is an inevitable result of respiration. During cold exposure, the amount of heat and water loss can be minimized by a decrease of the expired air temperature, a mechanism found in both birds and mammals[3-7]. In addition, a reduced air convection requirement could further reduce the loss of heat and water. A higher lung oxygen extraction, causing the air convection requirement to decrease, has actually been described recently in 2 species of birds exposed to low ambient temperatures[3,8]. However, since simultaneously obtained data on oxygen consumption, breathing rate and tidal volume, which are necessary for the estimation of the

oxygen extraction, only exist for a limited number of bird species, the establishment of the described phenomenon as general for birds has to await further studies.

The aim of the present study was to provide information on the ventilatory requirement in an arctic gull, the Kittiwake, at thermoneutral and low ambient temperatures.

Materials and methods. Two specimens (b.wt 358 and 363 g) captured near Ny Aalesund, Svalbard (79° N, 12° W) in July 1982 were studied at the Biological Station at Ny Aalesund. Ventilatory parameters were measured by pneumotachography. Fleisch-tubes were placed on individually designed masks (weight 1.4 g), and the pressure differentials generated in the tube were monitored by a Statham-Godart pneumotachograph (model 17212)[9,10]. The birds were placed in a plexiglass box from which air was sucked by a pump. A dried fraction of the outlet air was passed through a Taylor Servomex paramagnetic O_2-analyzer and the O_2-content was continuously recorded on a Riken Denshi pen-recorder. Air flow through the box was measured by a calibrated flowmeter (Fisher and Porter), and oxygen consumption ($\dot{V}_{O_2}$) was calculated on the basis of the air flow and the O_2-content in the excurrent gas[11]. In these calculations a respiratory exchange ratio ($\dot{V}_{CO_2}/\dot{V}_{O_2}$) of 0.85 was assumed, inducing a maximal possible error of 3%[11]. Body temperature (T_B) was measured with a thermocouple probe inserted 4–6 cm into the rectum. Experiments were conducted in darkness at 2 standard ambient temperatures (6 and 22 °C). Each bird were exposed to the experimental temperature for 8–10 h. After 1–2 h of stabilization, in which the birds were accustomed to the experimental situation, readings of T_B, respiratory frequency (f) and tidal volume (V_T) were made and $\dot{V}_{O_2}$ was calculated. Total ventilation ($\dot{V}_E$) was calculated as the product of f and V_T. Similar data were obtained approximately every 30 min during the remaining experimental period.

Results and discussion. The results are summarized in the table. At 6 °C the oxygen consumption increased by 19% compared to 22 °C. However, total ventilation showed a small decrease. This caused the ventilatory requirement ($\dot{V}_E/\dot{V}_{O_2}$) to show a marked and significant decrease from 24.7 to 19.1 ml min^{-1}. The oxygen extraction (calculated as $E_{O_2} = 100 \times \dot{V}_{O_2}/0.2095 \times \dot{V}_E$) simultaneously changed from 19.7% at 22 °C to 25.5% at 6 °C. The small change in total ventilation at low ambient temperature was the result of a decreased respiratory frequency and an increased tidal volume. Since dead space (V_D) has been found to represents a constant fraction of the tidal volume at thermoneutrality ($V_D = V_T/3.6$)[12], the lung (parabronchial) ventilation can be calculated as $f \times (V_T - V_D)$. Using this formula, a small increase in the parabronchial ventilation from 150.8 ml min^{-1} at 22 °C to 157.4 ml min^{-1} at 6 °C becomes apparent. Corresponding lung oxygen extraction values were 26.9% at 22 °C and 30.6% at 6 °C. It thus appears that the lower ventilatory requirement at 6 °C is achieved by a combination of an altered ventilatory pattern with lower respiratory frequency and higher tidal volumes, as a result of which a smaller part of the total ventilation is dead space ventilation, and there is an increased lung oxygen extraction.

Body temperature, oxygen consumption and ventilatory parameters in the Kittiwake at 2 ambient temperatures. Values are mean ±2SEM, n is number of experiments

	$T_A = 6$ °C (n = 25)	$T_A = 22$ °C (n = 23)	p*
T_B (°C)	39.6 ± 0.6	39.8 ± 0.6	n.s.
$\dot{V}_{O_2}$ (ml O_2 min^{-1})	10.1 ± 0.4	8.5 ± 0.3	< 0.05
f (min^{-1})	16.4 ± 1.3	23.2 ± 0.8	< 0.05
V_T (ml)	12.1 ± 1.2	9.0 ± 0.4	< 0.05
V_E (ml min^{-1})	190.0 ± 8.3	207.8 ± 9.2	< 0.05
$\dot{V}_E/\dot{V}_{O_2}$ (ml ml^{-1})	19.1 ± 1.1	24.7 ± 1.4	< 0.05
E_{O_2} (%)	25.5 ± 1.5	19.7 ± 1.2	< 0.05

*Fisher-Behrens test, n.s. = not significant.

A decreased ventilatory requirement at low ambient temperatures has obvious thermoregulatory importance by reducing the relative amount of respiratory heat and water loss[3,8]. A decreased exhaled air temperature, associated with nasal counter current heat exchange seems, however, to play the most important role in minimizing the respiratory heat and water loss. Brent et al.[3] found that the decreased exhaled air temperature and increased lung oxygen extraction contributed 88 and 12%, respectively, to the total amount of heat and water recovered during exposure to an ambient temperature of −25 °C in the European coot *(Fulica atra)*.

So far, an increased lung oxygen extraction has been reported in 4 species of birds exposed to temperatures below the thermoneutral zone. These includes, besides the Kittiwake, as described here, a tropical parakeet *(Bolborhynchus lineola)*[8], the European Coot and the domestic duck *(Anas platyrhynchos)*[13]. In 2 species, the pigeon *(Columba livia)*[14] and the fish crow *(Corvus ossifragus)*[15], an unchanged oxygen extraction has been reported during exposure to low ambient temperatures. However, it might well be that the ambient temperatures used in these studies did not involve temperatures low enough to induce changes in the lung oxygen extraction. It is also worth noting that in both studies an increased tidal volume was the principal factor in enhancing the ventilation during cold exposure. This implies that, just as in the present study, a relatively smaller part of the total ventilation at low ambient temperatures was dead space ventilation.

Further studies, involving more species and extremely low ambient temperatures, are needed in order to establish the importance of a decreased ventilatory requirement at low ambient temperatures as a mechanism to reduce respiratory heat loss in birds.

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