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References

Andrews, K.J.H. 1966. The distribution and life history of *Calanoides acutus* (Giesbrecht). *Discovery Reports*, 34, 117–162.

Holm-Hansen, O., and M. Vernet. 1990. RACER: Phytoplankton distribution and rates of primary production during the austral spring bloom. *Antarctic Journal of the U.S.*, 25(5).

Hopkins, T.L. 1985. Food web of an Antarctic midwater ecosystem. *Marine Biology*, 89, 197–212.

Huntley, M.E., and F. Escritor. In press. Dynamics of *Calanoides acutus* (Copepoda: Calanoida) in Antarctic coastal waters. *Deep-Sea Research*.

Niiler, P.P., J. Illeman, and J.-H. Hu. 1990. RACER: Dynamic observations of circulation in the Gerlache Strait region. *Antarctic Journal of the U.S.*, 25(5).

Voronina, N.M. 1970. Seasonal cycles of some common Antarctic copepod species. In M.W. Holdgate (Ed.), *Antarctic ecology*. London and New York: Academic Press.

RACER: Carbon egestion rates of *Euphausia superba*

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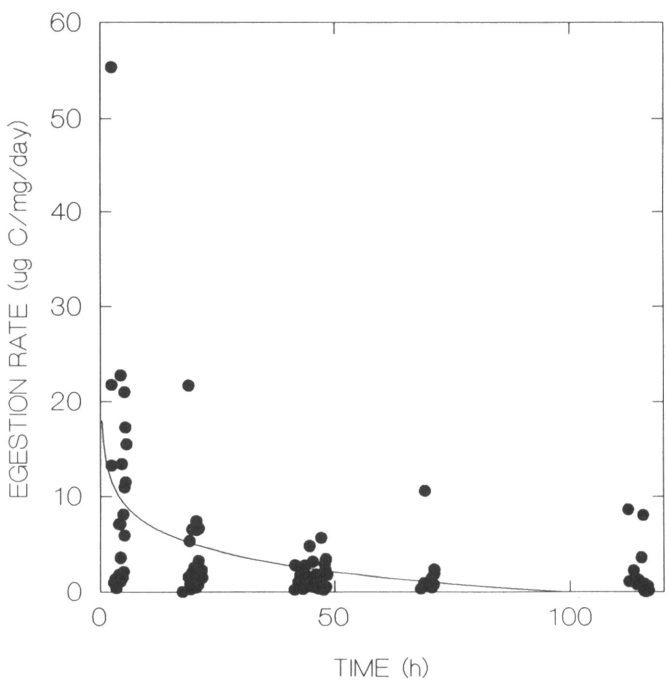
The vertical flux of organic material from the photic zone to deeper water and finally to the benthos is of fundamental importance in marine ecosystems. The production of fecal pellets (egestion) by herbivorous zooplankton is a major source of this material. *Euphausia superba* Dana is an herbivorous zooplankter of special interest in circumpolar antarctic waters due to its high abundance (Washburn and Wooster 1981). The relatively large size of its fecal strings and their high sinking speeds (about 60 meters per day) could provide a significant portion of this vertical flux of organic material. Only recently have there been attempts to quantify the egestion rates of *E. superba* (Clarke, Quetin, and Ross 1988).

Studies were performed on board the R/V *Polar Duke* as part of the Research on Antarctic Coastal Ecosystem Rates (RACER) program between 30 October and 25 November 1989 in the Gerlache Strait, near the Antarctic Peninsula (Huntley et al., *Antarctic Journal*, this issue). *E. superba* was collected from the upper 20 meters at station A in vertical tows of a 1 meter, 505 micron-mesh ringnet equipped with a 15-liter closed codend. Tows were performed at low winch speed and for short periods (10–15 minutes) to minimize stress on the krill. The sample was transferred to an insulated cooler and diluted with ambient surface seawater.

Individual *E. superba* were placed in 500-milliliter plastic containers filled with filtered seawater, after an intermediate rinse in filtered seawater, using a wide-bore pipet. All seawater used was filtered through GF/C glass fiber filters. Experimental suspensions were maintained at 0 °C in the dark.

To determine the individual egestion rate of *Euphausia superba*, krill were removed after a certain period of time and the water filtered through a GF/C filter to catch the feces produced; filtered seawater served as a control. The krill were transferred to fresh filtered seawater. Each glass fiber filter was immediately placed in a plastic petri dish and frozen at −80 °C for later laboratory analysis. This procedure was repeated at various intervals over a time of up to 5 days. At the end of each experiment, individuals were frozen (−80 °C) and later measured for length and for wet and dry weights. The fecal content of elemental carbon, hydrogen, and nitrogen was determined using a Perkin Elmer 2400 CHN-Elemental Analyzer.

All krill were immature at the beginning of their second year and between 24 and 39 millimeters long (mean = 30 millimeters). The wet weight ranged from 46 to 394 milligrams (mean = 164 milligrams), dry weights were 13 to 92 milligrams (mean = 40 milligrams). Individual egestion rates, expressed as micrograms carbon per milligram dry weight krill per 24 hours, were greatest in the first few hours after capture but continued to be significant for at least 24 hours (figure).



Fecal pellet production of *E. superba*. Egestion rates are given as micrograms carbon per milligram dry weight krill per day. The intercept, E_0, has a value of 18 micrograms carbon per milligram dry weight per day. (h denotes hour. ug C/mg/day denotes micrograms of carbon per milligram per day.)

The weight specific egestion of carbon can be described from:

$$E_t = E_0 \times e^{-\beta t}$$

where E_0 is the initial weight specific egestion rate (micrograms carbon per milligram dry weight per day), E_t is the egestion rate at time t and β is the rate at which the egestion rate declines with time. The slopes of the regressions of E_t versus time for 8 individual *E. superba* were not significantly different, but the intercepts were significantly different (table). Carbon egestion rates of all individuals are used in the figure. The estimated *in situ* egestion rate, E_0 was predicted to be 18 micrograms carbon per milligram dry weight per day (figure).

We employ an independent method to estimate *in situ* egestion rate, and hence to assess whether our experimental measurements are of expected magnitude. *In situ* egestion rate can be calculated by rearranging the equation for daily growth rate (G):

$$G = \frac{a \times (E_0 - R) \times W}{(1 - a)}$$

where E_0 is the *in situ* weight specific egestion rate, R is losses due to respiration, W is the krill dry weight, and a is the assimilation efficiency.

Individual *E. superba* in their second year increase in dry weight from about 10 milligrams at the beginning of the austral summer to about 150 milligrams at the end of the season, a period of approximately 4 months. The estimated growth rate over this period is 0.022 milligrams dry weight per day. We further assume a 70 percent assimilation efficiency (Conover 1978), a respiration rate of 50 milliliters of oxygen per milligram dry weight per day and a respiratory quotient of 0.8 (Ikeda and Mitchell 1982). By rearranging the growth equation, these assumptions yield a weight-specific carbon egestion rate of 20 micrograms per milligram dry weight per day, which is roughly equal to our measured E_0 of 18 micrograms carbon per milligram dry weight per day.

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Regression statistics for egestion rates (E) versus time (T) for animals of different dry weights. log E = b × log T + log x, where b = slope and log x = intercept.

r^2	log x	b	p[a]	Dry weight[b]
0.99	1.70	0.46	0	57.8
0.87	0.50	0.74	0.020	46.9
0.97	1.56	0.31	0.003	48.2
0.99	1.67	0.53	0	45.3
0.97	2.26	0.29	0.002	69.1
0.70	1.45	0.56	0.077	18.5
0.67	2.01	0.08	0.088	31.1

[a] Probability of b not equal 0.
[b] Dry weight in milligrams.

References

Clarke, A., L.B. Quetin, and R.M. Ross. 1988. Laboratory and field estimates of the rate of fecal pellet production by Antarctic krill, *Euphausia superba*. *Marine Biology*, 98, 557–563.

Conover, R.J. 1978. Transformation of organic matter. In O. Kinne, (Ed.), *Marine ecology*, (Vol. IV: *Dynamics*). Chichester: John Wiley.

Huntley, M.E., P. Niiler, O. Holm-Hansen, M. Vernet, E. Brinton, A.F. Amos, and D.M. Karl. 1990. RACER: An interdisciplinary study of spring bloom dynamics. *Antarctic Journal of the U.S.*, 25(5).

Ikeda, T., and A.W. Mitchell. 1982. Oxygen uptake, ammonia excretion and phosphate excretion by krill and other antarctic zooplankton in relation to their body size and chemical composition. *Marine Biology*, 71, 283–298.

Washburn, A.L., and W.S. Wooster. 1981. Foreword to report of committee to evaluate Antarctic marine ecosystem research. In J.H. Steele (Ed.), *An evaluation of antarctic marine ecosystem research*. Washington, D.C.: Polar Research Board.

RACER: Phaeopigment photooxidation during the spring bloom in northern Gerlache Strait

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Photooxidation rates of phaeopigments in polar waters are of particular importance due to the high phaeopigment concentrations often found in surface waters of these regions (Rey, Sjkoldal, and Slagstad 1987; Holm-Hansen and Mitchell in press). Weight ratios of chlorophyll *a*:phaeopigments ranging from 2:1 to 1:1 are not unusual in the euphotic zone suggesting either a high production rate or lower loss rates of phaeopigments than in temperate and tropical waters. If phaeopigments in seston originate from zooplankton grazing (Currie 1962; Shuman and Lorenzen 1975) and light is their main source of degradation (SooHoo and Kiefer 1982; Welschmeyer and Lorenzen 1985), it follows that either grazing is higher than previously expected and/or photooxidation rates are lower in polar regions.

Rates of pigment photooxidation are dependent on light intensity and quality, oxygen, temperature (SooHoo and Kiefer 1982), and probably factors such as type of material attached to or surrounding the phaeopigments. Other factors, such as the type of sensor used to measure radiation fluxes (Laws et al. 1988), can affect indirectly our estimates of photooxidation rates.

Previous studies on phaeopigment photooxidation rates in Antarctica showed temperature dependence (Letelier et al. 1987)