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Seasonal changes in nitrogen fractions in the Antarctic krill (*Euphausia superba Dana*) Part 1. Basic nitrogen fractions

ABSTRACT: Changes in the amount of basic nitrogen fractions (total, protein and non-protein nitrogen) were studied in an annual cycle. Significant seasonal changes were noted, minima occurring in Antarctic winter and maxima during spring-summer season. These changes are due mainly to high fluctuations of water content in krill in the annual cycle.

Key words: Antarctic krill, chemical composition, nitrogen fractions.

1. Introduction

Seasonal fluctuations of chemical composition in krill influence greatly both its nutritional values as food and its technological utility as potential raw material for processing.

The available information are limited mainly to seasonal changes of chemical composition in krill in the Antarctic summer (Mori and Yasuda 1976, Roschke 1978, Yanagimoto et al. 1979, Sugii, Watanabe and Kinumaki 1982), with no data on such changes in a full annual cycle. Besides some of the data were based on assays made on frozen krill after various storage time, which made comparison of seasonal changes in particular nitrogen fractions impossible, for krill being known as very flexible to proteolytic processes while stored in frozen (Kołakowski and Lachowicz 1982, Christians and Leinemann 1983).

The aim of the present work was to follow seasonal changes of basic nitrogen fractions content in fresh krill in full annual cycle.

2. Material and methods

The Antarctic krill (*Euphausia superba* Dana) were being caught over period of 28 Dec. 1983 — 27 Nov. 1984 in the Admiralty Bay (King George Island, South Shetlands) by means of pelagic trawl with a 2 m×1 m rectangular mouth towed by the motor boat "Dziunia".

Experiments were carried out in biological laboratory at the H. Arctowski Polish Station. For chemical analysis the live krill after 5 to 15 min of storage in an aerated seawater were used. Due to the catch volume in one net haul (usually 0.5 to 5 kg) samples of 100 to 200 g equivalent to 200—400 individuals, were collected, then filtered and homogenized in a fast rotating mixer (5—10 s) to a homogenous mass. Each homogenate was tested for:

— water content — by drying up the sample (about 5 g) to a steady weight (at 105°C for app. 6 h),

— non-protein nitrogen (after primary extraction with 4% TCA acid solution) and total nitrogen — by the Kjeldhal method with the Parnas-Wagner apparatus of macro type for distillation. The non-protein nitrogen content in extracts was determined additionally with the Kjel-Foss-Automatic apparatus when brought back to Poland,

— protein nitrogen; determined from the difference between total and non-protein nitrogen. To convert nitrogen into protein a conversion factor 6.25 was used.

3. Results and discussion

Significant changes of the tested components content in the Antarctic krill were noted, throughout the annual cycle. The water content ranged from 77.14 to 85.37%; total nitrogen from 10.21 to 15.30%; pure protein from 7.23 to 11.23% and non-protein nitrogen from 0.425 to 0.669%. When converted to a dry matter, the span of the nitrogen fractions content was less visible and varied: for total protein from 58.8 to 71.9% (average 65.3%); for pure protein from 40.8 to 52.1% (average 47.7%); for non-protein nitrogen from 2.05 to 3.58% (average 2.91%). The lowest nitrogen fractions content was noted for krill caught during autumn-winter season, while for krill caught during spring-summer time was the highest (Table 1). It proves there to be a correlation between the nitrogen fractions content in the krill dry matter and its feeding activity.

A correlation between each nitrogen fraction content in the krill dry matter and number of a consecutive day of a calendar year can be described, with a high precision, by the sinusoidal equation (Fig. 1,

Table 1

Relationship between the catchery season (1984) and the water/dry matter and nitrogen fractions content in the Antarctic krill[x] (*Euphausia superba* Dana)

Antarctic season	Period of time	Number of assays $N_{\bar{x}}$ N_i	Water or dry matter %	Nitrogen, g/100g				
				total		protein		non-protein
				N	Nx6.25	N	Nx6.25	N
A. Convertion to a wet matter								
summer	1.01. – 18.02.	9 (36)	80.65 ±1.96 (77.14 – 83.75)	2.008 ±0.214 (1.742 – 2.449)	12.55 ±1.34 (10.89 – 15.30)	1.390 ±0.208 (1.157 – 1.797)	8.69 ±1.30 (7.23 – 11.23)	0.618 ±0.058 (0.560 – 0.669)
autumn	27.03. – 10.05	10 (40)	79.35 ±0.13 (79.11 – 79.50)	2.004 ±0.041 (1.942 – 2.091)	12.53 ±0.26 (12.14 – 13.07)	1.535 ±0.029 (1.466 – 1.578)	9.59 ±0.18 (9.16 – 9.86)	0.472 ±0.026 (0.425 – 0.513)
winter	6.08. – 21.09	8 (32)	80.19 ±0.96 (78.83 – 81.93)	2.035 ±0.074 (1.902 – 2.101)	12.72 ±0.46 (11.89 – 13.13)	1.510 ±0.072 (1.384 – 1.587)	9.44 ±0.45 (8.65 – 9.92)	0.525 ±0.019 (0.505 – 0.558)
spring	25.09. – 23.11	13 (52)	83.27 ±1.45 (80.14 – 85.37)	1.845 ±0.154 (1.633 – 2.171)	11.53 ±0.96 (10.21 – 13.57)	1.335 ±0.133 (1.159 – 1.559)	8.34 ±0.83 (7.24 – 9.74)	0.510 ±0.041 (0.474 – 0.612)
year 1984	1.01. – 23.11	40 (160)	81.11 ±2.06 (77.14 – 85.37)	1.958 ±0.158 (1.633 – 2.449)	12.24 ±0.99 (10.21 – 15.30)	1.405 ±0.231 (1.157 – 1.797)	8.78 ±1.44 (7.23 – 11.23)	0.538[xx] ±0.066 (0.425 – 0.669)
B. Convertion to a dry matter								
summer	23.12. – 18.02	10 (40)	19.09 ±2.02 (17.71 – 22.86)	10.600 ±0.76 (9.475 – 11.326)	66.24 ±4.76 (59.22 – 70.79)	7.411 ±0.81 (6.067 – 8.300)	46.32 ±5.06 (37.92 – 51.88)	3.189 ±0.283 (2.759 – 3.578)
autumn	27.03. – 10.05	10 (40)	20.66 ±0.12 (20.50 – 20.89)	9.705 ±0.227 (9.407 – 10.200)	60.66 ±1.42 (58.79 – 63.75)	7.431 ±0.156 (7.100 – 7.700)	46.45 ±0.97 (44.38 – 48.13)	2.274 ±0.133 (2.104 – 2.500)
winter	6.08. – 21.09	8 (32)	19.81 ±0.96 (18.07 – 20.42)	10.281 ±0.193 (9.924 – 10.524)	64.26 ±1.20 (62.04 – 65.79)	7.626 ±0.111 (7.593 – 7.815)	47.66 ±0.69 (46.86 – 48.84)	2.655 ±0.160 (2.427 – 2.868)
spring	20.09. – 23.11	13 (52)	16.73 ±1.45 (14.62 – 20.42)	11.016 ±0.286 (10.263 – 11.505)	68.97 ±1.76 (64.14 – 71.91)	7.959 ±0.171 (7.634 – 8.132)	49.74 ±1.07 (47.71 – 52.07)	3.057 ±0.195 (2.566 – 3.455)
year	1.01. – 23.11	40 (160)	18.84 ±2.06 (14.63 – 22.86)	10.455 ±0.660 (9.407 – 11.505)	65.34 ±4.13 (58.79 – 71.91)	7.631 ±0.476 (6.067 – 8.331)	47.69 ±2.98 (40.79 – 52.07)	2.914[xx] ±0.389 (2.053 – 3.578)

[x] The whole, live krill according to the catch volume, partly filtered.

[xx] The average content data of non-protein nitrogen over the year were calculated from the assays on the Parnas-Wagner ($N_{\bar{x}} = 40$; $N_i = 160$) and Kjell-Foss-Automatii apparatus ($N_{\bar{x}} = 31$; $N_i = 124$) alltogether.

Table 2), where "a" value stands for the amplitude of seasonal changes. Non-protein nitrogen gives highest relative amplitude of seasonal changes when compared to the average results within the tested period (y_0), while for protein nitrogen is the lowest, i.e. 3.54% in relation to y_0.

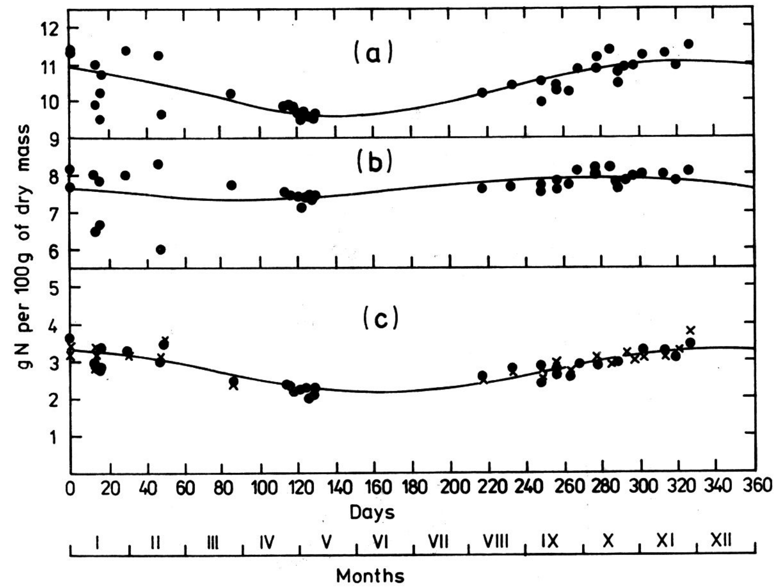

Fig. 1. Changes of total nitrogen (a), protein nitrogen (b) and non-protein nitrogen (c) content in dry matter of the Antarctic krill, in an annual cycle, described by the sinusoidal equation: $y = y_0 + a \cdot \sin[b(x-1)+c]$ where: y_0 = the harmonic average of results within the
equation: $y = y_0 + a \cdot \sin[b(x-1)+c]$ where: y_0 = the harmonic average of results within
the tested period, a = a maximum value of seasonal fluctuation amplitude, $b = = \frac{2\Pi}{365{,}25}$
c = value of the curve phase shift, x = number of a consecutive day of a calendar year. The equation parameters are given in Table 2. Determined with the Parnas-Wagner apparatus (●) and with the Kjell-Foss Automatic (x)

There is a negative correlation between the total and pure protein within the dry matter and the dry matter content in krill itself (Fig. 2), which means, the higher the dry matter content in krill, the lower its protein content. Seemingly, such correlation can be explained by a rise of lipid content in the dry matter of krill in winter (Kołakowska 1985). It confirms indirectly the results of Roschke study (1978), who, taking the summer krill for example, indicated a negative correlation between protein and lipid content in the dry matter.

When expressed in percentage by wet matter of krill a curve shape for seasonal changes of non-protein nitrogen was almost identical, being

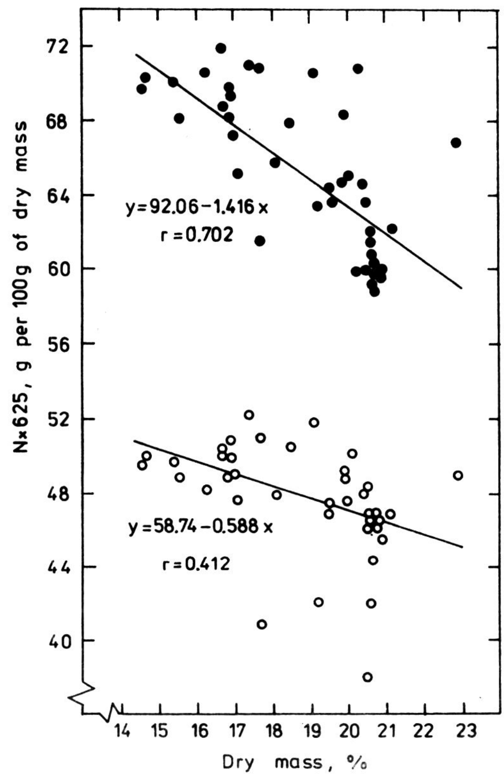

Fig. 2. Relationship between the content of total (●——●) and pure (○——○) protein in a dry matter and the content of a dry matter in krill itself

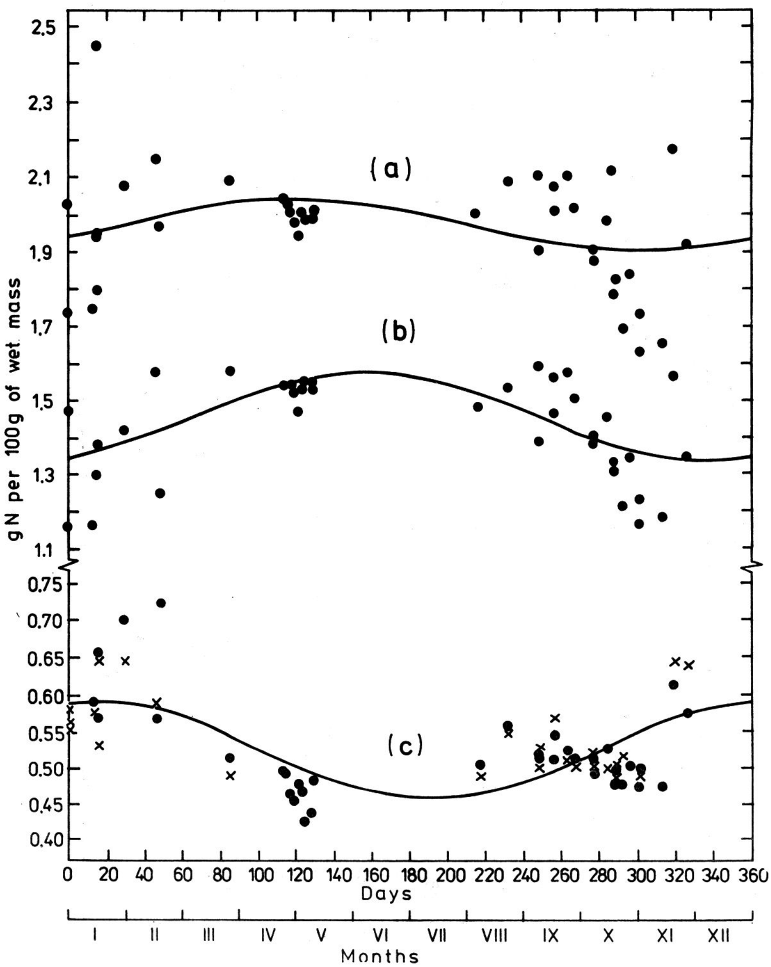

Fig. 3. Changes of total nitrogen (a), protein nitrogen (b) and non-protein nitrogen (c) content in "wet" matter of the Antarctic krill in an annual cycle described by the sinusoidal equation as on Fig. 1 (The equation parameters are given in Table 3)

quite different for total and protein nitrogen changes, when converted to the dry matter (Fig. 1, Fig. 3). For wet mass of the whole krill the maximum of the protein nitrogen content occurs during winter season (May—June) while minimum fals on the turn of spring and summer (December). These rather surprising results one can explain by seasonal changes of water content in krill. Low in the whole krill during winter season (average about 80.2%), the water content increases in the spring time (average about 83.3%) (Fig. 4). It can testify to a considerable

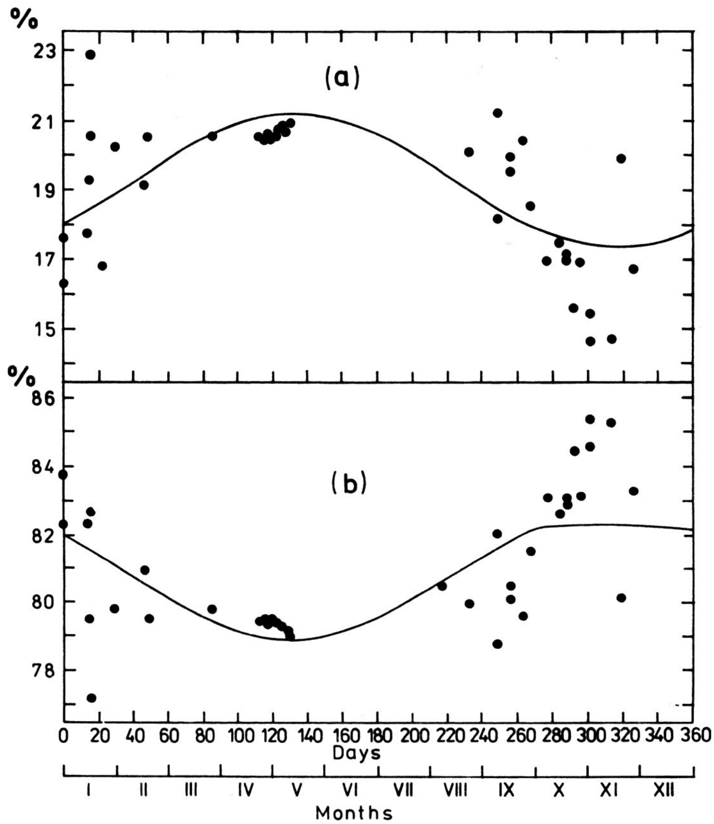

Fig. 4. Changes of the dry matter (a) and water (b) content in the Antarctic krill, in an annual cycle, described by the sinusoidal equation as on Fig. 1 (The equation parameters are given in Table 3)

influence of feeding intensity (alimentary tract filling level) on chemical composition of the whole krill. Probably, together with a vegetable food some of the sea water gets into the digestive tract of krill, which gives a rise in water content and decrease protein percentage in krill at the same time. One can expect this spring-summer rise of water content in krill to affect mainly the krill cephalothorax, where main part of the alimentary

Table 2

The parameters value of the sinusoidal equation: $y = y_0 + a \cdot \sin[b(x-1)+c]$, presenting relationship between the nitrogen content in the krill dry matter and number of the cosecutive day of the calendar year

Nitrogen fraction	Equation parameters		
	y_0	a	c
total	10.3053	−0.7234	−0.8996
protein	7.5906	−0.2690	−0.0464
non-protein	2.7344	−0.5808	−1.2307

Table 3

The parameters values of the sinusoidal equation: $y = y_0 + a \cdot \sin[b(x-1)+c]$, presenting relationship between water, dry matter and nitrogen fractions content in the krill wet matter and number of the consecutive day of the calendar year

Component	Equation parameters		
	y_0	a	c
water	80.7305	−1.8926	−0.6557
dry matter	19.2416	1.9429	−0.7110
N-total	1.9716	0.0708	−0.4842
N-protein	1.4528	0.1224	−1.1102
N-non-protein	0.5264	0.0681	1.4297

tract is situated. It would be interesting, therefore, to test seasonal changes of chemical composition in krill separately for cephalothorax and abdomen. It would let, in between, to find out how catching season influence the chemical composition of abdomen tissue, excluding this way, an influence of intestinal filling.

4. Conclusions

1. The nitrogen fractions content (i.e. total nitrogen, protein and non-protein nitrogen) in the krill dry mass changes throughout a year, having its minimum during Antarctic winter and its maximum during spring-summer season.
2. For wet krill mass similar changes were noted for non-protein nitrogen only, with other fractions, on the contrary having its maximum during autumn-winter season.
3. Various sources of the nitrogen fractions changes in "wet" and "dry" mass of the whole krill are to be explained mainly by high fluctuations of water content throughout an annual cycle. The water content in

krill during spring-summer season increases fast, supposedly due to some sea water which gets into a digestive tract together with a vegetable food.

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6. Streszczenie

Zawartość frakcji azotowych (azot ogólny, białkowy, niebiałkowy) w suchej masie kryla zmienia się cyklicznie w ciągu roku, przyjmując minimum w czasie antarktycznej zimy i maksimum w okresie wiosenno-letnim. W surowej masie kryla podobne zmiany wykazuje tylko azot niebiałkowy, natomiast zawartość pozostałych frakcji przeciwnie — maksimum przyjmuje w okresie jesienno-zimowym. Różny przebieg zmian frakcji azotowych w "mokrej" i "suchej" masie kryla całego należy tłumaczyć przede wszystkim dużymi wahaniami zawartości wody w krylu w cyklu rocznym. W okresie wiosenno-letnim zawartość wody w krylu szybko wzrasta, ponieważ wraz z pobieranym pokarmem roślinnym do żołądka kryla przedostaje się prawdopodobnie pewna część wody morskiej, co w konsekwencji powoduje obniżenie procentowej zawartości białka w krylu całym.