Seasonal Changes in Organic Composition and Caloric Value of an Arctic Marine Amphipod, *Onisimus (=Boeckosimus) affinis*

J. A. Percy and J. Walbridge

Arctic Biological Station
Fisheries and Marine Service
Department of Fisheries and the Environment
Ste. Anne de Bellevue, Quebec H9X 3L6

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SEASONAL CHANGES IN ORGANIC COMPOSITION AND CALORIC VALUE OF AN ARCTIC MARINE AMPHIPOD, *ONISIMUS* (=BOECKOSIMUS) *AFFINIS*

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J. A. Percy and J. Walbridge

Arctic Biological Station
Fisheries and Marine Service
Department of Fisheries and the Environment
Ste. Anne de Bellevue, Quebec H9X 3L6

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ABSTRACT

Percy, J. A. and J. Walbridge. 1978. Seasonal changes in organic composition and caloric value of an arctic marine amphipod, *Onisimus* (= Boeckosimus) *affinis*. Fish. Mar. Serv. Data Rep. 46: 28 p.

This report contains data on seasonal changes in gross biochemical composition and caloric value of the benthic marine amphipod *Onisimus affinis*. The samples were collected in the Eskimo Lakes, adjacent to the Mackenzie Delta in the Northwest Territories. Changes in ash, protein, lipid, carbohydrate and chitin content were examined. Results are expressed both in terms of percent dry tissue weight and as dry weight per "standard" 10 mm animal. Regression equations relating head length to body length and body length to dry weight and ash-free dry weight are also presented.

Key words: Arctic, biochemical composition, amphipod, caloric value, *Onisimus affinis*, season.

RESUME

Percy, J. A. and J. Walbridge. 1978. Seasonal changes in organic composition and caloric value of an arctic marine amphipod, *Onisimus* (= Boeckosimus) *affinis*. Fish. Mar. Serv. Data Rep. 46: 28 p.

Ce rapport contient les données du sujet des variations saisonnières de la composition biochimique et la valeur calorifique de l'amphipode benthique marin, *Onisimus affinis*. Les échantillons ont été obtenues des "Lacs Eskimo", près du Delta du Mackenzie dans les Territoires du Nord-Ouest. Les variations au quantité de cendre, de protéine, de lipide, d'hydrate de carbone et de chitine furent examinés. Les résultats sont exprimés comme pourcentage du poids sec du tissu et aussi comme poids sec d'un animal "Taille courante" de 10 mm. Les équations de régressions de la longueur de la tête à la longueur du corps et la longueur du corps au poids sec et au poids sec sans cendre sont aussi présentées.

length. This length is close to mid point of the animal's size range, is usually the most abundant size group in the population, and is the approximate size at which the animals become adults. To permit computations of regressions of weight of biochemical component on body length, the total lengths and dry weights of the animals were measured before analysis. Where it proved necessary to pool animals to provide adequate samples only animals of a similar length were combined. As wide a range of animal lengths as were available were examined in each seasonal group. The regression equation of the logarithm of the weight of each biochemical component per animal on the logarithm of total body length was calculated for each sampling period. From these equations the equivalent weights of each component in a 10 mm "standard" animal were determined. In addition the regression of the logarithm of dry body weight on the logarithm of body length was calculated for each sampling period and from this the seasonal variations in the dry weight of a "standard" animal were determined.

BIOCHEMICAL ANALYSES

Chitin

Chitin was determined only once during the winter (February) and again during the summer (August) using a method similar to that of Bamstedt (1974). Ten to 12 dried animals were finely pulverized in a Wig-l-bug amalgamator (Crescent Dental Mfg. Co., Chicago, Ill.) for 30 seconds. Samples of 50-90 mg of the powdered material were redried at 60°C and weighed. The samples were transferred to centrifuge tubes and 8 ml of 1N HCl was added. The tubes were placed in boiling water for 5 minutes and then cooled and centrifuged at 400 g for 10 minutes. The precipitate was washed with 5 ml of distilled water and again centrifuged. 8 ml of 4N NaOH was added and the tubes placed in a boiling water bath for 30 minutes. The precipitate was washed with distilled water and then with 8 ml absolute methanol and finally with 8 ml of chloroform-methanol (2:1), centrifuging and decanting between each step. The material was then transferred to a tared crucible and dried at 60°C and weighed. The residue was then ashed at 550°C for 12 hours, cooled and weighed. The loss of weight during ashing was attributed to pure chitin.

Ash

Individuals of known length were dried at 60°C, weighed and ashed at 550°C for 12 hours and reweighed.

Carbohydrate

Total carbohydrate was determined spectrophotometrically with anthrone reagent following digestion in trichloacetic acid. Ten mg of ground dry tissue (1-2 animals) was digested in 10% TCA in a boiling water bath for 1 hour. The sample was centrifuged at 400 g and the supernatant and 2 rinses were transferred to a 10 ml volumetric flask

and made up to volume with distilled water. Duplicate 2-4 ml subsamples were transferred to test tubes. A distilled water blank and a glucose standard (100 µg/ml) were run with each series of samples. Ten ml of anthrone reagent was added to each tube with a fast flow pipet. The covered tubes were placed in a boiling water bath for exactly 10 minutes. The tubes were then cooled in an ice bath and the optical density of the sample measured at 620 mµ. Results are expressed in terms of glucose equivalents.

Lipid

Total lipid was determined gravimetrically following microsoxhlet extraction. Ground samples of 50-100 mg dry weight (5-10 animals) were extracted with 12 ml of chloroform-methanol (2:1) in a microsoxhlet extractor for 6-8 hours. The solvent was transferred to a weighing vessel with rinsing and evaporated at 60°C to constant weight. The residue was cooled in a dessicator and weighed.

Protein

Total nitrogen was determined by microkjeldahl analysis essentially as outlined in Barnes (1959). Dried ground samples of approximately 50 mg (4-6 animals) were digested in boiling concentrated H_2SO_4 with a small quantity of catalyst mixture and Hengar granules. The cooled digestion mixture was transferred to a Markham still (Markham, 1942) and treated with 2 ml of 40% Na OH. The ammonia was distilled off and collected in a 4% boric acid solution. The ammonia was titrated with 0.02 N HCl using a mixed methyl-red, methylene blue indicator. Protein was estimated by multiplying the total nitrogen content by 6.25.

CALORIC ANALYSIS

The caloric content of pelletized 10-20 mg samples was determined with a Phillipson micro bomb calorimeter. Details of the basic method are given in Prus (1975).

INTRODUCTION

In studying the bioenergetics of a species it is useful to know something about the relative organic composition of the organism during different stages of its life cycle and at different times of the year. The gross biochemical composition of many marine invertebrates has been determined and in many instances has been shown to change markedly with season as the animal first stores and later utilizes nutritional reserves. The majority of such studies have been carried out on temperate species although recently a number of antarctic species have been examined. Few such studies have been conducted in the Arctic.

Studies of energy storage and utilization in polar marine organisms are of particular interest because of the very pronounced seasonality of primary production in these areas. The duration of primary production is extremely abbreviated and energy input into the ecosystem occurs as widely spaced relatively intense pulses. However, the subsequent cycling of this captured energy within the ecosystem is spread over the whole year. One would anticipate that herbivorous zooplankton species would be particularly susceptible to the pronounced seasonal changes in food availability. Lee (1974) has shown that herbivorous copepods in the Arctic store lipids during the season of maximum primary production and then utilize them during the ensuing winter. Carnivorous copepods in polar regions have been shown to exhibit a similar seasonal fluctuation in nutritional reserves (Littlepage, 1964; Lee *et al.*, 1972).

Little information is available concerning seasonal variations in organic composition of benthic organisms in the Arctic. Many of these are sediment feeders, carnivores or omnivorous scavengers and are thus not directly dependent upon the annual phytoplankton bloom. It is not yet clear whether such species are able to procure sufficient food continuously throughout the year, or are also forced to rely upon an organic storage strategy to tide them over the long winter. In addition, many of these species spend a considerable amount of energy synthesizing reproductive products during the late winter when primary production is still minimal.

In this study we have examined seasonal changes in the gross biochemical composition and caloric value of a benthic marine amphipod *Onisimus* (= Boeckosimus) *affinis* Hansen, from the inshore waters of the Southern Beaufort Sea. The present report serves as a repository for the morphometric, biochemical and calorimetric data obtained during the study.

METHODS

COLLECTING SITE

Animals were collected in about 20 meters of water at a site adjacent to the Arctic Biological Station field laboratory near the entrance to the Eskimo Lakes [Station 507 of Wacasey (1974); 69°25'N, 131°16'W]. A brief description of the collecting site is presented in Percy, 1975.

COLLECTION OF SAMPLES

Animals were caught in minnow traps lined with fine nylon screen and baited with fish. Traps were set on the bottom in 20 meters of water. Both summer and winter samples were collected at the same site, the latter through about 2 meters of ice. Animals were transported rapidly to the laboratory in seawater in insulated containers. There they were usually held for a few hours without food at a low temperature and then rinsed in distilled water to remove salts and dried at 60°C for 24 hours. The dried samples were placed in small stoppered vials and stored frozen until analyzed.

DETERMINATION OF LENGTH-WEIGHT RELATIONSHIPS

Subsamples, including animals of the greatest available size range, were taken from a summer (August) and a winter (February) sample for a determination of length-weight relationships. Because the animal normally assumes a curled position it is difficult to measure total body length. For this reason the relationship between head length (which can be readily measured on a linear scale) and body length was examined. The animals were first sexed and the head length measured with an ocular micrometer of a dissecting microscope. Total body length (from tip of rostrum to end of telson) was measured using an upright projector of the type designed for reading fish scales. The length of the magnified image was measured with a flexible ruler. The animals were then dried at 60°C for 24 hours, cooled in a dessicator and weighed. They were then ashed at 550°C in a muffle furnace for approximately 12 hours and reweighed. Regressions of total body length on head length, dry weight on total body length and ash free dry weight on total body length were calculated.

USE OF A "STANDARD" ANIMAL

The relative biochemical composition of animals may vary considerably with age (size). Furthermore seasonal changes in body weight (independent of length changes) may occur as the animal stores and utilizes nutritional reserves. The availability of particular size groupsof the species may vary during the year. Each of these factors make it difficult to compare the relative biochemical composition of an organism during different seasons. To overcome these difficulties the amounts of the various components are expressed both as a percentage of total dry tissue weight and as an absolute amount (dry weight) estimated for a "standard" animal of 10 mm in

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Table 1. Regression of log dry weight (mg) on log body length (mm) of *Gammarus affinis* during summer (August 15) and winter (February 28).

Season	Sex	N	Size range (mm)	a[1]	b[1]	S.E.R.[2]	S.E.E.[3]	r
Summer	Male	29	11.1-16.6	-0.46	1.30	0.32	0.08	0.62
	Female	144	9.1-20.0	-1.94	2.54	0.07	0.10	0.95
	Juvenile	39	3.5-10.9	-2.17	2.78	0.12	0.10	0.97
	Combined	212	3.5-20.0	-2.11	2.71	0.05	0.10	0.97
Winter	Male	33	11.6-16.3	-1.41	2.09	0.24	0.05	0.85
	Female	42	9.5-16.9	-1.88	2.53	0.19	0.07	0.91
	Juvenile	18	7.0-10.9	-2.73	3.35	0.25	0.07	0.96
	Combined	93	7.0-16.9	-2.23	2.83	0.08	0.07	0.96

[1]coefficients of the regression equation:
log dry weight (mg) = a + b log (body length, mm)

[2]standard error of the regression coefficient.

[3]standard error of estimate.

r coefficient of correlation.

Table 2. Regression of log ash free dry weight (mg) on log body length (mm) during summer (15.8.73) and winter 28.2.75).
Symbols as in Table 1.

Season	N	Size range (mm)	a	b	S.E.R.	S.E.E.	r
Summer	216	3.5-20.0	-2.33	2.80	0.05	0.12	0.96
Winter	98	7.0-16.9	-2.42	2.87	0.10	0.09	0.94

Table 3. Regression of log body length (mm) on log head length (mm) of *Orisimus affinis* (collected 28.2.75). Symbols as in Table 1.

N	Size range (mm)	a	b	S.E.R.	S.E.E.	r
98	7.0-16.9	1.18	0.96	0.05	0.04	0.90

Table 4. Chitin content of *Orisimus affinis* during summer (9.8.75) and winter (26.2.76).

Summer			Winter		
Tissue wt (mg)	Chitin wt (mg)	% chitin	Tissue wt (mg)	Chitin wt (mg)	% chitin
70.36	5.79	8.2	83.46	6.54	7.8
68.20	5.66	8.3	55.66	4.25	7.6
87.17	6.83	7.8	61.78	5.13	8.3
77.08	6.35	8.2	76.93	5.89	7.7
74.56	6.39	8.6	69.53	5.44	7.8
69.14	5.64	8.2	77.40	5.88	7.6
82.50	6.73	8.2	67.84	5.48	8.1
75.69	6.33	8.4	89.53	6.99	7.8
		N = 8			N = 8
		$\bar{X}$ = 8.2			X = 7.8
		S.D. = 0.2			S.D. = 0.2

Table 5. Seasonal variation in ash content of *Odostomia affinis* expressed as percentage of dry body weight.

Date	N	Size range (mm)	%Ash	S.D.[1]	Max.	Min.	C.V.[2]
2.3.74	15	10.5-15.1	25.9	2.5	30.0	21.5	9.6
25.5.74	18	8.3-14.2	21.3	1.4	23.6	18.9	6.4
20.7.74	18	5.3-13.3	26.1	3.1	29.5	17.9	11.8
1.8.74	18	9.5-15.0	27.2	2.0	30.5	23.0	7.3
27.8.74	18	8.8-14.1	25.3	2.0	29.3	22.6	7.8
28.2.75	18	9.2-17.4	26.1	2.7	31.0	20.9	10.2
7.5.75	18*	10.7-16.0	23.9	2.1	27.9	20.4	8.6
7.5.75	18	11.4-16.3	25.9	2.1	30.2	22.5	8.1
15.6.75	18	11.1-16.8	23.1	2.3	28.7	20.2	9.8
11.7.75	18	8.7-12.7	25.3	2.3	29.6	21.5	9.3
9.8.75	18	8.1-13.2	25.7	2.4	30.5	20.8	9.3
26.2.76	18	10.3-15.5	27.2	2.1	29.8	21.8	7.8

*Gravid females

[1]Standard deviation

[2]Coefficient of variation $\left(\frac{S.D.}{\bar{X}} \times 100\right)$

Table 6. Seasonal variation in total carbohydrate content of *Jaera albifrons affinis* expressed as a percentage of dry body weight. Symbols as in Table 5.

Date	N	Size range (mm)	% Carbohydrate	S.D.	Max.	Min.	C.V.
15.8.73	19	11.7-18.0	2.4	1.1	4.9	0.9	46.0
31.8.73	20	7.3-15.5	4.0	0.7	5.4	2.8	17.6
2.3.74	30	8.1-16.5	2.3	1.3	6.2	0.9	57.7
25.5.74	18	5.4-13.3	3.7	0.8	4.9	2.0	22.4
2.7.74	20	5.3-12.0	2.8	0.9	5.1	0.8	31.9
20.7.74	20	5.2-13.9	2.8	0.9	4.8	1.3	33.9
1.8.74	20	6.0-14.4	3.5	0.9	5.3	1.8	26.0
27.8.74	19	7.9-13.6	3.4	0.6	5.1	2.5	18.5
28.2.75	16	8.9-17.0	1.8	1.0	4.2	0.6	57.0
7.5.75	17*	10.9-16.2	2.8	0.7	4.6	1.7	25.5
7.5.75	18	7.4-16.0	2.3	1.2	4.9	0.7	53.6
15.6.75	18*	13.3-16.6	3.1	0.9	5.8	1.9	29.0
15.6.75	18	7.9-17.0	3.7	0.8	5.2	2.3	22.1
11.7.75	18	7.1-13.9	3.7	1.1	6.0	2.4	29.6
9.8.75	18	7.7-15.3	2.6	0.8	3.8	1.1	31.4
26.2.76	18	7.5-17.0	2.1	0.8	4.2	1.1	36.9

*Gravid females

Table 7. Seasonal variations in total lipid content of *Onisimus affinis* expressed as a percentage of dry body weight. Symbols as in Table 5.

Date	N	Size range (mm)	% Lipid	S.D.	Max.	Min.	C.V.
15.8.73	18	9.3-17.1	16.6	3.1	23.9	12.5	18.4
31.8.73	6	10.7-15.6	17.8	1.9	20.7	14.9	10.6
2.3.74	20	8.3-19.6	20.9	3.2	28.6	17.2	15.4
25.5.74	24	7.8-13.3	14.0	1.8	20.0	11.5	13.2
2.7.74	7	7.2-12.4	14.2	6.7	29.1	10.0	46.8
20.7.74	24	6.0-13.4	25.4	4.3	34.0	19.0	16.8
1.8.74	24	5.5-16.4	18.2	2.2	23.6	15.4	11.8
27.8.74	24	6.4-14.5	16.3	2.9	22.2	9.9	17.9
28.2.75	23	8.6-14.7	20.3	3.1	30.8	15.9	15.0
7.5.75	18*	10.8-14.6	21.2	1.3	23.6	18.2	6.1
7.5.75	18	10.8-16.4	17.9	1.7	22.5	15.7	9.2
15.6.75	18*	13.0-17.2	27.0	1.9	31.3	23.2	6.9
15.6.75	18	10.4-17.4	26.0	1.8	28.4	22.6	7.0
11.7.75	18	7.5-13.6	17.2	2.0	21.1	13.5	11.7
9.8.75	18	7.7-14.5	17.3	1.3	20.1	14.8	7.5
26.2.76	18	10.3-14.7	21.4	1.9	25.5	18.1	8.8

*Gravid females

Table 8. Seasonal variation in protein content of *Onisimus affinis* expressed as a percentage of dry body weight. Symbols as in Table 5.

Date	N	Size range (mm)	% Protein	S.D.	Max.	Min.	V
15.8.73	17	11.5-16.6	32.8	1.93	35.7	29.5	5.9
31.8.73	18	8.8-17.7	31.2	1.38	33.7	28.9	4.4
2.3.74	16	11.8-15.0	31.8	1.93	34.1	27.6	6.1
25.5.74	19	7.7-12.2	34.4	3.04	37.7	26.9	8.8
20.7.74	19	5.6-13.4	27.7	3.62	34.2	21.5	13.1
1.8.74	20	5.8-12.9	31.8	1.89	35.2	27.7	5.9
27.8.74	20	6.1-12.6	33.0	1.85	35.7	28.4	5.6
28.2.75	37	10.4-18.2	36.1	1.87	42.4	32.8	5.2
7.5.75	18*	10.5-15.8	38.2	1.00	40.0	36.5	2.6
7.5.75	38	9.7-15.9	36.6	1.11	38.9	34.0	3.0
15.6.75	18*	12.4-19.1	34.9	1.46	37.1	31.9	4.2
15.6.75	18	10.5-17.7	33.7	1.11	35.8	32.1	3.3
11.7.75	18	8.0-13.8	35.2	1.74	38.0	31.6	4.9
9.8.75	16	7.5-12.7	37.6	0.83	39.2	36.4	2.2
26.2.76	18	6.4-15.5	38.3	1.45	40.7	34.7	3.8

*Gravid females

Table 9. Summary of seasonal variation in percent composition of *Chlorinus officialis*.

Date	Percent Composition					
	Chitin[1]	Ash	Carbohydrate	Lipid	Protein	Total
15.8.73	8.0	-	2.4	16.6	32.8	-
31.8.73	8.0	-	4.0	17.8	31.2	84.3
2.3.74	8.0	21.3	2.3	20.9	31.8	-
25.5.74	8.0	-	3.7	14.0	34.4	-
2.7.74	8.0	-	2.8	14.2	-	-
20.7.74	8.0	26.1	2.8	25.4	27.7	90.0
1.8.74	8.0	27.2	3.5	18.2	31.8	88.7
27.8.74	8.0	25.3	3.4	16.3	33.0	86.0
28.2.75	8.0	26.1	1.8	20.3	36.1	92.3
7.5.75*	8.0	23.9	2.8	21.2	38.2	94.1
7.5.75	8.0	25.9	2.3	17.9	36.6	90.7
15.6.75*	8.0	-	3.1	27.0	34.9	-
15.6.75	8.0	23.1	3.7	26.0	33.7	94.5
11.7.75	8.0	25.3	3.7	17.2	35.2	89.4
9.8.75	8.0	25.7	2.6	17.3	37.6	91.2
26.2.76	8.0	27.2	2.1	21.4	38.3	97.0

*Gravid females

[1]mean of summer and winter values.

Table 10. Seasonal variation in caloric content of [illegible] expressed as cal/mg dry wt.

Date	N	Size range (mm)	cal/mg	S.D.	Max.	Min.	C.V.
31.8.73	15	9.8-18.2	3.51	0.28	4.03	3.09	12.3
25.5.74	14	7.6-14.6	3.74	0.41	4.42	3.01	9.1
20.7.74	15	8.7-13.7	4.06	0.53	5.13	3.37	7.7
1.8.74	15	9.1-14.1	3.79	0.37	4.42	3.17	10.2
27.8.74	15	8.7-15.7	3.62	0.24	3.95	3.23	14.9
28.2.75	14	10.9-15.9	3.61	0.25	4.01	3.23	14.2
7.5.75	14*	10.5-16.2	3.88	0.26	4.30	3.41	14.9
7.5.75	14	10.4-16.3	3.29	0.24	3.72	2.91	14.0
15.6.75	15*	11.4-20.1	4.18	0.40	5.10	3.64	10.4
15.6.75	15	8.9-18.1	3.67	0.31	4.35	3.03	11.8
11.7.75	15	7.1-15.7	3.54	0.30	4.11	2.95	11.8
9.8.75	15	7.8-16.5	3.64	0.21	4.17	3.37	17.1
26.2.76	17	11.1-16.0	3.47	0.42	4.65	2.76	8.2

*Gravid females

Table 11. Seasonal variation in dry weight of a "standard" 10 mm *Onisimus affinis*. Symbols as in Table 1.

Date	N	Size range (mm)	a	b	r	S.E.E.	S.E.R.	Dry wt. (mg)
15.8.73	54	9.3-18.0	-1.50	2.15	0.89	0.06	0.15	4.47
31.8.73	60	7.3-18.2	-1.48	2.15	0.96	0.05	0.08	4.68
2.3.74	68	8.1-19.6	-1.27	2.00	0.84	0.09	0.16	5.37
25.5.74	76	5.4-14.6	-2.14	2.99	0.97	0.05	0.09	7.08
2.7.74	27	5.3-12.4	-2.18	3.08	0.98	0.05	0.12	7.94
20.7.74	79	5.2-14.8	-2.56	3.35	0.97	0.09	0.09	6.17
1.8.74	79	5.5-16.4	-2.21	2.92	0.97	0.07	0.08	5.13
27.8.74	79	6.1-15.7	-2.25	3.03	0.96	0.07	0.10	6.03
28.2.75	93	8.6-18.2	-1.73	2.43	0.93	0.07	0.10	5.01
7.5.75	69*	10.1-16.2	-2.24	3.01	0.94	0.06	0.13	5.89
7.5.75	88	7.4-16.4	-2.25	2.88	0.97	0.04	0.07	4.27
15.6.75	60*	11.4-20.1	-2.02	2.72	0.94	0.05	0.13	5.01
15.6.75	69	7.9-18.1	-2.03	2.69	0.95	0.07	0.11	4.57
11.7.75	69	7.1-15.7	-2.04	2.87	0.97	0.06	0.09	6.76
9.8.75	68	7.5-16.5	-2.18	2.99	0.98	0.05	0.08	6.46
26.2.76	72	6.4-17.0	-2.06	2.71	0.95	0.06	0.11	4.47

*Gravid females

Table 12. Seasonal variation in ash content of a "standard" 10 mm *Onisimus affinis*. Symbols as in Table 1.

Date	N	Size range (mm)	a	b	r	S.E.E.	S.E.R.	mg ash
2.3.74	15	10.5-15.1	-1.55	1.74	0.75	0.06	0.43	1.55
25.5.74	18	8.3-14.2	-2.51	2.72	0.99	0.03	0.09	1.62
20.7.74	18	5.3-13.3	-2.40	2.53	0.95	0.08	0.21	1.35
1.8.74	18	9.5-15.0	-2.58	2.65	0.93	0.06	0.26	1.17
27.8.74	18	8.8-14.1	-3.51	3.68	0.97	0.06	0.24	1.48
28.2.75	18	9.2-17.4	-2.69	2.72	0.97	0.06	0.17	1.07
7.5.75	18*	10.7-16.0	-1.97	2.19	0.91	0.05	0.25	1.66
7.5.75	18	11.4-16.3	-2.22	2.31	0.81	0.07	0.42	1.23
15.6.75	18	11.1-16.8	-2.82	2.79	0.94	0.06	0.26	0.93
11.7.75	18	8.7-12.7	-2.33	2.57	0.97	0.04	0.17	1.74
9.8.75	18	8.1-13.2	-2.75	2.95	0.95	0.06	0.25	1.58
26.2.76	18	10.3-15.5	-2.06	2.18	0.97	0.03	0.13	1.32

*Gravid females

Table 13. Seasonal variation in total carbohydrate content of a "standard" 10 mm *Chiasmia affinis* (expressed as glucose equivalents). Symbols as in Table 1.

Date	N	Size range (mm)	a	b	r	S.E.E.	S.E.R.	µg glucose
15.8.73	19	11.7-18.0	2.39	-0.10	-0.03	0.19	0.84	194.9
31.8.73	20	7.3-15.5	0.24	2.04	0.90	0.09	0.24	190.6
2.3.74	30	8.1-16.5	-0.09	2.10	0.53	0.25	0.63	102.3
25.5.74	18	5.4-13.3	-0.13	2.52	0.88	0.14	0.34	245.5
2.7.74	20	5.3-12.0	-1.15	3.51	0.83	0.21	0.55	229.1
20.7.74	20	5.2-13.9	-1.08	3.31	0.90	0.20	0.38	169.8
1.8.74	20	6.0-14.4	-1.16	3.40	0.92	0.17	0.35	173.8
27.8.74	19	7.9-13.6	-0.46	2.74	0.85	0.15	0.41	190.6
28.2.75	16	8.9-17.0	1.23	0.75	0.26	0.24	0.74	95.5
7.5.75	17*	10.9-16.2	-1.14	3.31	0.80	0.15	0.65	147.9
7.5.75	18	7.4-16.0	-0.75	2.65	0 57	0.37	0.95	79.4
15.6.75	18*	13.3-16.6	1.06	1.34	0.28	0.14	1.16	251.2
15.6.75	18	7.9-17.0	-1.63	3.79	0.88	0.15	0.52	144.6
11.7.75	18	7.1-13.9	-0.33	2.71	0.75	0.19	0.61	239.9
9.8.75	18	7.7-15.3	-0.20	2.40	0.73	0.19	0.56	158.5
26.2.76	18	7.5-17.0	-0.54	2.49	0.83	0.16	0.42	89.1

*Gravid females

Table 14. Seasonal variation in total lipid content of a "standard" 10 mm *Onisimus affinis*. Symbols as in Table 1.

Date	N	Size range (mm)	a	b	r	S.E.E.	S.E.R.	mg lipid
15.8.73	18	9.3-17.1	-2.66	2.48	0.85	0.11	0.38	0.66
31.8.73	6	10.7-15.6	-1.28	1.29	0.95	0.03	0.20	1.02
2.3.74	20	8.3-19.6	-2.16	2.11	0.76	0.17	0.43	0.89
25.5.74	24	7.8-13.3	-3.66	3.64	0.84	0.11	0.50	0.95
2.7.74	7	7.2-12.4	-4.03	4.10	0.95	0.14	0.62	1.17
20.7.74	24	6.0-13.4	-0.49	0.69	0.32	0.37	0.44	1.58
1.8.74	24	5.5-16.4	-2.62	2.64	0.98	0.07	0.13	1.05
27.8.74	24	6.4-14.5	-2.91	2.90	0.93	0.10	0.25	0.98
28.2.75	23	8.6-14.7	-2.64	2.68	0.91	0.08	0.27	1.10
7.5.75	18*	10.8-14.6	-3.65	3.70	0.98	0.04	0.25	1.12
7.5.75	18	10.8-16.4	-3.13	3.02	0.87	0.09	0.44	0.78
15.6.75	18*	13.1-17.2	-2.65	2.77	0.88	0.07	0.15	1.32
15.6.75	18	10.4-17.4	-2.36	2.45	0.97	0.04	0.38	1.23
11.7.75	18	7.5-13.6	-3.05	3.11	0.96	0.07	0.24	1.15
9.8.75	18	7.7-14.5	-2.66	2.73	0.98	0.04	0.13	1.17
26.2.76	18	10.3-14.7	-3.38	3.31	0.91	0.06	0.38	0.85

*Gravid females

Table 15. Seasonal variation in protein content of a "standard" 10 mm *Scrobicularia plana*. Symbols as in Table 1.

Date	N	Size range (mm)	a	b	r	S.E.E.	S.E.R.	mg protein
15.8.73	17	11.5-16.6	-3.01	3.01	0.81	0.10	0.57	1.00
31.8.73	18	8.8-17.7	-2.19	2.31	0.97	0.05	0.15	1.32
2.3.74	16	11.8-15.0	-1.38	1.66	0.59	0.07	0.61	1.91
25.5.74	19	7.7-12.2	-2.92	3.27	0.96	0.06	0.24	2.24
20.7.74	19	5.6-13.4	-3.37	3.61	0.99	0.06	0.13	1.74
1.8.74	20	5.8-12.9	-3.12	3.32	0.98	0.07	0.15	1.58
27.8.74	20	6.1-12.6	-3.20	3.49	0.98	0.06	0.17	1.95
28.2.75	37	10.4-18.2	-2.81	2.97	0.96	0.05	0.14	1.45
7.5.75	18*	10.5-15.8	-2.66	3.01	0.89	0.08	0.38	2.24
7.5.75	38	9.7-15.9	-2.43	2.65	0.93	0.05	0.18	1.66
15.6.75	18*	12.4-19.1	-1.48	1.85	0.83	0.07	0.32	2.34
15.6.75	18	10.5-17.7	-2.38	2.58	0.97	0.05	0.18	1.58
11.7.75	18	8.0-13.8	-2.72	3.10	0.98	0.04	0.15	2.40
9.8.75	16	7.5-12.7	-2.63	3.01	0.98	0.04	0.14	2.40
26.2.76	18	6.4-15.5	-2.25	2.48	0.92	0.09	0.27	1.70

*Gravid females

Table 16. Summary of seasonal variation in dry weight composition of a "standard" 10 mm *Chirimia affinis*. Symbols as in Table 1.

	Composition (mg/animal)						
Date	Chitin[1]	Ash	Carbohydrate	Lipid	Protein	Total wt.	Wt. of "standard" animal
15.8.73	0.36	-	0.19	0.66	1.00	-	4.47
31.8.73	0.37	-	0.19	1.02	1.32	-	4.68
2.3.74	0.43	1.55	0.10	0.89	1.91	4.88	5.37
25.5.74	0.57	1.62	0.25	0.95	2.24	5.63	7.08
2.7.74	0.64	-	0.23	1.17	-	-	7.94
20.7.74	0.49	1.35	0.17	1.58	1.74	5.33	6.17
1.8.74	0.41	1.17	0.17	1.05	1.58	4.38	5.13
27.8.74	0.48	1.48	0.19	0.98	1.94	5.07	6.03
28.2.75	0.40	1.07	0.10	1.10	1.45	4.12	5.01
7.5.75*	0.47	1.66	0.15	1.12	2.24	5.64	5.89
7.5.75	0.34	1.23	0.08	0.78	1.66	4.09	4.27
15.6.75	0.40	0.93	0.25	1.32	2.34	5.24	5.01
15.6.75	0.37	-	0.14	1.23	1.58	-	4.57
11.7.75	0.54	1.74	0.24	1.15	2.40	6.07	6.76
9.8.75	0.52	1.58	0.16	1.17	2.40	5.83	6.46
26.2.76	0.36	1.32	0.09	0.85	1.70	4.32	4.47

*Gravid females

[1]estimated from percent composition and weight of "standard" animal.

Table 17. Seasonal variation in caloric content of a "standard" 10 mm *Onisimus affinis*. Symbols as in Table 1.

Date	N	Size range (mm)	a	b	r	S.E.E.	S.E.R.	Cal.
31.8.73	15	9.8-18.2	-0.92	2.11	0.94	0.07	0.21	15.5
25.5.74	14	7.6-14.6	-1.63	3.09	0.97	0.06	0.23	28.8
20.7.74	15	8.7-13.7	-2.94	4.32	0.86	0.14	0.70	24.0
1.8.74	15	9.1-14.1	-1.64	2.93	0.87	0.09	0.47	19.5
27.8.74	15	8.7-15.7	-1.72	3.09	0.95	0.07	0.27	23.4
28.2.75	14	10.9-15.9	-1.39	2.64	0.90	0.07	0.36	17.8
7.5.75	14*	10.5-16.2	-1.90	3.25	0.96	0.07	0.27	22.4
7.5.75	14	10.4-16.3	-1.69	2.84	0.95	0.06	0.27	14.1
15.6.75	15*	11.4-20.1	-2.21	3.42	0.98	0.05	0.18	16.2
15.6.75	15	8.9-18.1	-1.90	3.06	0.97	0.07	0.20	14.5
11.7.75	15	7.1-15.7	-1.25	2.65	0.95	0.08	0.24	25.1
9.8.75	15	7.8-16.5	-1.67	3.03	0.98	0.06	0.17	22.9
26.2.76	17	11.1-16.0	-2.23	3.36	0.89	0.07	0.45	13.5

*Gravid females

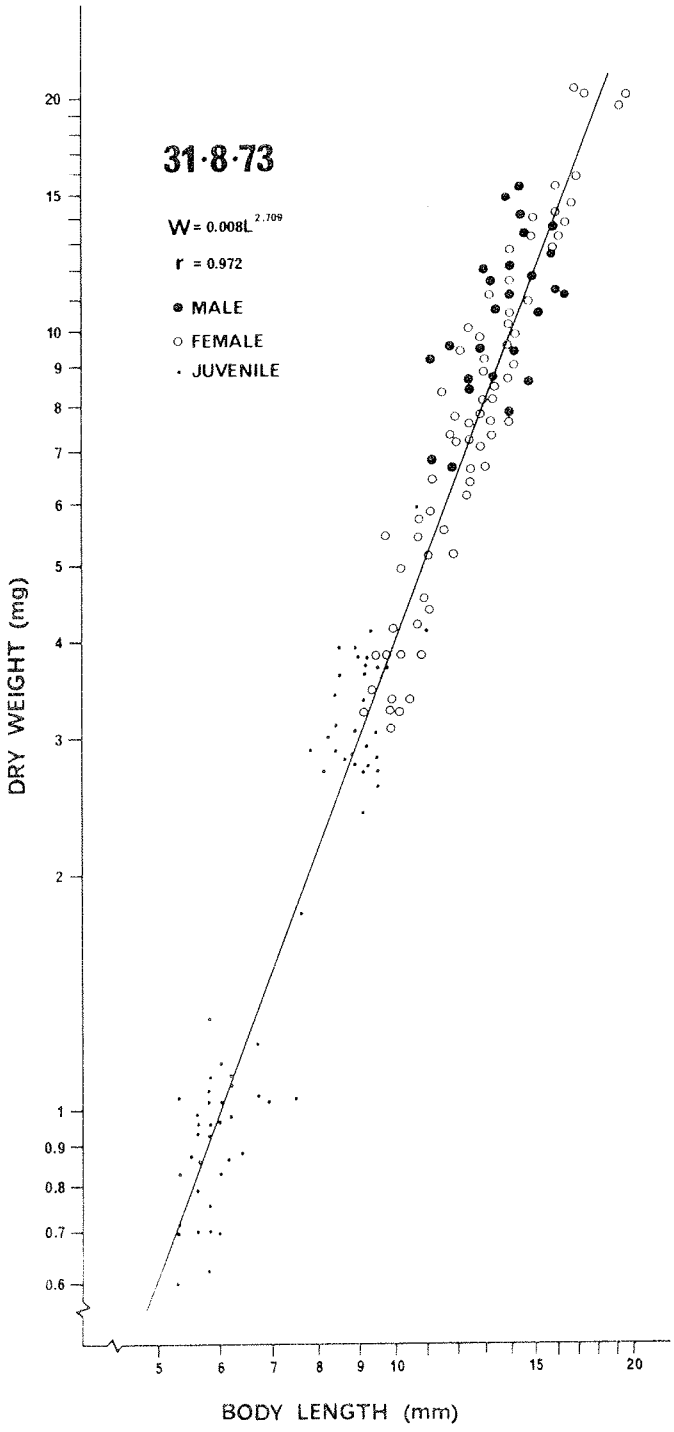

Figure 1. Relationship between dry weight (mg) and body length (mm) for male, female and juvenile *Onisimus affinis* collected during the summer (31.8.73).

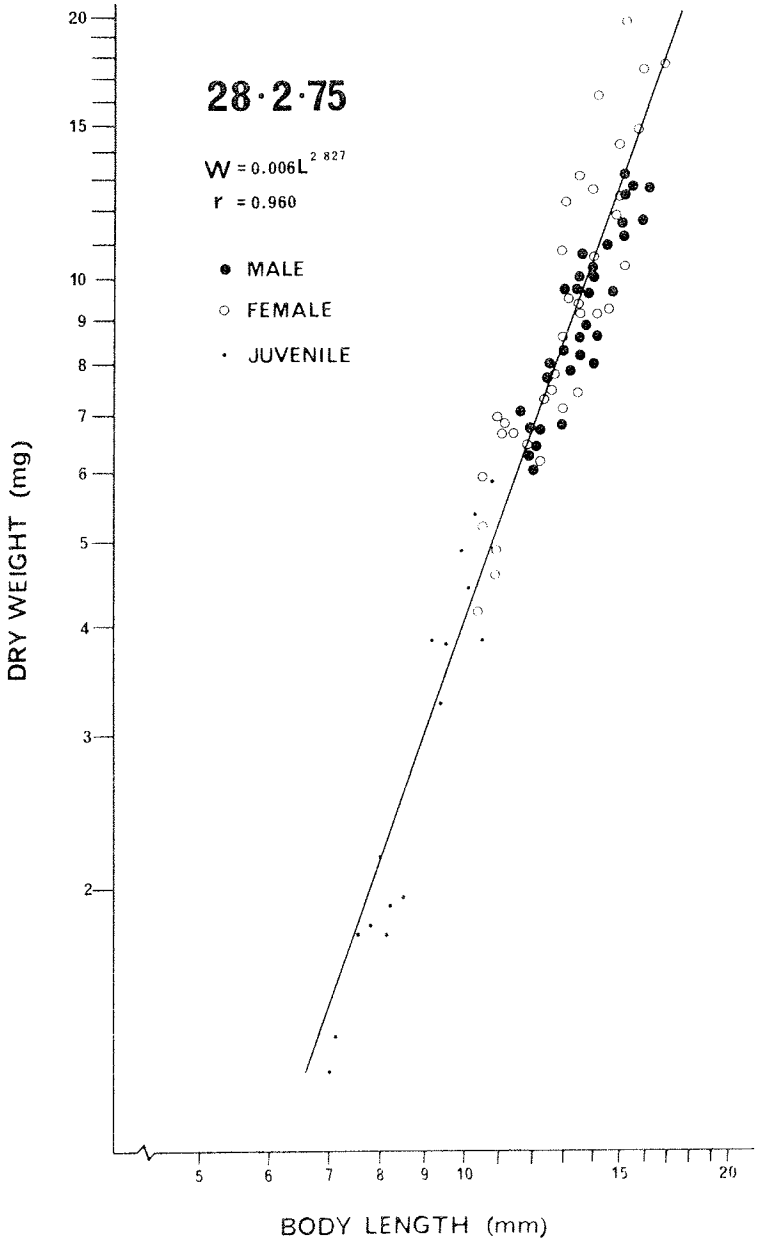

Figure 2. Relationship between dry weight (mg) and body length (mm) for male, female and juvenile *Oxisimus affinis* collected during the winter (28.2.75).

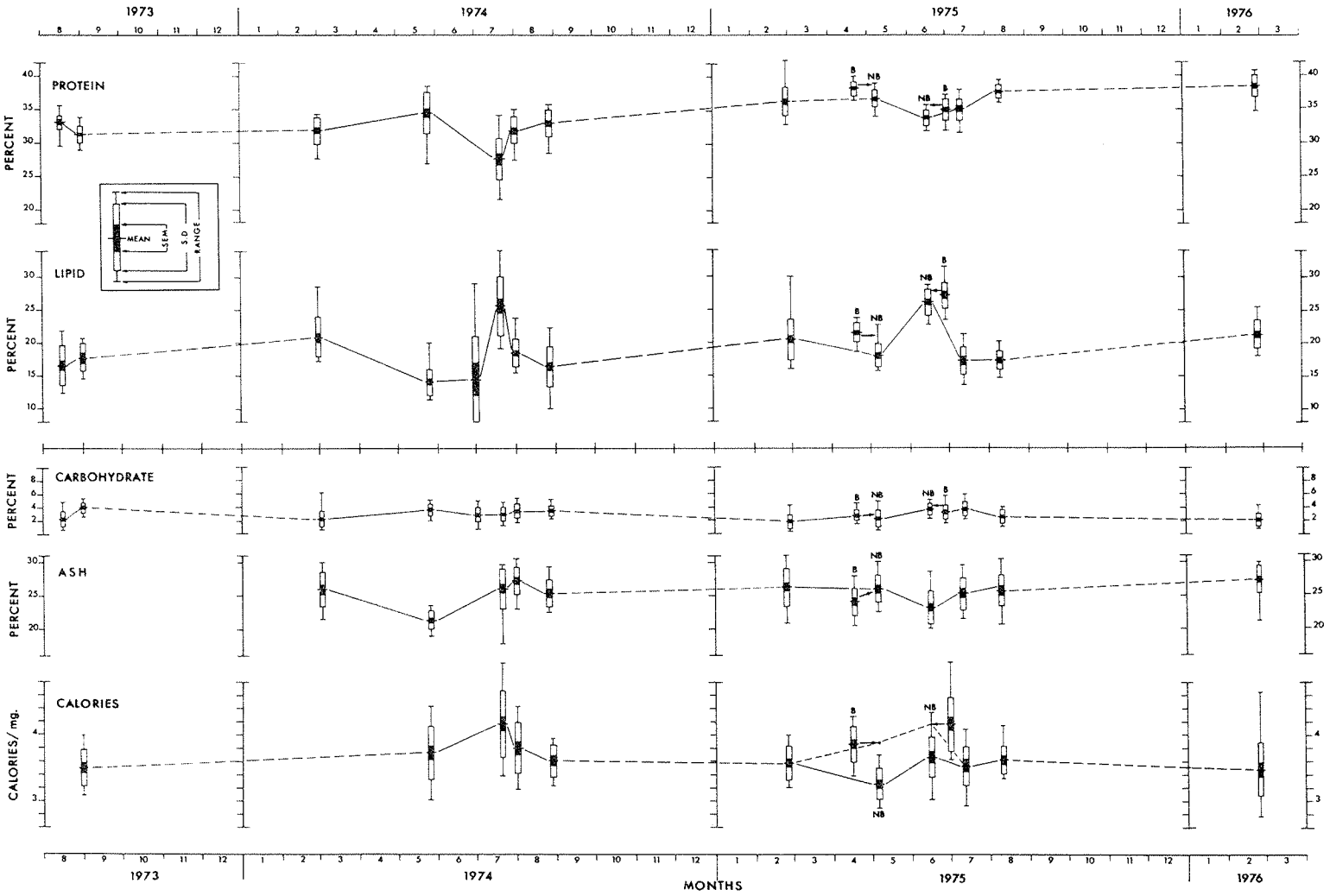

Figure 3. Seasonal changes in percent composition and caloric value of *Onisimus affinis*.

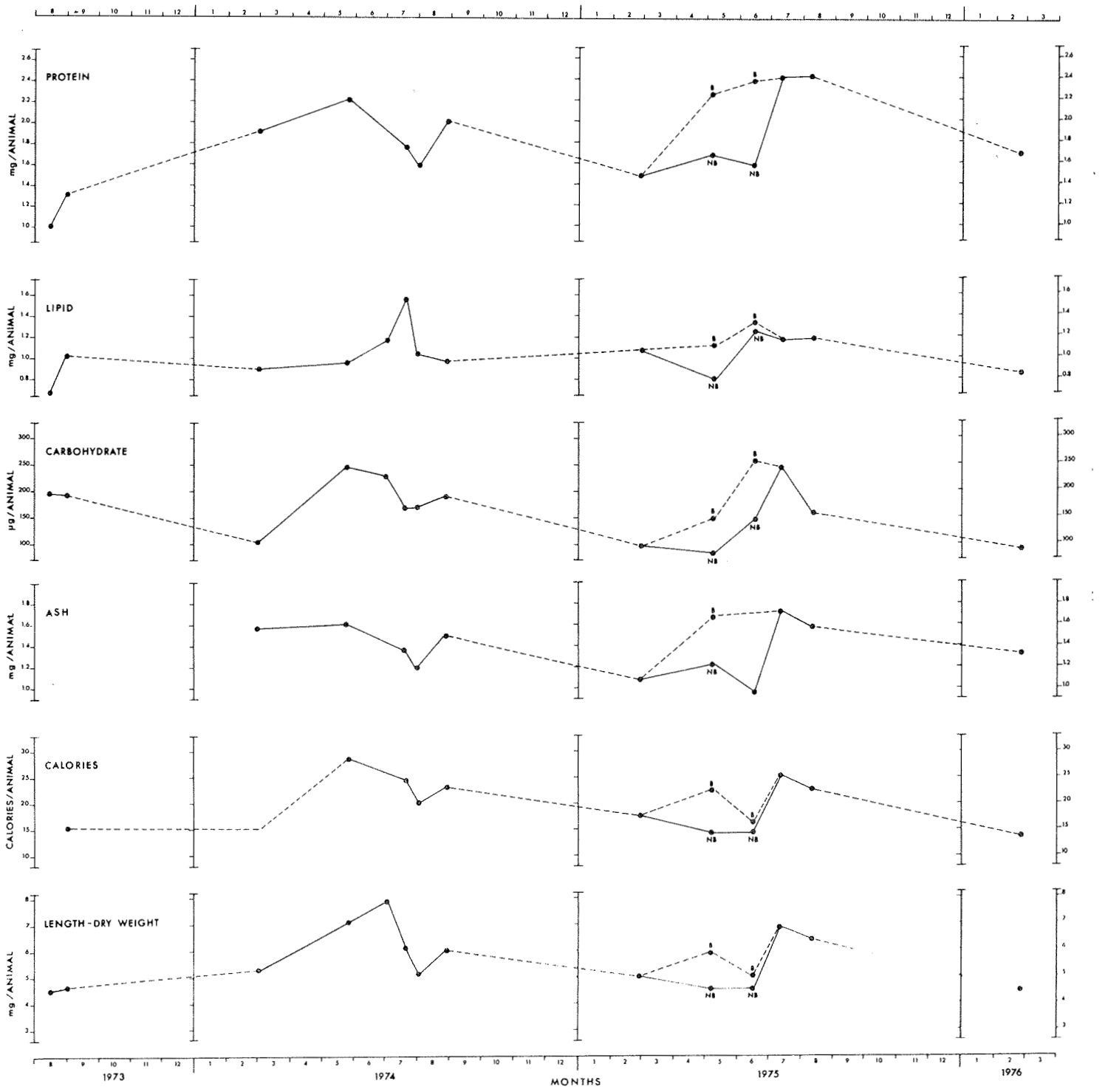

Figure 4. Seasonal changes in biochemical composition, total dry weight and caloric value of a "standard" 10 mm *Onisimus affinis*.

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