CHEMICAL COMPOSITION OF OYSTERS FROM SÃO PAULO AND PARANÁ, BRAZIL

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SYNOPSIS

During the years 1966/67 a comparative study of the chemical composition of oysters was performed on protein, water, ash, trimethylamine oxide, trimethylamine, crude glycogen, iron (Fe+++), calcium, magnesium, total and inorganic phosphorus, with oysters coming from the lagoon regions of the State of São Paulo, namely Cananéia and Bertioga Channel (Santos), and from the State of Paraná.

The oyster discussed here is the species found on mangrove tree stilt roots. It was determined as *Ostrea arborea* Chemnitz, by Dr. Hugo de Souza Lopes, Museu Nacional do Rio de Janeiro. Other zoologists have placed the present species in the genus *Crassostrea*.

Appraisal of the analytical results of the oysters was made taking into consideration the reproductive cycle and the meteorological conditions of the three regions under study.

A seasonal variation was observed regarding fat, crude glycogen, dry matter and energy content when related to fresh and dry matter, and of protein when expressed in relation to dry matter.

The seasonal variation are related to the reproductive cycle of oysters and is probably influenced by water temperature variations which depend on the solar radiation incidence, and also by phytoplankton abundance.

We endeavoured to determine the season when distinct phases of the oyster reproductive cycle occurs, fattening, ripening, gonadal and sexual products discharge, for each one of the three regions studied, as well as the most favorable time of the year for comsumption (winter and spring).

This paper shows that oysters are a complementary source of food and income, that their production must be managed for an optimum return to the population inhabiting the lagoon regions of Brazil southern coast.

INTRODUCTION

Considering the poor standard of living conditions of the population inhabiting the lagoon regions of Brazil southern coast, specially in the States of São Paulo and Paraná, where these studies were carried out, we endeavoured to obtain the essential knowledge which is necessary for improving the commercial production of oysters. The oyster is a complementary source of food and income that must be managed for obtaining an optimum return.

At present the exploitation of this mollusc is based on collecting from natural beds, although LIMA & VAZZOLER (1963) have shown clearly the possibility of establishing oyster culture in the Bertioga Channel (Santos), similar to the mangrove lagoon region of Cananéia.

Since the knowledge on these moluscs from this part of Brazil is limited to the information given by those authors, we have attempted a comparative study of oysters from regions where they are endemic in the States of São Paulo and Paraná. The most important natural beds are so distributed: State of São Paulo: Bertioga Channel (Santos) and Cananéia; State of Paraná: channel connecting with the Paranaguá Bay.

We have obtained information on the chemical composition and energetic value, on the seasonal variation of the chemical composition and its relation to the reproductive cycle, on the environmental factors (mainly water temperature) that may influence the reproductive cycle of the oyster and hence its chemical composition; the seasons during which the oyster has a higher nutritive value and when it is best accepted for its palability.

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MATERIAL AND METHODS

Whenever possible, monthly analyses were made during the period March 1966-June 1967. The samples came from Paranaguá (Paraná), Cananéia (São Paulo) and Bertioga Channel (Santos, São Paulo).

Samples were collected by two different methods. Ten samples were taken directly on natural banks at the same places visited by fishermen. Twenty-five other samples were taken from lots of oysters collected by fishermen and distributed for sale at the market in Santos.

The period between sampling and analysis varied from 3 h to one day (Bertioga Channel) and 3 to 4 days (Cananéia and Paranaguá). The following data were recorded for each sample: date and place of capture, type of packing and transport; individual length, width, height; total weight; weight of flesh. In addition, the individual fillet value was calculated.

Preparation of Sample

The oysters were carefully opened to avoid breaking the valves and soiling the flesh with debris, to prevent errors in the chemical analysis. The flesh was dried, weighed, separated in groups, homogenized and analysed in duplicate.

Analysis

Protein: (total N × 6.25) by the Kjeldahl method according to Lepper (1950).

Humidity: drying to constant weight in a dry chamber at 105°C temperature.

Fat: (fat extract in ether) by Soxhlet method according to Lepper (1950).

Ash: Muffle combustion at 550°C, after incinaration at low temperature in an electric resistence oven.

Trimethylamine (TMA) and *Trimethylamine oxide* (TMO) according to the DYER (1945) and DYER *et al.* (1952) methods. Analysis were made with Zeiss Spectophotometer MM 12 at 410 mμ.

Calcium, magnesium and *iron* (Fe^{+++}): by chelometry, titriplex III, according to Merck specifications.

Total and *inorganic phosphorus*: according to the NAKAMURA method, reading taken with a Zeiss Spectophotometer MM 12 at 710 mμ.

The indications and further characteristics of the above mentioned methods may be found in ITÔ *et al.* (1968).

Crude glycogen: according to the ROESS method employing the following procedure: parallel weight of 10 g of homogenized flesh is taken, add 50 ml distilled water and heat in water-bath up to the boiling temperature during 30 minutes. The mixture is left to rest and filtered overnight. Add 1.23 ml of 20% trichloracetic acid to each 50 ml of the filtered mixture and allow to stand overnight. Add three volumes of absolute ethilic alcohol and store for two days. Filter through filter paper previously dehidrated ånd weighed. Dehydrate in a vacuum dehydrator and weigh. The glycogen retained was calculated by the weight difference. All these operations of alternative filtering and standing were achieved in a common refrigerator with the temperature ranging from 0 to 5°C.

Meteorological Data

Meteorological data for Cananéia were supplied by the southern station of the Instituto Oceanográfico da Universidade de São Paulo; for Bertioga, by the Força Aérea Brasileira, Santos meteorological Station and AZEVEDO, AZEVEDO (1965); by the Departamento de Agricultura, State of Paraná, for Paranaguá. The global radiation at Cananéia was obtained with a calibrated actinograph and with a standard solarigraph of the Oceanographic Institute and at Santos it was calculated on the basis of daily month radiation (n) obtained with a heliograph and the radiation incident per cm^2 on a given day on horizontal surface lying on the ground was calculated by the following formula:

$$Q/Q_o = 0.24 + 0.58\ n/N\ .$$

This formula was given by CERVELINE, SALATI & GODOY (1967) who calculated this to be the average equation for the State of São Paulo, where: Qo is the total solar radiation in $cal/cm^2/day$ that reaches the ground level in the absence of the atmosphere, obtained from Tables of the Meteorological Service, *in* SALATI & others (1967). N is the number of hours of possible radiation calculated from the annual date of the São Paulo Observatory (Univ. São Paulo, Inst. Astr. Geof., 1966). The water temperature was obtained by means of a "mercury in steel" hydrothermograph with remote bulb, about one meter below the water level.

RESULTS AND DISCUSSION

The results of the chemical analyses of oysters brought to Santos from different regions are presented under different aspects.

Chemical composition — The maximum average and minimum values obtained are shown in Table II together with values obtained by other authors for comparison.

Data show that the oysters studied here have a relatively high water content, similar to that observed in the genus *Crassostrea* rather than in *Ostrea* VINOGRADOV (1953), ESTABLIER (1966). The magnesium content is higher than the calcium content, differing from the observation of most authors who analysed oysters. It agrees however with the observations by NILSON & COULSON, 1937 (*in*: VINOGRADOV, *op. cit.*) on *Crassostrea gigas* from the Pacific coast of the United States.

TABLE I — Chemical analysis of oysters — Paranaguá - Cananéia - Bertioga Channel

				IN FRESH MEAT												IN DRY MATTER			
Place of capture	Number of specimens in the sample	Date of analysis	Average length (cm)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Calcium (mg/100 g)	Magnesium (mg/100 g)	Crude glycogen (%)	Trimethylamine (mg/100 g)	Trimethylamine oxide (mg/100 g)	Total phosphorous (mg/100 g)	Inorganic phosphorous (mg/100 g)	Iron (Fe+++) (mg/100 g)	Protein (%)	Fat (%)	Ash (%)	Crude glycogen (%)
Bertioga Channel (Santos)	18	03/12/66	11,7	86,9	7,9	1,00	1,5	99,5	105,5	0,742	0,12	4,0	210,0	150,0	2,9	60,3	7,39	11,4	5,6
	18	05/17/66	8,8	85,1	7,8	1,72	1,7	110,3	125,3	1,852	0,14	0,0	350,0	113,0	3,0	52,3	11,54	11,4	12,4
	18	06/24/66	8,0	88,1	5,9	0,88	2,2	83,8	173,6	1,830	0,00	0,0	386,1	161,4	2,9	49,5	7,39	18,4	15,3
	18	07/18/66	9,5	85,3	7,9	1,32	2,1	83,9	111,9	2,158	0,04	0,2	358,9	153,8	2,2	53,7	8,97	14,2	14,6
	18	08/09/66	10,5	83,0	8,1	1,86	1,5	68,5	103,6	2,753	0,00	0,0	364,9	162,2	4,5	47,6	10,40	8,8	16,1
	18	09/14/66	10,1	82,9	8,5	1,87	2,0	54,9	112,8	2,398	0,10	1,6	701,3	316,2	2,1	49,7	10,90	11,60	14,0
	18	10/11/66	8,2	83,9	8,2	1,83	1,7	—	—	1,949	00,0	0,0	600,4	367,4	3,2	50,9	11,30	10,5	12,1
	18	11/09/66	9,9	82,7	9,3	2,32	1,7	34,2	88,80	2,949	0,10	0,8	700,4	—	2,8	53,7	13,40	9,8	17,0
	18	12/01/66	9,2	82,4	9,5	2,37	1,3	68,1	82,60	2,588	0,00	0,7	886,4	423,5	2,0	54,0	13,50	7,4	14,7
	6	12/05/66	9,7	84,3	8,8	2,15	1,9	84,9	110,9	1,033	0,00	0,01	—	—	—	56,0	13,69	12,1	6,6
	16	12/22/66	9,8	85,2	7,8	1,79	1,0	36,7	64,1	1,089	0,00	0,1	564,9	211,8	—	52,7	12,10	6,7	7,4
	11	01/22/67	13,0	87,9	7,7	1,00	2,1	68,8	117,3	1,119	0,10	2,4	—	—	—	63,6	8,30	17,3	9,9
	10	03/02/67	9,6	90,2	6,2	0,73	1,6	68,0	87,5	0,562	0,04	0,0	349,3	67,0	6,6	63,3	7,40	16,3	5,8
	16	04/17/67	13,0	88,0	6,7	1,06	1,8	69,1	105,6	0,800	0,02	2,0	203,9	81,4	8,3	55,8	8,80	15,0	6,6
Average	—	—	—	85,4	7,87	1,56	1,7	71,5	106,8	1,707	0,08	1,31	473,0	200,7	—	—	—	—	—
S.D.	—	—	—	2,53	1,01	0,53	0,36	20,07	24,47	0,78	0,03	1,24	204,8	114,1	—	—	—	—	—
Cananéia	18	05/16/66	8,3	88,9	6,5	0,82	1,80	91,8	151,7	0,875	0,00	2,0	735,0	188,0	3,5	58,55	7,39	16,2	7,88
	18	06/24/66	7,6	85,9	6,9	1,09	2,10	60,2	188,9	1,877	0,00	0,0	352,8	176,5	2,2	48,93	7,73	14,9	13,31
	18	07/22/66	7,6	82,2	7,9	1,30	2,20	90,4	152,2	3,761	0,00	0,4	255,2	127,6	4,0	44,40	7,30	12,3	21,13
	18	08/19/66	8,5	84,9	6,9	1,24	2,10	79,9	120,8	2,797	0,00	0,2	217,4	118,5	4,0	45,70	8,21	13,9	18,52
	18	09/25/66	7,9	85,6	7,9	1,20	2,10	51,9	157,7	1,703	0,90	0,6	31,4	19,9	1,4	54,90	8,33	14,6	11,83
	18	10/24/66	7,7	86,4	6,6	1,20	1,90	50,5	—	1,217	0,50	0,2	45,40	28,6	1,0	48,50	8,82	13,9	8,94
	18	12/05/66	9,8	87,8	6,9	—	1,60	64,0	142,5	1,042	0,40	0,0	—	—	1,2	56,50	—	13,1	8,54
	14	02/21/67	7,1	90,8	6,8	0,81	1,10	57,9	124,3	—	0,04	—	—	—	12,3	73,90	8,80	11,9	—
	15	03/20/67	8,4	91,7	6,4	0,71	1,90	67,9	93,4	1,061	0,30	0,0	—	—	6,6	77,10	8,55	22,9	12,78
	21	04/28/67	7,7	85,8	8,1	1,11	2,40	87,7	102,72	2,440	0,50	6,0	—	—	—	57,00	7,81	16,9	17,18
	24	06/05/67	7,4	87,2	—	—	2,45	—	—	1,128	0,50	0,0	286,2	70,97	9,42	—	—	19,1	8,81
Average	—	—	—	87,0	7,0	1,05	1,90	70,2	135,1	1,790	0,50	1,56	175,1	104,30	—	—	—	—	—
S.D.	—	—	—	2,46	0,6	0,278	0,39	15,10	28,16	0,810	0,32	2,07	136,07	62,02	—	—	—	—	—
Paranaguá	18	05/30/66	9,5	87,4	7,7	1,06	1,2	74,2	117,7	1,495	0,00	0,0	218,0	157,0	3,5	61,1	8,41	9,5	11,86
	18	06/27/66	7,3	87,7	6,4	0,85	1,9	123,4	142,9	1,417	0,1	0,4	318,3	156,4	3,4	52,0	6,91	15,4	11,52
	18	08/31/66	8,5	83,8	7,4	1,59	1,9	72,2	88,1	2,213	0,0	0,0	67,3	33,4	4,1	45,7	9,81	11,7	13,65
	18	10/24/66	7,9	83,9	1,4	1,59	1,9	55,4	151,8	1,997	0,0	0,0	90,5	33,9	1,0	50,0	11,24	13,0	12,40
	18	11/28/66	6,6	84,8	7,5	1,29	3,0	36,9	140,5	1,355	0,2	1,6	364,8	179,8	1,2	49,3	8,48	19,7	8,91
	18	01/11/67	—	86,6	9,5	1,26	2,07	—	—	—	0,2	3,6	—	—	—	70,9	9,40	15,4	—
	15	02/22/67	8,1	89,7	6,9	0,82	2,62	84,34	135,58	—	—	—	—	—	13,2	67,0	8,00	25,4	—
	24	04/10/67	6,9	87,2	9,9	1,10	1,67	67,40	77,20	0,935	0,0	0,0	205,7	80,4	3,9	77,3	8,59	13,0	7,30
	20	05/03/67	6,8	89,2	6,3	0,96	1,65	91,75	134,94	0,061	0,1	1,2	—	99,37	12,0	58,3	8,88	15,3	0,565
Average	—	—	—	86,7	7,7	1,19	2,01	75,70	123,6	1,353	0,075	0,825	210,80	105,8	7,14	34,0	—	—	—
S.D.	—	—	—	2,02	1,18	0,33	0,50	24,00	25,42	0,65	0,08	1,13	108,28	55,74	—	—	—	—	—

TABLE II — Chemical composition of oyster from different places (fresh meat)

		Protein (%)	Ash (%)	Water (%)	Fat (%)	Glycogen (%)	Calcium mg/100 g	Magnesium mg/100 g
Crassostrea angulata (Portugal) SILVA *et al.*, 1954 *		8,62 (10,37 −7,06)	2,70 (3,13 −2,00)	83,05 (86,34 −77,85)	1,72 (2,27 −1,09)	1,72 (5,50 trace)	— —	— —
C. rhizophora (Cuba) SAENZ, 1965		11,73 (13,37 −8,75)	—	78,49 (80,43 −71,35)	1,98 (2,79 −1,30)	2,89 (3,90 −2,50)	—	—
C. virginica (Southern, USA) LEE *et al.*, 1960 *		— 6,3	— 1,5	— 87,8	— 1,3	— —	— —	— —
C. angulata (Cadiz Bay, Spain) ESTABLIER, 1966		11,28 (13,91 −8,99)	2,62 (2,89 −2,37)	80,40 (83,80 −75,91)	1,67 (2,73 −0,76)	11,28 (13,91 −8,99)	— —	— —
Ostrea edulis GAARDER, 1941*		10,00 (11,2 −8,8)	1,3 (1,5 −1,2)	78,7 (81,9 −76,0)	1,3 (2,5 −1,6)	6,8 (7,9 −5,1)	— —	— —
O. edulis (Mali Ston Bay, Adriatic) KRVARIC, 1953		11,34 (12,58 −9,82)	1,48 (1,80 −1,19)	79,84 (81,6 −75,4)	2,02 (2,78 −1,44)	4,02 —	— —	— —
Gulf oyster (La., USA) FIEGER *et al.*, 1958	HS	10,71 (12,06 −10,06)	— —	81,78 —	0,89 (1,45 −0,41)	1,28 (4,28 −0,10)	— —	— —
	LS	9,50 (11,00 −7,58)	—	84,06 —	0,79 (1,18 −0,41)	0,76 (1,52 −0,08)	—	—
C. gigas		—	—	—	—	—	62,8	480,0
O. lurida (Pacific coast, USA)		—	—	—	—	—	63,2	24,0
C. virginica (Pac. coast, USA) NILSON & COULSON, 1937 **		—	—	—	—	—	57,9	32,0
O. arborea Santos, Brazil		7,87 (9,5 −5,9)	1,7 (2,37 −1,0)	85,4 (90,2 −82,4)	1,56 (2,37 −0,73)	1,707 (2,941 −0,56)	71,5 (110,3 −34,2)	106,8 (173,8 −82,6)
Cananéia, Brazil		7,0 (8,11 −6,44)	1,9 (2,45 −1,1)	87,0 (91,7 −82,2)	1,05 (1,30 −0,81)	1,790 (3,761 −0,805)	70,2 (91,8 −50,5)	135,1 (188,9 −93,4)
Paranaguá, Brazil ANTUNES & ITÔ		7,7 (9,9 −6,4)	2,0 (2,62 −1,20)	86,7 (89,7 −83,8)	1,19 (1,81 −0,82)	1,353 (2,213 −0,935)	75,7 (123,4 −36,9)	123,6 (151,8 −77,2)

* *in* ESTABLIER, 1966 — ** *in* VINOGRADOV, 1953. HS = High saline; LS = Low saline.

As a rule the protein and ash content is lower than that observed by other authors.

The presence of trimethylamine oxide (TMO) in 19 out of 32 analysis differs considerably from the observations of the total absence of TMO recorded by NORRIS & BERNOIT, 1945 (*in*: DYER, 1952) in *Ostrea japonica*, in *O. virginica* respectively from the Atlantic and the Pacific Oceans. We found no other references to TMO content in oysters.

The results obtained for iron (Fe^{+++}) agree in general with those found by other authors, but the maximum and minimum values are quite distant from each other (CLEMENTS & HUTCHINSON, 1939; NILSON & COULSON, 1939 *in*: VINOGRADOV, 1953).

Iron (Fe^{+++}) and Phosphorous determination in oysters (mg/100 g of fresh meat)

	Fe^{+++}	*Phosphorous*
Crassostrea commercialis	5,0	150,0
CLEMENTS & HUTCHINSON, 1939 *		
C. gigas	7,5	192,0
C. virginica	6,1	112,1
Ostrea lurida	4,9	315,4
NILSON & COULSON, 1939 *		

Energetic values — The energetic values shown in Table III were observed in connection with Rubner index: 4.1 for protein and glycogen, 9.3 for fats.

The average results calculated per season are shown and compared to those obtained by other authors. Our data indicate that oysters (from Santos, Cananéia and Paranaguá) show a lower food values than that found by other authors for oysters from other grounds.

Oyster characteristics for consumption — According to ENGLE (1958), there is a close relationship between the glycogen content and acceptance of oyster for consumption. ENGLE (*op. cit.*) also suggests that glycogen content, percentual value of dry weight or total solid matter and condition factors are the acceptable way by which the quality of oysters may be measured.

FIEBER *et al.* (1958), noticed that a decrease in the glycogen content causes the oyster flesh to become watery. These observations agree with ours, i.e., when they are said to be "fat" and have a better taste, they also have a higher glycogen content. The increase in glycogen content coincides with the season of the year when gonads become ripe and the fat content also increases similarly to KRVARIC's observations (1953). This occurs here in winter and spring.

* In: VINOGRADOV, 1953.

Seasonal variation of the chemical composition and energetic value — The results of protein content, ash, water, glycogen, dry matter and energetic value are shown on Figure 1 for fresh material and Figure 2 for dry material. Both graphs are drawn from our data.

The analysis of the variation shown on Figures 1 and 2 will be divided as follows:

1 — Variation: observation and description of variables.

2 — Relation among the different analysis and their meaning.

3 — Factors influencing the season variation.

4 — Analysis of the present data.

Variation — Observations and description. Table V shows graphically the trend of variation of the variables analysed: glycogen, fat and dry matter.

Table V shows a correlation between the specimens from Cananéia, Paranaguá and Santos, taken in June/July 1966 and March/April 1967, increase on glycogen, fat and dry matter value; in November 1966 until February 1967 there is a decrease of dry matter. Oysters from Paranaguá and Santos in May//June 1966 show a decrease on the value of the three factors while in July/August 1966 there is an increase. Oysters from Paranaguá and Cananéia in October/November 1966 and April/May 1967 show a decrease of the three factors in Paranaguá and glycogen and dry matter in Cananéia.

Glycogen and fat generally vary in a similar way, however they show an opposite trend of variation in August/September 1966 for Paranaguá oysters and November/December 1966 for Santos oysters.

Relation among the different analysis and their meaning — It is well known that animals generally store energy in the form of fat and that molluscs, including oysters do it under a different form, namely glycogen. Glycogen is thus more important than fat. STETTEN & STETTEN, 1959 (*in*: WILBUR & YONGE, 1966) showed conclusively that glycogen is used by oysters as main energy storage substance.

Several authors noticed a correlation between the glycogen and fat content during the reproductive cycle of oysters. RUSSELL, 1923 and GAARDER, 1928 (*in*: WILBUR & YONGE, 1966) have shown that the reproduction cycle is paralleled by a reduction in glycogen content, indicating that gametogenesis causes an increase in metabolic requirements.

OKASAKI & KOBAYASHI, 1929 (*in*: WILBUR & YONGE, 1966) found a minimal glycogen content during the breeding season in *Ostrea circunspicta*. MATSUMOTO *et al.*, 1934 (*in*: WILBUR & YONGE, 1966) observed a positive correlation between the reproductive cycle and glycogen, fat and total nitrogen content in *Crassostrea gigas*. They divide the reproductive cycle into three stages: fattening, gonadal ripening and discharge of sexual products.

TABLE III — Energy content (calories/*100 g fresh meat) of oysters

Place	Season	Date	Protein % × 4,1	Fat % × 9,3	Glycogen % × 4,11	Total
Bertioga Channel (Santos)	Summer	03/12/66	32,4	9,3	3,0	44,7
	Fall	05/17/66	32,0	16,0	7,6	55,6
		06/24/66	24,2	8,2	7,5	39,9
	Winter	07/18/66	32,4	12,3	8,8	53,5
		08/09/66	33,2	17,3	11,3	61,8
		09/14/66	34,8	17,4	9,8	62,0
	Spring	10/11/66	33,6	17,0	8,0	58,6
		11/09/66	38,1	21,6	12,1	71,8
		12/01/66	38,9	22,0	10,6	71,5
		12/05/66	36,1	20,0	4,2	60,3
		12/22/66	32,0	16,6	4,5	53,1
	Summer	01/22/67	31,6	9,3	4,9	45,8
		03/02/67	25,4	6,8	2,3	34,5
Cananéia	Fall	05/16/66	26,6	7,6	3,6	37,8
	Winter	06/24/66	28,3	10,1	7,7	46,1
		07/22/66	32,4	12,1	15,4	59,9
		08/19/66	28,3	11,5	11,5	51,3
	Spring	09/25/66	32,4	11,2	7,0	50,6
		10/24/66	27,1	11,2	5,0	43,3
		12/05/66	28,3	—	—	—
	Summer	02/21/67	27,9	7,5	—	—
		03/20/67	26,2	6,6	4,3	37,1
	Fall	04/28/67	33,2	10,3	10,0	53,5
Paranaguá	Fall	05/30/66	31,5	9,8	6,1	47,4
	Winter	06/27/66	26,2	7,9	5,8	39,9
		08/27/66	30,3	14,8	9,1	54,2
	Spring	10/24/66	30,3	16,8	8,2	55,3
		11/28/66	30,7	12,0	5,5	48,2
	Summer	01/11/67	38,9	11,7	—	—
		02/22/67	28,3	7,6	—	—
	Fall	04/10/67	40,6	10,2	3,8	54,6
		05/03/67	25,8	8,9	0,2	34,9

* Rubner Index.

TABLE IV — Energy content of oysters in various seasons (calories/100 g fresh meat)

	Spring	Summer	Fall	Winter	Average
Ostrea lurida (Columbia — Canadá * TULLY, 1935	75	68	72	70	71
Ostrea gigas (Columbia — Canadá) TULLY, 1935	89	75	72	82	79
Ostrea virginica (Columbia — Canadá)	88	65	63	75	73
Ostrea edulis (Mali Sto Bay, Adriatic) KRVARIC, 1953	90	76	77	85	82
Ostrea arborea (Santos — Brazil)	63	41	48	59	54
(Paranaguá — Brazil)	52	—	46	48	48
(Cananéia — Brazil) ANTUNES & ITÔ	47	37	46	52	47

* *in* KRVARIC, 1953.

The fattening period occurs in autumn and winter according to MATSUMOTO (*op. cit.*), and during this period the glycogen content increases and reaches its maximum. Fat content remains near average.

Both glycogen and fat content increase during this period; however, the word "fattening" is misleading since the glycogen increase is much greater than that of fat content as the word would suggest.

The gonadal ripening period occurs by late spring, when the fat matter reaches its maximum and glycogen begins to decline. The general trend is therefore opposite, positive for fat matter and negative for glycogen, a fact which originates the crossing in Table V.

According to BAKER, 1942 (*in*: WILBUR & YONGE, 1966) glycogen is mobilized more easily than fat, according to GODDARD & MARTINS, 1966 (*in*: WILBUR & YONGE, 1966) may be converted into fat during this period of the reproductive cycle even though the animal is not actively feeding. The major part of the fat material is stored in the sexual products. No loss of weight was observed during this phase and the fat produced comes directly from the reduction in glycogen. The discharge of sexual products is accompanied by a fall in glycogen and fat content and by an increase of nitrogen as shown in Table V. According to MATSUMOTO (*op. cit.*) this occurs in summer (Japan). Other authors found a similar relationship between glycogen and fat content and the reproductive cycle, emphasizing that the period of the year when such changes occur are influenced by local factors. OKAZAKI & KOBAYASHI, 1929 (*in*: WILBUR & YONGE, 1966) noticed a maximum glycogen content during spring in *O. circunspicta* and the level attained remained unaltered until July, reaching its minimum in September. BIERRY *et al.* 1937 (*in*: WILBUR & YONGE, 1966) confirmed these results in *O. edulis* and *C. angulata* where as VENKATARAMAN & CHARI, 1951 (*in*: WILBUR & YONGE, 1966) working on oysters from the Madras Coast

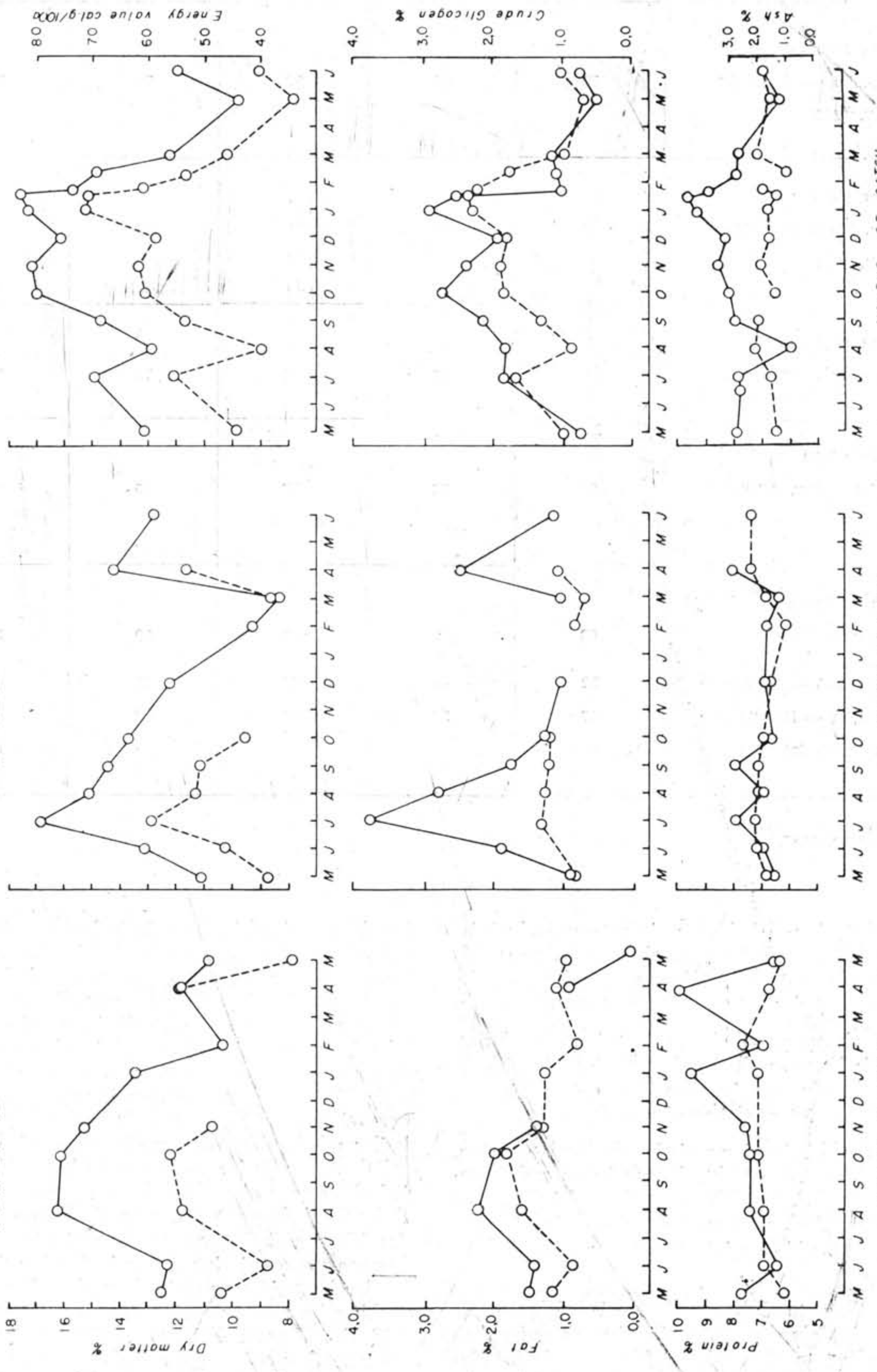

Fig. 1 — Chemical composition in fresh meat (1966-67).
o——o = Dry matter, crude glycogen and protein.
o-----o = Fat, ash and energy value.

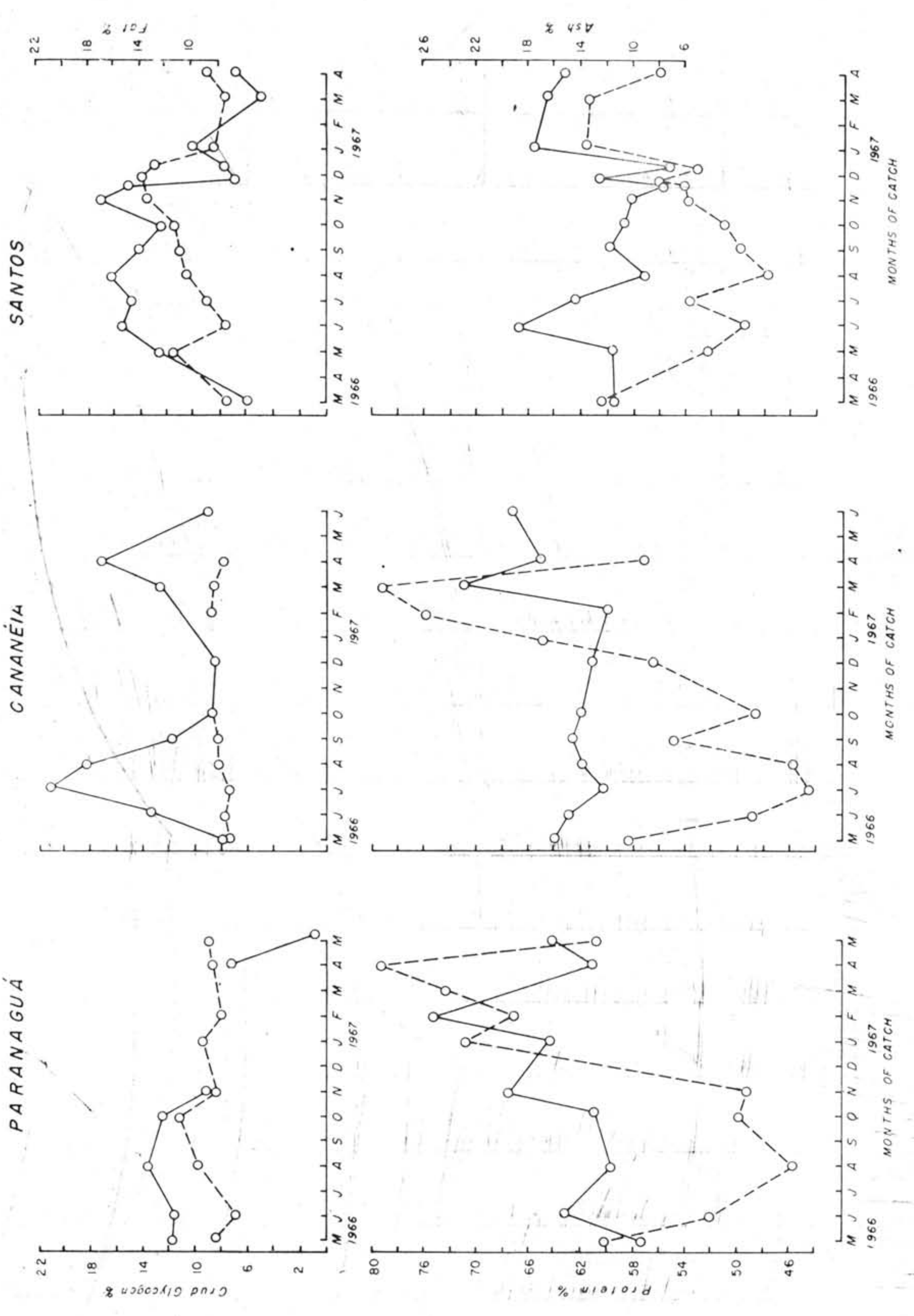

Fig. 2 — Chemical composition in dry meat.
o——o = Crude glycogen, ash.
o-----o = Protein, fat.

TABELA V

DATE OF ANALYSIS	PARANAGUÁ			CANANÉIA			SANTOS		
Mar/Apr-1966 3-4							↗	↗	↗
Apr/May 4-5							↗	↗	↗
May/Jun 5-6	↘	↘	↘	↗	↗	↗	↘	↘	↘
Jun/Jul 6-7	↗	↗	↗	↗	↗	↗	↗	↗	↗
Jul/Aug 7-8	↗	↗	↗	↘	↘	↘	↗	↗	↗
Aug/Set 8-9	↗↘		→	↘	↘	↘	↗↘		→
Set/Oct 9-10	↗↘		→	↘	→	↘	↘	↘	↘
Oct/Nov 10-11	↘	↘	↘	↘		↘	↗	↗	↗
Nov/Dec 11-12	→		↘	↘		↘	↗↘		↘
12/01/67	→		↘		↘		↗	↘	↘
Jan/Feb 1-2		↘	↘		↘		↘	↘	↘
Feb/Mar 2-3	↗		↗	↘		↘	↘	↘	↘
Mar/Apr 3-4	↗		↗	↗	↗	↗	↗	↗	↗
Apr/May 4-5	↘	↘	↘	↘		↘			
May/Jun 5-6				↘		↘			
Stable	→			Decrease ↘			Increase ↗		
Glycogen	——▷			Fat - - -▷			Dry matter - - -▶		

found a larger fat ratio from August to December with a minimum in October. These authors observed a coincidence during this time of the year with a greater availability of food in the period preceding sexual maturity. Recently ESTABLIER (1966), reached similar conclusion for *C. angulata* and found a correlation between glycogen, fat matter and spawning and hydrobiological conditions such as water temperature, and especially the presence of abundant phytoplankton.

The fluctuation of total fat and glycogen content observed here and reflecting the observations on oysters and phytoplankton in this area, a tentative conclusion was reached that here too the fluctuations are correlated to the reproductive cycle.

Figure 1 show that dry matter is correlated to glycogen and fat matter content. These observations confirm those by ENGLE, 1958 who reached similar conclusions after a 10-year period of analysis on oysters from Maryland (U.S.A.) and with those reported by ALVAREZ-SEOANE, 1960, who worked on another mollusc, *Tapes pulastra* in Spain. These observations also suggest that dry matter may be used as an indicator of a series of variations of glycogen and fat.

effect of salinity on both spawning and level survival. RANSON, 1940 (*in*: ESTABLIER, 1966) considers the salinity interval 18-23$^0/_{00}$ to be the favorable condition for the development of *Crassostrea* larvae while MARTEIN 1957-60 (*in*: ESTABLIER, 1966) who carried out similar investigations on *C. angulata* from Morbihan found them to spawn at 29-35$^0/_{00}$ salinity, while the larvae live between 28-35.7$^0/_{00}$ salinity; VILLELA (1954) found oysters to lay eggs in Tejo river estuary between 22, 23-32, 39$^0/_{00}$ salinity. AMEMYA 1926, (*in*: WILBUR & YONGE, 1966) found the lower and upper level that would permit development of *C. angulata* to be 21 and 43$^0/_{00}$.

For what concerns water temperature, MARTEIN, 1957-60 (*in*: *op. cit.*) observed that temperature of 18°C or higher induced sexual maturity and spawning; spawning was also induced by a sudden rise in temperature from 18° to 22°C. VILLELA, 1954 (*in*: ESTABLIER, 1966) observed similar temperature intervals and reported spawning to occur between 18°C and 23.8°C. Recently ESTABLIER, 1966 noticed spawning to be induced by temperature higher than 18°C and a parallel drop in glycogen and fat content.

Summarizing:

	Water temperature	Rain	Salinity	Variation of chemical components
April to	Above 18°C	Scarce	High	Early May, glycogen drop.
October,			(34-36$^0/_{00}$)	Early June, fat drop.
November				September, November.
				Minimum - glycogen, fat.
(in Establier, 1966)				

Protein content did not respond to any seasonal variation in relation to the wet weight of fresh material (Fig. 1), but it varied in relation to dry matter. Figure 2 shows a clear variation opposite to that of glycogen and fat, thus confirming observations by KRVARIC (1953) for *O. edulis* and LOPES BENITO (1955) for *Pecten jacobeus*. Opposite trends are well marked from May to October at Paranaguá and Cananéia, from March to October at Santos, and from April to May at Paranaguá and Santos.

Factors influencing the seasoning variation — After establishing the correlation between the reproductive cycle of oysters, the glycogen content and fat variation with dry matter, we must analyze the factors that may be involved in the system. The problem is complex due to the influence of temperature, salinity and food availability for the oysters.

Obviously, many authors working on different species from various places have noticed a different

The reproductive cycle is closely dependent on the temperature conditions and is paralleled by the glycogen and fat content values.

The behaviour of the oyster in relation to temperature in this area may be analyzed. It is impossible however to analyze the oysters reproductive cycle in relation to salinity, because we have no data for some of the points and yet given the estuary situation of the localities studied, salinity is known to be very variable. We have thus analyzed our data as a function of total precipitation in the area, and as a function of water temperature and the principal cause of water temperature variation, i.e. total incident radiation.

Analysis of the present data — According to Figure 1 and Table V connection with reproductive cycle periods as shown by MATSUMOTO, 1934 (*in*: WILBUR & YONGE, 1966) we have:

Place — Period of analysis — Analytical evidence.

Fattening — glycogen increase

Paranaguá	6/66 to 8/66	Glycogen, dry matter, fat
	2/67 to 4/67	Dry matter, fat
Cananéia	5/66 to 6/66	Glycogen, dry matter, fat
	3/67 to 4/67	Glycogen, dry matter, fat
Santos	3/66 to 5/66	Glycogen, dry matter, fat
	6/66 to 8/66	Glycogen, dry matter, fat
	10/66 to 11/66	Glycogen, dry matter, fat
	3/67 to 4/67	Glycogen, dry matter, fat

Gonadal ripening — drop in glycogen and increase in fat

Paranaguá	8/66 to 10/66
Santos	8/66 to 9/66
	11/66 to 12/66

Discharge of sexual products — drop in glycogen, fat, dry matter and energetic value

Paranaguá	5/66 to 6/66
	10/66 to 12/66
	1/67 to 2/67
	4/67 to 5/67
Cananéia	7/66 to 9/66
	9/66 to 12/66
	12/66 to 2/67
	2/67 to 3/67
	4/67 to 6/67
Santos	5/66 to 6/66
	9/66 to 10/66
	12/66 to 3/67

LIMA & VAZZOLER, 1963 studied samples from the Bertioga Channel and observed:

a) lack of fixation of spat during the time interval March/May 1961. In our work (1966-67) we observed a coincidence in the first months with the fattening period, and therefore with a glycogen and fat matter storage and not with spawning period.

b) no spawning during the rainy season that causes a salinity drop, thus inhibiting egg laying and spat fixation.

However our observations show three different periods for spawning thus distributed: May/June — dry season; September/October — moderate rainfall; December-66/March-67 — heavy rainfall (see rainfall in Fig. 3).

This observation disagrees with that of LIMA & VAZZOLER (*op. cit.*) that no spawning occurs during the rainy season that causes a salinity drop inhibiting egg laying and spat fixation.

GARCIA OCCHIPINTI (1963) studied the climatology of Cananéia and concluded that water temperature variations are mainly caused by solar radiation variation due to the following causes: water column; high absorption of incident radiation caused by dark mud on the banks, by the dark color of the water due to suspended organic matter and dissolved humidic acids; low exchange of temperature in the air-sea water surface.

We observed that absorbed radiation is the main factor influencing the seasonal variation of the chemical composition of oysters causing distinct phases of their reproductive cycle to undergo the influence of the water. The absorved radiation also influences their feeding behavior and the importance of this factor is stressed during the fattening period.

We must correlate: absorbed radiation (Q), average water temperature, rainfall and as it was impossible to obtain the water temperature from the three regions studied, the air temperature in connection with the glycogen, fat and dry matter variation must be considered as indicators of oysters reproductive cycle. To ascertain whether the chemical composition variations observed during the period 1966-67 could be considered as average for those regions, we compared the variation of the meteorological findings for each region. Thus we will be able to evaluate the possibility of the same conditions observed being reproduced.

We have for Cananéia region the longer and most complete series of meteorological observations (Universidade de São Paulo. Instituto Oceanográfico, 1965) and the following variables: air and water temperature; absorbed radiation (Q); rainfall. Data for Cananéia will be used for comparison with those obtained for the other two regions for which we have data covering only some variables.

Santos — air temperature, solar radiation and rainfall.

Paranaguá — air temperature and rainfall.

So as to be able to use these data and have them compared with those of Cananéia, studies by GARCIA OCCHIPINTI (1963) were considered which relate air/temperature (regression equation $\overline{T}_w = 1.15\ T_a - 0.55$, where $\overline{T}_w$ = mean monthly temperature of water in lagunar region (°C); $\overline{T}_a$ = mean monthly temperature of air in lagunar region (°C).

A correlation in the three regions has also been observed both in 1966-67 and as far as we know in previous periods.

The variations of air and water temperature are similar and this may possibly the cause of the similarities on the variations of glycogen content, fat and dry matter observed in the oyster from the regions referred to.

The water temperature in Cananéia ranged from 19.4 to 26.5°C from July 1966 to March 1967 and from April to May 1967 as an average and the daily variations were quite close to those observed by VILLELA, 1954; MARTEIN, 1957 and ESTABLIER, 1966 (*in*: ESTABLIER, 1966).

Figure 4 shows the inverse correlation existing between Q and t and the glycogen, fat and dry matter content. These three factors are here considered as indicators of the reproductive oyster cycle and the incident radiation (Q) and water temperature (t) thus appear to be the main determinants of the oyster's cycle locally.

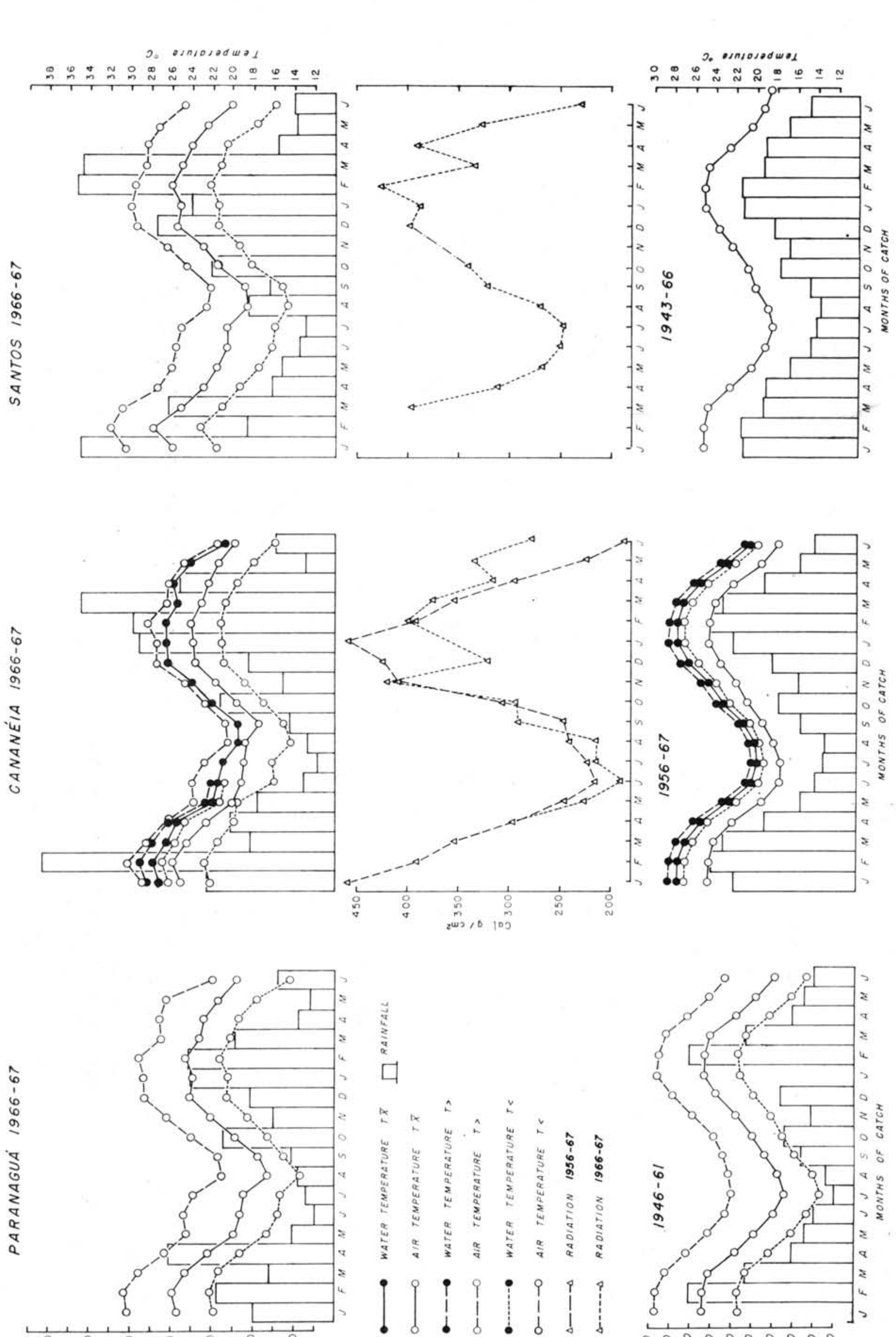

Fig. 3 — Air and water temperatures, rainfall and radiation at soil.

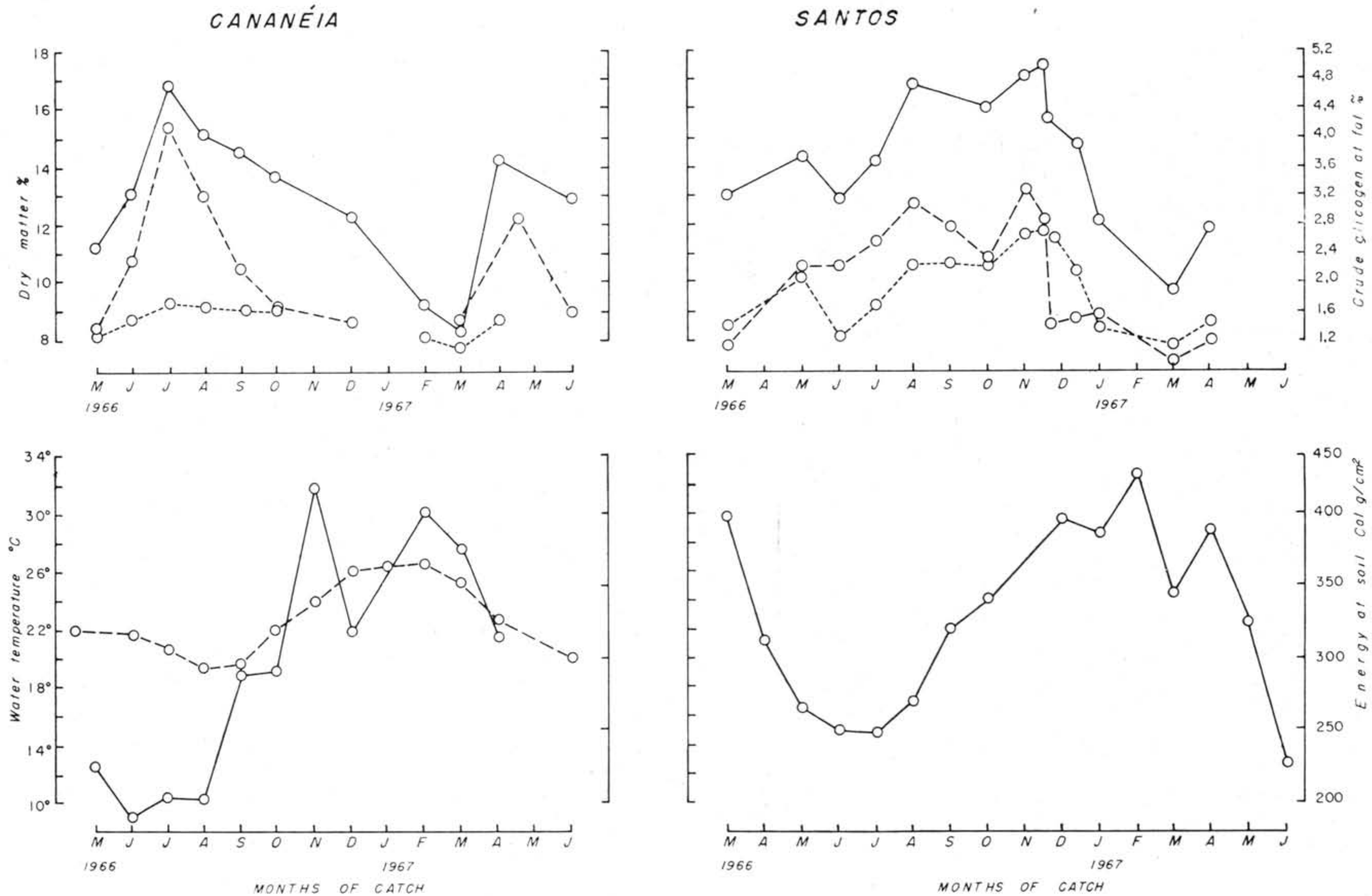

Fig. 4 — Relation between chemical composition of oysters, water temperature and incident radiation (Q).

o——o = Dry matter, energy at soil.

o-----o = Water temperature, crude glycogen.

TABLE VI — The fractionation of nannophytoplankton in two different size range net, Phytoplankton in percent (TEIXEIRA *et al*, 1967)

1965	Nannophytoplankton 5,0 — 65,00 μ		C-14 Fixation
	Surface	Depth	
February	70.69	56.51	
April	82.50	67.92	95,83% maximum relative fixation
June	62.30	54.48	
August	54.39	32.04	64,32% minimum relative fixation
October	89.21	55.00	
December	79.60	36.89	

Filtered in silk (pore size = 65 μ) and retained in SM filter (pore size of 5,00 μ)

Considering the results obtained by TEIXEIRA *et al.* (1967), for the region of Cananéia (Tables VI and VII) one verify correspondence between the increase of phytoplankton, C_{14} fixation and the acumulation of energy in oysters, however these data were taken independently of this work.

CONCLUSIONS

1 — The humidity content of the oysters analyzed here are more comparable to the observations of other authors for the genus *Crassostrea* than for *Ostrea*.

2 — The magnesium content was found to be higher than that of calcium, differring from the results obtained by most authors. It agrees with NELSON & COULSON, 1939 (*in*: VINOGRADOV, 1953) who also found a higher magnesium content in *C. gigas* from the Pacific coast of the United States.

3 — Protein and ash values are in general lower than those found by other investigators.

4 — Trimethylamine oxide (TMO) was present in 19 out of a total of 32 analyses, differring from the observations by NORRIS & BERNOIT, 1945 (*in*: DYER, 1952) who never found TMO in *O. japonica* (Pacific Ocean) and by DYER, 1952 in *O. virginica* (Atlantic Ocean).

5 — The energetic values were lower than those measured by RUSSELL, 1923 and TULLEY, 1935 (*in*: KRVARIC, 1953).

6 — A seasonal variation for the energetic values was observed in these oysters being higher in

TABLE VII — Phytoplankton in Cananéia, 1967 (cel/1)

BAÍA DE TREPANDÉ

Month	Light penetration %	Ebb tide	High tide
March	100	604.000	1522.400
	60	716.400	1691.600
	10	1635.300	12570.000
	1,5	1798.400	1232.800
	0,0	2549.000	1556.400
April	100	334.800	514.800
	60	403.200	2128.800
	10	170.800	832.400
	1,5	170.800	536.000
	0,0	590.000	—
May	100	676.800	887.200
	60	1306.000	968.400
	10	408.400	828.000
	1,5	560.800	966.000
	0,0	1458.000	930.600
June	100	196.600	876.400
	60	354.000	1288.400
	10	400.400	589.000
	1,5	176.000	959.000
	0,0	396.000	820.800

ILHA DA CASCA, SALVATERRA AND BAÍA PEREQUE

Station	Month	Depth (m)	Phytoplankton (cel/l)
Ilha da Casca	August	0,0	438.400
		2,40	844.800
		3,75	868.400
		8,50	706.000
Salvaterra	August	0,0	287.200
		1,35	526.000
		3,90	416.000
		6,00	487.600
Baia Pereque	August	0,0	505.800
		1,20	284.000
		2,30	443.200
		6,00	243.200
Ilha da Casca	July	0,0	260.800
		1,90	345.800
		4,95	310.000
Salvaterra	July	0,0	345.000
		1,80	725.200
		4,80	733.000

Personal comunication — C. TEIXEIRA *et col.* (1967), Instituto Oceanográfico da Universidade de São Paulo.

winter and spring and lower in summer and autumn in agreement with RUSSELL, 1923 and TULLEY, 1935 (*in*: KRVARIC, 1953) and KRVARIC, 1953.

7 — Glycogen, fat content and dry matter vary in a similar manner in relation to weight and dry weight.

8 — Protein showed seasonal variation in relation to dry matter and the variation is opposite to the glycogen and fat variation.

9 — Glycogen, total fat and dry matter are related to the reproductive cycle of the oysters. The following periods as proposed by MATSUMOTO *et al*, 1934 (*in*: WILBUR & YONGE, 1966) may be reported to our conditions.

a) *Fattening*

Paranaguá — July to August 1966 — February to April 1967.

Cananéia — May to July 1966, October to November 1967 and March to April 1967.

Santos — March to May 1966, July to August 1966 and March to April 1967.

b) *Gonadal ripening*

Paranaguá — August to October 1966.

Santos — August to September 1966 — November to December 1966.

c) *Discharge of sexual products*

Paranaguá — May to July 1966 — October to December 1966 — January-February 1967, April to May 1967.

Cananéia — July to March 1967 — April to July 1967.

Santos — May to June 1966 — September to October 1966 — December to March 1967.

10 — The variations in the reproductive cycle of the glycogen, total fat and dry matter content are related to water temperature and this in turn is related to solar radiation (*Q*).

11 — We noticed an inverse correlation between solar radiation (*Q*) on one side and glycogen, fat and dry matter content of the oysters analyzed.

12 — The similarity observed between the variations of chemical composition of oysters coming from Paranaguá, Cananéia and Santos may be a consequence of similar meteorological factors such as water and air temperature, rainfall and solar radiation.

13 — Most probably the chemical composition variation and the reproductive cycle observed in 1966-67 were influenced by the meteorological conditions prevailing in that period, is representative of the average for each region since the climatologiacl data were representative of the average known for each.

14 — Oysters have a better food value as energetic value and palability during winter and spring.

15 — Dry matter value may be used under our conditions as indicative of glycogen and fat content variation and consequently of the reproductive cycle as well.

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Sincere thanks are due to "Pescados Oceania do Brasil Ltda." for yielding us some samples; to Prof. Carlos Ometto, from Escola Superior de Agricultura "Luiz de Queiroz" for data of his papers on insolation time, radiation received by the soil; to Mr. Luiz Sanchez and Miss Dulcinda Rodrigues da Silva for technical help regarding the analysis; to the Meteorological Sector of the Brazilian Air Force (Santos and São Paulo); to the Meteorology Division of the Department of Agriculture of the State of Paraná; to the oceanographers, Mrs. Clovis Teixeira and José G. Tundisi from the Oceanographic Institute, University of São Paulo for the original data of their papers; to Dr. Hugo de Souza Lopes, Museu Nacional do Rio de Janeiro; to the oceanographers Mr. Gelso Vazzoler and Mrs. Anna Emília A. de Moraes Vazzoler for suggestions and revision of the manuscript; to Dr. Marta Vannucci for the facilities and stimulation for the fulfilment of this paper.

RESUMO

Durante 1966-1967, foi efetuado um estudo comparativo da variação da composição química da ostra (proteína, matéria graxa, água, cinza, óxido de trimetilamina, glicogênio cru, cálcio, magnésio, ferro (Fe^{+++}), fósforo total e inorgânico), proveniente de regiões lagunares do Estado de São Paulo: Cananéia e Canal da Bertioga (Santos), e do Estado do Paraná: Paranaguá.

A análise dos resultados foi efetuada, levando-se em consideração o ciclo reprodutivo da ostra e as condições meteorológicas das três regiões em estudo.

Com base no observado pode-se considerar o seguinte:

1 — Os teores de umidade das ostras analisadas estão mais próximos dos obtidos por outros autôres no gênero *Crassostrea* do que no gênero *Ostrea*;

2 — Os teores de magnésio mais elevados que os de cálcio, divergem da maioria dos dados de outros autôres, concordando sòmente com os de NELSON & COULSON (1939), para *Crassostrea gigas* da costa do Pacífico, Estados Unidos.

3 — Os teores de proteína e cinzas, são em geral mais baixos que os constatados por outros autôres;

4 — Foi constatada em 19 análises, dentre 32, a presença de óxido de trimetilamina (TMO), divergindo das observações de ausência total de TMO feita por NORRIS & BERNOIT (1945), para *O. japonica*, no Pacífico, e DYER (1952), para *O. virginica*, no Atlântico, únicos que citam trabalhos de TMO em ostra;

5 — Os valôres energéticos observados se revelaram mais baixos que os constatados por RUSSEL (1923), TULLEY (1935) e KRVARIC (1953);

6 — Foi observada uma variação sazonal nos teores energéticos das ostras: inverno e primavera, elevados; verão e outono, baixos, concordando com RUSSEL, TULLEY e KRVARIC (*op. cit.*);

7 — Foi constatada variação sazonal correspondente entre si para os teores de glicogênio, matéria graxa e matéria sêca, para a expressão em função da matéria fresca e sêca;

8 — A proteína sòmente apresentou variação sazonal quando expressa em função da matéria sêca, sendo oposta à de glicogênio e matéria graxa;

9 — As variações de glicogênio, matéria graxa e matéria sêca, estão relacionadas com o ciclo reprodutivo das ostras, sugerindo os seguintes períodos propostos por MATSUMOTO *et al.* (1934) e analisados para as nossas condições:

a) "Fattening": Paranaguá — julho à agôsto/66; fevereiro à abril/67; Cananéia — maio à julho/66; março à abril/67; Santos — março à maio/66; julho à agôsto/66; março à abril/67.

b) "Gonadal ripening": Paranaguá — agôsto à outubro/66; Santos — agôsto à setembro/66; novembro à dezembro/66.

c) "Discharge of sexual products": Paranaguá — maio à julho/66; outubro a dezembro/66; janeiro à fevereiro/67; Cananéia — julho/66 à março/67; abril à julho/67; Santos — maio à junho/66; setembro à outubro/66; dezembro/66 à março/67.

10 — As variações do ciclo reprodutivo são evidenciadas pela variações dos teores de glicogênio, matéria graxa e matéria sêca, estando possìvelmente relacionadas com a temperatura da água e esta com a radiação solar recebida (Q);

11 — Observou-se uma relação inversa da energia solar recebida (Q) e os teores de glicogênio e de matéria sêca das ostras analisadas;

12 — As semelhanças observadas entre a composição química das ostras procedentes de Paranaguá, Cananéia e Canal da Bertioga (Santos), poderão ser consequentes da semelhança dos fatôres meteorológicos atuantes, temperatura da água e do ar, precipitação e radiação solar;

13 — É possível que as variações da composição química e portanto o ciclo reprodutivo, observados para 1966/67, influenciados pelas condições meteorológicas dêsse período, sejam representativos para cada região em virtude da concordância dêste período com o representativo da região;

14 — As ostras apresentam melhores características para o consumo, sob o ponto de vista energético e aceitabilidade durante o inverno e primavera;

15 — A determinação da matéria sêca poderá ser usada, nas nossas condições, como indicadores das variações dos teores de glicogênio e matéria graxa e, conseqüentemente, do ciclo de reprodução.

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