

# Seasonal changes in the biochemical composition and calorific content of the black scallop *Chlamys varia* (L.) from Lanveoc, Bay of Brest

Scallop  
*Chlamys varia*  
Allometric relationships  
Biochemical composition  
Calorific values  
  
Pectinidé  
*Chlamys varia*  
Allométrie  
Composition biochimique  
Valeurs calorifiques

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## ABSTRACT

Allometric relationships involving height and weight measurements were computed for the black scallop, *Chlamys varia* (L.) from Lanveoc, Bay of Brest. No significant differences were found, either between males and females or between mature or immature scallops, with respect to height-tissue weight relationships, but regular significant differences were noticed in respect to seasons.

Seasonal changes in the biochemical composition of the somatic tissue and gonads were analysed during the years 1976-1978 to study the relationships between the reproductive cycle in adult *C. varia* and the storage or utilization of food reserves. The increase in dry weight of somatic tissue in spring was due to the accumulation of protein and lipid reserves, while carbohydrate was used for the energy requirements of the developing gonad. For the second spawning in autumn, all reserves including glycogen showed a reciprocal decline following the loss of weight of the somatic tissue. During the winter, all reserves fell to minimal values both in gonad and somatic tissue. It is postulated that in *C. varia* like in mussels, the loss of glycogen in the somatic tissues during reproductive periods, is in synchronous with gonad development.

Direct estimates of calorific values (kcal/g) for the somatic tissue showed little seasonal variation. The total calorific content of somatic tissues followed the dry weight of the somatic tissue. The calorific values of the gonadal tissue varied between 4.1 to 5.6 kcal/g, with minimal values in October to March when the gonads were empty. During spawning periods the female gonads showed higher calorific content than males due to their higher lipid content.

Unlike mature animals which accumulate reserves in spring, the spat built up energy reserves in summer for utilization in winter.

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## RÉSUMÉ

Variations saisonnières de la composition biochimique  
et des réserves énergétiques du pétoncle noir,  
*Chlamys varia* (L.) de Lanvéoc (rade de Brest).

Les relations allométriques entre la hauteur de la coquille et le poids sec de différents organes du pétoncle noir *Chlamys varia* (L.) de Lanvéoc (rade de Brest) ont été calculées. Aucune différence significative n'a été mise en évidence, que ce soit entre mâles et femelles ou entre adultes et juvéniles. En revanche des différences saisonnières significatives ont été notées.

Les variations saisonnières de la composition biochimique du tissu somatique et des gonades ont été suivies durant les années 1976-1978, afin d'étudier la relation entre le cycle de reproduction et l'utilisation des réserves alimentaires. Au printemps, une augmentation en poids sec du tissu somatique est possible grâce à une accumulation de réserves protéiques et lipidiques, alors même qu'il y a utilisation des réserves glucidiques

pour couvrir les besoins énergétiques de la gonade en développement. Durant la seconde ponte de l'automne, toutes les réserves, y compris celles de glycogène, manifestent une baisse pondérale parallèle à celle du poids du tissu somatique. Durant l'hiver, les teneurs atteignent des valeurs minimales dans la gonade et le tissu somatique. Il semble raisonnable de postuler que chez *C. varia* la baisse en glycogène somatique pendant la reproduction est liée à l'activité de la gonade.

Une estimation directe de l'énergie par gramme de tissu somatique a montré peu de variations saisonnières. La teneur en calories des gonades a varié entre 4,1 et 5,6 kcal/g avec des valeurs minimales d'octobre à mars quand les gonades étaient vides. En période de ponte, les gonades des femelles ont une teneur en calorie plus élevée que celles des mâles, en raison de leur teneur en lipides plus importante.

Contrairement aux animaux adultes, qui accumulent leurs réserves au printemps, les juvéniles augmentent leurs réserves énergétiques en été pour les utiliser en hiver.

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## INTRODUCTION

The seasonal cycle of storage and utilization of food reserves in adult temperate bivalves is related to the available food supply and the annual reproductive cycle (Gabbott, 1975). The accumulation of reserves in the gonad may take place at the expense of stored reserves in the body tissues or may be drawn directly from ingested food or from both (Bayne, Thompson, 1970; Gabbott, Bayne, 1973; Gabbott, 1975; 1976). The extent to which the pectinids resemble other temperate bivalves, in building up reserves during periods of greater food availability (spring, summer and autumn) for subsequent utilisation in winter months when the food availability is too low to meet the metabolic demands, has induced some workers to pay considerable attention to the variations in their biochemical composition over a seasonal cycle (Comely, 1974; Ansell, 1974 a; 1978; Thompson, 1977 and Taylor, Venn, 1979). Though pectinids utilise part of their stored reserves for gonad development and gametogenesis (Ansell, 1978), the relationship between storage or utilisation of reserves and the changes associated with gonad proliferation and gametogenesis may differ among species according to the timing of their reproductive cycle. In *Pecten maximus* (L.) as reported by Comely (1974) and in *Chlamys opercularis* (L.) as reported by Taylor and Venn (1979), the gonadal proliferation and gametogenesis take place in winter at the expense of the stored reserves in the body tissues; however, the findings of Ansell (1974 a) in *Chlamys septemradiata* (Müller) and of Thompson (1977) in *Placopecten magellanicus* (Gmelin) indicate that the proliferation of gonads occurs mainly in the spring supported by feeding activities of the scallop and is independent of stored reserves.

The present study on the seasonal changes in the biochemical composition and allometric relationships of various body parts, describes the relationships between the reproductive cycle in adult *Chlamys varia* (L.) and the storage or utilization of food reserves. The biochemical changes result in seasonal variation in the calorific content of individual animals, and consequently influence production and standing crop estimates for energy flow studies. Therefore, the paper also includes direct estimate of calorific values of mature and immature scallops during the period of study (1976-1978).

## MATERIAL AND METHODS

### Measurements of body parts and preparation of materials

*Chlamys varia* were collected from the Lanveoc area (Fig. 1), by dredging at monthly intervals during the period 1976-1978. Fifty to one hundred animals of various sizes were scrubbed clean to remove fouling

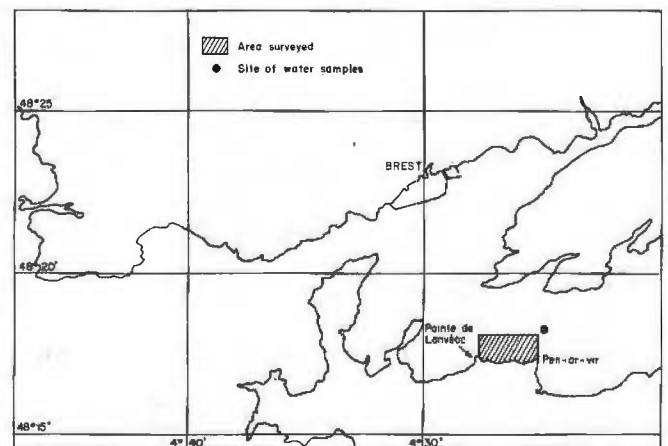
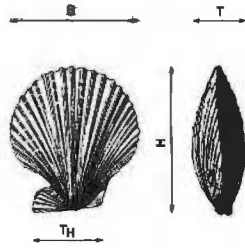


Figure 1  
Geographic location of area surveyed.

organisms and washed well with sea water. These animals were kept in running sea water to defaecate for 24 to 48 hours. The weight of the whole individual scallop was determined to the nearest mg. Height (H), breadth (B), thickness of the animal (T) and length of the hinges ( $T_H$ ) were measured as shown in Figure 2 to the nearest 0.1 mm. The volume (V) of the shell was determined directly by filling the valves with water and measuring the volume of water in each valve. The wet weight and dry weight (after drying at 60°C for 48 hours) of the gonad, somatic tissue and shell of each mature animal was recorded to the nearest 0.1 mg, and the sex noted. In immature animals (<18 mm in height) the gonad and the somatic tissue were not separated before weighing. The dried gonad and body tissues were homogenised separately. The tissues from 10 to 25 scallops (measuring 40 to 55 mm in shell height) were mixed together for biochemical analyses and determination of calorific value. During periods when the sex could

Figure 2

Linear measurements used for allometric studies in *Chlamys varia*: B: breadth; H: height;  $T_H$ : length of hinges; T: thickness.



be distinguished, the tissues of males and females were treated separately. Similarly, dried body tissues of immature scallops were mixed together and homogenised during every sampling period for estimation of calorific values. The dried materials were stored in a vacuum desiccator until biochemical analyses.

### Biochemical analyses

Total protein was estimated by the method of Lowry *et al.* (1951), with minor modifications as suggested by Samain *et al.* (1977). Total glycogen was determined by the enzymatic method described by Murat and Serfaty (1974). Total lipid was determined by a gravimetric method (Folch *et al.*, 1957). Ash determinations were carried out by burying the tissues in a muffle furnace at 550°C for 12 hours. All determinations were made in triplicate and the mean value was expressed for each sample. When marked discrepancies occurred between replicate determinations (variation of more than 5% from the mean), another triplicate analysis was carried out. The results are expressed both as the percentage of the dry tissue weight and as the absolute content of a standard animal (50 mm height).

### Determination of calorific values

The calorific values of the dried tissues of mature animals was determined by using an adiabatic Bomb Calorimeter-CB 100, and that of immature scallops by using Phillipson Microbomb Calorimeter. The determinations were made in triplicate and the mean values were expressed as kcal/g ash free dry weight. The total calorific content (per animal without shell) was calculated from the dry weight of a standard animal during the sample period.

## RESULTS

### Allometric relationships

Quantitative estimates of various biomass parameters from linear measurements would facilitate secondary productivity studies. Allometric study would also provide means for comparing seasonal differences in growth rates of different parts. For scallops, height is the most important parameter for studying changes in natural populations. The regressions of dry body weight on height for mature and immature scallops were compared, by using the graphical analysis described by Draper and Smith (1966) and Conan (1978), to test

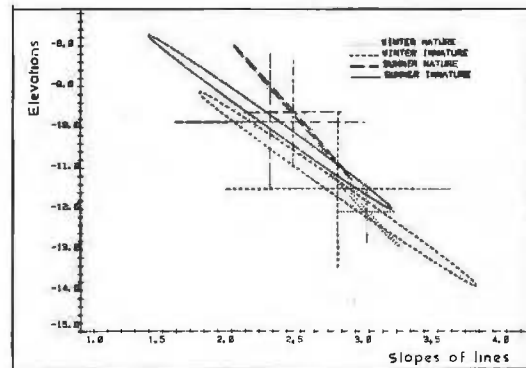


Figure 3

Comparisons of regressions relating body weight on height for mature (>18 mm) and immature (<18 mm) *Chlamys varia* (L.). Elevations and slopes for each regression are plotted on a common graph. Around each point of elevations and slopes of respective regressions, are drawn joint 95% confidence limits (Draper, Smith, 1966; Conan, 1978).

whether there were any seasonal difference in growth patterns between groups. Figure 3 shows that the regressions for mature animals were not significantly different from those of immature ones. Therefore, both mature and immature animals could be grouped together for each sampling period. Similarly, the differences between height-weight regressions of male and female scallops were tested by comparing samples collected during the spawning periods (June and July 1977). No significant differences were found between the sex in this analysis (Fig. 4). Hence, males and females could also be grouped together; during such regression analyses, since both X (height) and Y (dry tissue weight) variates were subjected to error measurements, the geometrical mean estimates of functional regressions, advocated by Ricker (1973), would give more precise estimates when transforming one parameter into another. Therefore, functional regressions were calculated for pairs of parameters whose ordinary predictive regressions did not show any regular seasonal differences as tested by the graphical analysis (Table 1). The relationships between the linear measurements and tissue weights showed regular seasonal differences. The regressions of gonadal weights on heights did not give as good a fit as those of gonadal weights on dry body weights and hence for the gonad, regressions involving height were not considered further in the present study. The functional regressions of

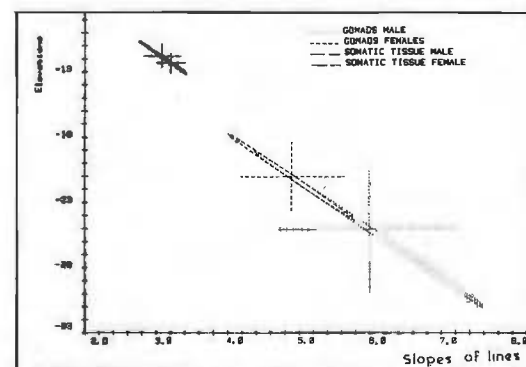


Figure 4

Comparisons of the regressions relating dry tissue weight on height between male and female *Chlamys varia* (L.).

Table 1

Allometric relationships between various parameters of *Chlamys varia* (L.), which do not show any significant seasonal differences.

Relationship	Regression	Equation	95% CI		$r^2$	N
			$u$	$v$		
Height (H) and Whole live weight (W)	W on H	$\ln W = -8.3725 + 2.8844 \ln H$	0.0622	0.0172	0.99	1324
	Functional	$\ln W = -8.4336 + 2.9015 \ln H$				
Height (H) and Breadth (B)	B on H	$\ln B = -0.3329 + 1.0563 \ln H$	0.0216	0.0060	0.99	1272
	Functional	$\ln B = -0.3523 + 1.0617 \ln H$				
Height (H) and Thickness (T)	H on T	$\ln T = -1.2212 + 1.0626 \ln H$	0.0704	0.0198	0.93	910
	Functional	$\ln T = -1.3666 + 1.1036 \ln H$				
Height (H) and Hinges ( $T_H$ )	$T_H$ on H	$\ln T_H = -0.4726 + 0.9501 \ln H$	0.0702	0.0200	0.90	1041
	Functional	$\ln T_H = -0.6607 + 1.0039 \ln H$				
Whole live weight (W) and Shell weight ( $W_s$ )	$W_s$ on W	$\ln W_s = -0.5586 + 0.9218 \ln W$	0.0144	0.0068	0.98	1322
	Functional	$\ln W_s = -0.5748 + 0.9302 \ln W$				
Height (H) and Shell weight ( $W_s$ )	$W_s$ on H	$\ln W_s = -8.6934 + 2.7744 \ln H$	0.1106	0.0308	0.96	1330
	Functional	$\ln W_s = -8.8944 + 2.8304 \ln H$				
Height (H) and Volume (V)	V on H	$\ln V = -8.8457 + 2.9556 \ln H$	0.1286	0.0366	0.96	1100
	Functional	$\ln V = -9.0614 + 3.0172 \ln H$				

height and dry weight of whole body, height and weight of dry somatic tissue and dry body weight and dry gonad weight are listed in Tables 2, 3 and 4. These tables (1 to 4) also show 95% C.I. of "u" (elevations) and "v" (slopes), number of observations (n) and the coefficients of determination ( $r^2$ ) of their respective predictive regressions, where  $r^2 \times 100$  is the percent variability of the data explained by the model.

In many of the predictive regressions involving height and dry weight of the tissues, the slopes when tested by *t*-tests, were found not to be significantly different from 3 (refer Tables 2 and 3) showing isometric relationships. Similarly, the slopes of the regressions of dry gonad weights over dry body weights, in most cases, were isometric (not significantly different from 1) as shown in Table 4.

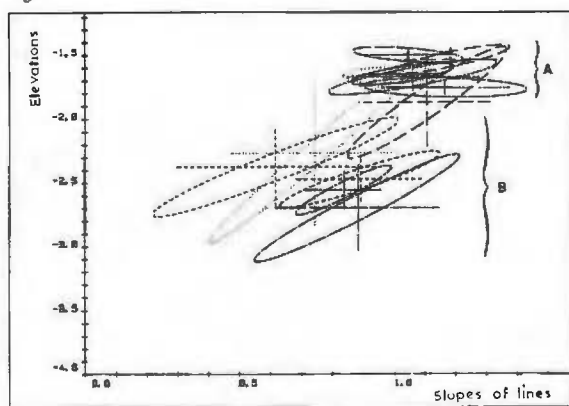


Figure 5  
95% confidence intervals of the slopes and elevations of the regressions relating dry gonad weight on wet gonad weight, during the year 1976 (refer text for explanation of symbols).

Figure 5 shows the slopes and elevations of dry gonad weights/wet gonad weight relationships for the year 1976-1977. The water content of gonads showed lower values during the spawning period "A" (April to September) and higher values during the resting period "B" (October to March). The relationships between wet body weight and dry body weight, wet somatic weight and dry somatic weight and between wet gonad weight and dry gonad weight were isometric (the

slopes when tested by *t*-tests did not differ significantly from 1). The slopes were adjusted to one and the elevations of the respective regressions were calculated. The percentage water content (M) was calculated as follows:

$$M = (1 - A) \cdot 100. \quad (2)$$

Where "A" is the elevation of the respective regressions. The seasonal variations in the percentage water content of the various body components are in Tables 5 and 6. Neither somatic nor the whole body tissue showed any regular seasonal variation in the water content.

### Biochemical composition of mature scallops

#### Seasonal changes in the gonad

The seasonal changes in tissues weight of the gonad for a standard animal of 50 mm, have been calculated using the regressions of dry body weight on height and of dry gonad weight on dry body weight (Tables 2 and 4) and are shown in Figure 6. The absolute weights of the gonad are multiplied by 10 to facilitate visual comparison with the other weights of the body components.

The dry weight of the gonad showed minimal values during October-March (0.03 to 0.06 g) and maximal values during May-September (0.25 g in 1976 and 0.32 g in 1977). The gonads began to develop in April and the major fall in gonad dry weight occurred in September-October, although there was a slight decrease in June-August indicating a first spawning in the spring (see Shafee, Lucas, 1980). The decrease in gonad weight due

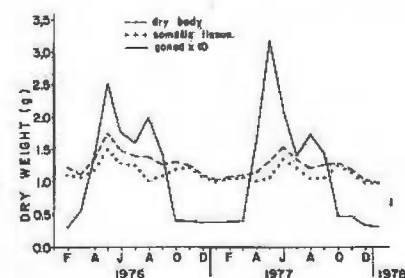


Figure 6  
Seasonal changes in dry tissue weights of standard animal (50 mm).

Table 2

Allometric relationships between dry body weight and height in *Chlamys varia* (L.).

Months	1976				1977				1978			
	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$
January					$-9.0468 \pm 1.8803$	$2.3188 \pm 0.4859$ (*)	0.50	47	$-13.5054 \pm 1.4092$	$3.4596 \pm 0.4069$	0.96	15
February	$-12.9706 \pm 0.9623$	$3.3659 \pm 0.2705$ (*)	0.82	111	$-12.5836 \pm 0.3724$	$3.2358 \pm 0.1009$ (*)	0.96	144	$-12.4126 \pm 0.3136$	$3.1977 \pm 0.0862$	0.96	155
March	$-11.7875 \pm 0.6519$	$3.0398 \pm 0.1761$	0.93	91	$-12.7483 \pm 0.4201$	$3.2831 \pm 0.1166$	0.98	97	$-12.4664 \pm 0.3802$	$3.2134 \pm 0.1041$ (*)	0.96	188
April	$-11.1792 \pm 0.7423$	$2.9348 \pm 0.2034$	0.87	108	$-13.9508 \pm 0.8623$	$3.6007 \pm 0.2338$ (*)	0.90	97				
May	$-11.4180 \pm 1.0634$	$3.0602 \pm 0.2874$	0.82	91	$-10.1218 \pm 1.7852$	$2.6587 \pm 0.4647$	0.67	45				
June	$-12.1099 \pm 2.0525$	$3.1939 \pm 0.5213$	0.79	39	$-12.7006 \pm 0.8105$	$3.3560 \pm 0.2190$	0.90	97				
July	$-10.5929 \pm 1.3113$	$2.7926 \pm 0.3421$	0.83	48	$-9.5398 \pm 1.4499$	$2.5142 \pm 0.3790$ (*)	0.88	24				
August	$-12.3587 \pm 1.0111$	$3.2407 \pm 0.2851$	0.83	96	$-8.6946 \pm 3.2393$	$2.2717 \pm 0.8360$	0.43	17				
September	$-11.2294 \pm 1.9638$	$2.9311 \pm 0.4974$	0.66	50	$-10.0631 \pm 3.2909$	$2.6319 \pm 0.3080$	0.67	15				
October	$-11.8839 \pm 1.3154$	$3.1059 \pm 0.3654$	0.64	106	$-11.1775 \pm 1.1497$	$2.9239 \pm 0.3080$	0.74	98				
November	$-13.9203 \pm 1.8475$	$3.6170 \pm 0.4797$ (*)	0.81	44	$-12.5279 \pm 2.5654$	$3.2468 \pm 0.6783$	0.85	16				
December	$-12.9537 \pm 2.2586$	$3.3369 \pm 0.5879$	0.66	46	$-11.6664 \pm 1.4527$	$2.9904 \pm 0.3885$	0.98	16				

(\*) The slopes of the predictive regressions were significantly different from 3.

Table 3

Allometric relationships between dry somatic weight and height in *Chlamys varia* (L.).

Months	1976				1977				1978			
	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$
January					$-9.6428 \pm 2.0524$	$2.4642 \pm 0.5302$	0.50	49	$-13.4918 \pm 1.4029$	$3.4426 \pm 0.4051$	0.96	15
February	$-13.9651 \pm 2.3412$	$3.5947 \pm 0.6095$	0.74	38	$-12.6640 \pm 0.3772$	$3.2480 \pm 0.1021$ (*)	0.96	144	$-12.7395 \pm 0.3595$	$3.2700 \pm 0.0964$ (*)	0.96	184
March	$-14.7794 \pm 2.6106$	$3.7948 \pm 0.6690$	0.69	43	$-12.8313 \pm 0.4201$	$3.2963 \pm 0.1166$	0.98	97	$-12.8469 \pm 0.3365$	$3.3003 \pm 0.0910$ (*)	0.98	140
April	$-9.7475 \pm 2.3519$	$2.5339 \pm 0.6033$	0.50	42	$-13.8418 \pm 0.8155$	$3.5406 \pm 0.2211$ (*)	0.90	97				
May	$-11.9758 \pm 2.6202$	$3.1639 \pm 0.6684$	0.51	46	$-10.7196 \pm 1.9100$	$2.7567 \pm 0.4972$	0.66	45				
June	$-11.9458 \pm 1.7016$	$3.1158 \pm 0.4371$	0.83	37	$-12.1457 \pm 0.7853$	$3.1805 \pm 0.2122$	0.90	97				
July	$-11.1040 \pm 1.2989$	$2.8945 \pm 0.3388$	0.85	48	$-9.9254 \pm 1.3664$	$2.5858 \pm 0.3571$ (*)	0.90	24				
August	$-9.6668 \pm 2.1016$	$2.4757 \pm 0.5372$	0.50	47	$-9.0374 \pm 3.4324$	$2.3234 \pm 0.8856$	0.50	20				
September	$-11.4717 \pm 1.9613$	$2.9540 \pm 0.4968$	0.66	50	$-11.4249 \pm 3.5236$	$2.9357 \pm 0.8934$	0.71	15				
October	$-9.1311 \pm 1.7622$	$2.3791 \pm 0.4510$ (*)	0.58	50	$-11.3027 \pm 1.1713$	$2.9479 \pm 0.3138$	0.72	98				
November	$-14.0263 \pm 1.9754$	$3.6361 \pm 0.5130$	0.79	44	$-12.5066 \pm 2.6937$	$3.2314 \pm 0.7122$	0.83	16				
December	$-13.1492 \pm 2.2802$	$3.3805 \pm 0.5935$	0.66	46	$-11.4495 \pm 1.5079$	$2.9248 \pm 0.4033$	0.98	16				

(\*) The slopes of the predictive regressions were significantly different from 3.

Table 4  
Allometric relationships between dry gonad weight and dry body weight in *Chlamys varia* (L.).

Months	1976					1977						
	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$	$\mu \pm 95\% \text{ CI}$	$v \pm 95\% \text{ CI}$	$r^2$	$n$
January	-3.7949 ± 0.1012	1.4636 ± 0.3127	0.69	38	-3.2864 ± 0.1068	2.1679 ± 0.5744	0.41	49	-3.4195 ± 0.6928	1.103 ± 0.4751	0.40	15
February	-2.9830 ± 0.0847	1.0115 ± 0.2668	0.45	48	-3.3102 ± 0.1331	1.2864 ± 0.1360	0.59	146	-3.4427 ± 0.1058	1.2368 ± 0.1198	0.58	184
March	-2.6002 ± 0.1746	2.1022 ± 0.5946	0.38	45	-3.3145 ± 0.2070	1.2632 ± 0.1593	0.62	97	-3.1495 ± 0.1320	1.3542 ± 0.1224 (*)	0.71	145
April	-2.4710 ± 0.2898	1.9664 ± 0.4695	0.42	46	-2.0104 ± 0.1699	1.5372 ± 0.1854 (*)	0.66	97				
May	-2.3549 ± 0.1923	1.6108 ± 0.4056	0.58	44	-1.7427 ± 0.1171	2.1352 ± 0.5026	0.40	48				
June	-2.2535 ± 0.0875	1.2717 ± 0.3002	0.60	48	-2.3583 ± 0.1214	1.8789 ± 0.1772 (*)	0.79	97				
July	-2.4020 ± 0.1388	2.4659 ± 0.6127 (*)	0.55	47	-2.2778 ± 0.0918	1.0614 ± 0.3159	0.51	24				
August	-2.4896 ± 0.2163	2.2768 ± 0.5498 (*)	0.55	50	-2.2822 ± 0.1588	2.7303 ± 1.0749	0.55	20				
September	-3.8990 ± 0.1761	2.6773 ± 0.7100	0.40	50	-2.4685 ± 0.3931	2.2602 ± 1.0797	0.51	15				
October	-3.6336 ± 0.1816	1.9516 ± 0.5277	0.48	44	-3.3793 ± 0.1216	1.3773 ± 0.1940	0.52	98				
November	-3.4567 ± 0.1003	2.0012 ± 0.3711 (*)	0.47	93	-3.3511 ± 0.3897	1.8616 ± 0.5648	0.67	16				
December					-3.4189 ± 0.5414	2.0324 ± 0.5666 (*)	0.92	16				

(\*) The slopes of the predictive regressions were significantly different from 1.

to the first spawning was 0.90 g in 1976 and 0.18 g in 1977. The minimal gonad weights during the post spawning periods (October-March) were similar in the two years studied, but the maximum weights (May and September) differed considerably between the two years.

The percentage composition of the biochemical constituents in the gonads is shown in the Table 5. The gonad contained relatively little glycogen throughout the period of study and there was no difference in the quantity of glycogen present with respect to sex. The highest value for the testis was 2.5% and for the ovaries 3.0% when the gonads were full. For spent scallops in October to March, the values were very low (0.65 to 0.87%). In males the protein content increased more rapidly and usually contained greater amounts of protein than females indicating the importance of nucleoproteins for male gametes. In the females, there was a greater increase in lipid content with the result that the ripe female gonad contained approximately three times as much lipid as the male, indicating the importance of lipid as an energy source for the planktonic eggs and larvae of marine bivalves (see review by Holland, 1978). The percentage of protein in female gonads and of lipid in male gonads showed little seasonal fluctuation. The proximate composition of the gonadal tissues of a standard animal (Fig. 7) followed the changes in dry tissue weight (Fig. 6) fairly closely. The percentage ash content was maximal in spent gonads (31%), and showed lowest values in ripe gonads, females usually having more ash than males.

The seasonal changes in calorific value of the gonadal tissue (kcal/g ash free dry weight) and the calorific content of the gonad of standard animal, are shown in

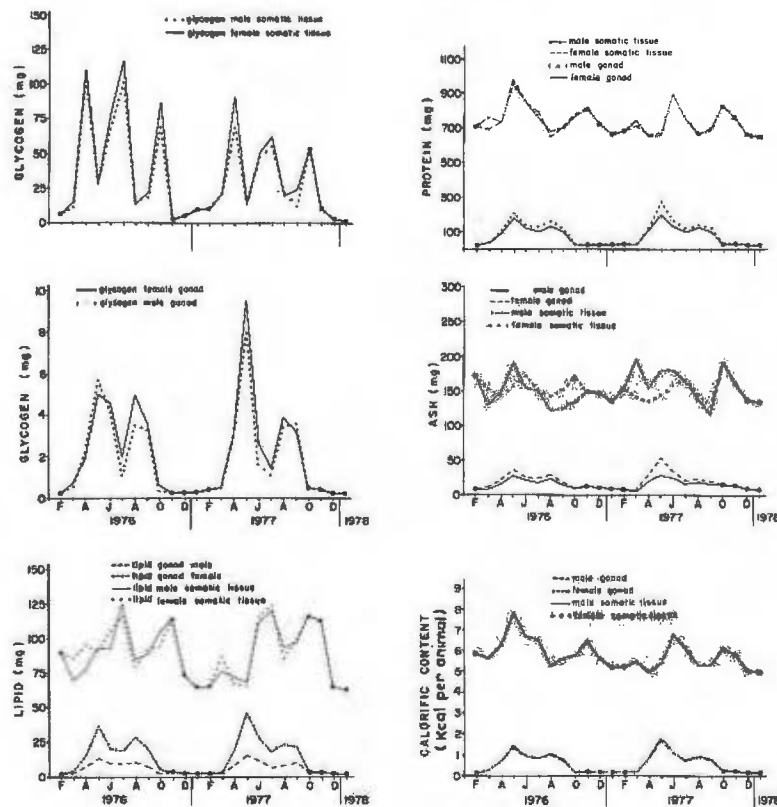


Figure 7  
Seasonal changes in biochemical composition of the gonad and somatic tissues of standard animal (50 mm).



Table 5

Seasonal variation in the percentage biochemical composition of the gonad tissues of *Chlamys varia* (L.). F: Female; M: Male; ND: not determined

Date	Sex	% of dry weight				% of wet weight Water	kcal/g ash free dry weight
		Glycogen	Protein	Lipid	Ash		
1976:							
20 February	ND	0.80	66.50	6.90	26.73	86.55	4.096
24 March	M	0.95	65.00	5.00	14.00	86.44	4.598
24 March	F	1.25	66.00	7.56	20.71		
13 April	M	1.55	74.19	5.20	11.05	80.35	5.152
13 April	F	1.35	66.50	10.80	15.01		
3 May	M	2.27	82.00	5.34	11.00	77.44	5.175
3 May	F	2.00	69.63	14.34	14.35		
2 June	M	2.38	75.19	5.50	12.00	82.55	5.246
2 June	F	2.60	67.19	11.34	14.52		
1 July	M	0.68	79.63	5.81	11.00	81.70	5.178
1 July	F	1.25	62.34	11.81	15.26		
25 August	M	1.78	80.63	5.29	11.60	80.99	5.047
25 August	F	2.50	66.44	14.21	14.50		
17 September	M	2.30	81.63	5.21	10.05	80.93	5.092
17 September	F	2.50	71.44	14.21	13.50		
1 October	M	0.78	69.63	5.80	25.13	86.55	4.528
1 October	F	1.50	64.00	12.79	22.04		
23 November	ND	0.67	62.31	8.3	29.59	86.99	4.440
15 December	ND	0.72	62.50	7.34	27.10	87.44	4.419
1977:							
20 January	ND	0.75	64.19	6.97	22.65	88.44	4.101
17 February	ND	1.00	67.80	5.96	18.78	87.20	4.115
7 March	M	1.15	65.75	5.96	12.56	87.50	4.270
7 March	F	1.25	62.13	8.00	18.94		
6 April	M	1.80	75.00	5.38	12.00	81.20	5.100
6 April	F	1.92	69.12	11.70	17.55		
12 May	M	2.50	85.00	4.98	8.82	80.53	5.200
12 May	F	3.00	62.00	14.45	16.68		
22 June	M	0.75	75.62	5.45	11.75	86.40	5.181
22 June	F	1.25	60.34	12.78	16.03		
3 July	M	0.82	80.62	4.91	11.50	81.20	5.097
3 July	F	1.05	69.50	13.05	14.85		
21 August	M	2.00	81.25	5.00	10.60	80.10	5.112
21 August	F	2.25	72.00	13.45	13.50		
11 September	M	2.50	83.00	5.25	10.50	80.50	5.185
11 September	F	2.25	70.12	14.86	13.98		
10 October	ND	1.01	58.82	7.78	31.00	89.04	4.597
15 November	ND	0.87	60.63	7.30	28.87	90.01	4.385
19 December	ND	0.65	61.62	6.80	25.00	86.90	4.325
1978:							
20 January	ND	0.66	63.12	6.10	21.85	87.80	4.076

Table 5 and in Figure 7 respectively. The calorific value of the gonadal tissue varied between 4.1 and 5.6 kcal/g, with minimum values in October to March when the gonads were empty and the ash content was high. During spawning periods female gonads showed a higher calorific value than males due to their higher lipid content. The total kcal in the gonad of a standard animal reached maximal values in May-June and August-September, and had the lowest values (0.17 kcal) during the non reproductive periods. The maximal values differed from year to year; being 1.4 kcal in 1976 and 1.8 kcal in 1977.

#### Seasonal changes in the somatic tissue

The dry weight of the somatic tissue of a standard animal during the period 1976-1978 has been plotted in Figure 6. There were two peak values of tissue weight, one in the spring and another in the late autumn, the spring peak was higher than that in the autumn. The maximum value was in May or June (1.5 g) and the lowest value was in

January of February (1.0 g) with the same seasonal trends during both years.

The seasonal changes in the biochemical composition of the somatic tissue are presented in Table 6. The percentage of protein did not show any obvious seasonal variation whereas the percentage of lipid exhibited a seasonal cycle, showing lower values in winter and higher values in spring, summer and autumn. Glycogen showed the greatest seasonal fluctuation, exhibiting three peak values (April, July and October) during the two years studied. The peak values of glycogen in April and July occurred prior to the spring and autumn spawning respectively, and the third peak was evident only in late autumn after the autumn spawning. The glycogen values were very low in winter (0.23 to 0.62% in 1976 and 0.33 to 1.0% in 1977). There was little difference between sexes in any of the three constituents in the somatic tissue. The absolute contents of the biochemical constituents (Fig. 7) followed the seasonal changes in dry weight of the tissues except for glycogen which showed three peak

Table 6

Seasonal variation in the percentage biochemical composition of somatic tissues of *Chlamys varia* (L.). F: Female; M: Male; ND: not determined

Date	Sex	% of dry weight				% of wet weight Water	kcal/g ash free dry weight
		Glycogen	Protein	Lipid	Ash		
1976:							
20 February	ND	0.61	64.00	8.03	15.63	83.56	5.320
24 March	M	1.06	70.64	6.38	12.23	82.56	{ 5.283
24 March	F	1.37	64.65	7.91	14.23		
13 April	M	8.65	61.92	6.43	12.58	81.94	{ 5.300
13 April	F	9.36	61.75	7.92	12.20		
3 May	M	2.04	63.32	6.13	12.72	81.63	{ 5.212
3 May	F	1.89	65.12	6.00	10.53		
2 June	M	5.47	66.05	7.13	12.10	81.59	{ 5.215
2 June	F	6.30	66.60	8.12	13.48		
1 July	M	8.13	60.72	9.87	12.04	80.68	{ 5.232
1 July	F	9.40	62.96	9.19	12.19		
25 August	M	1.64	66.09	8.19	12.04	82.02	{ 5.191
25 August	F	1.36	63.37	7.67	14.09		
17 September	M	1.70	63.70	8.65	11.43	82.83	{ 5.160
17 September	F	2.00	64.00	9.00	13.83		
1 October	M	5.70	63.75	8.64	11.24	82.01	{ 4.812
1 October	F	7.28	65.00	7.80	14.28		
24 November	ND	1.22	66.01	9.22	12.24	81.29	5.278
15 December	ND	1.45	66.53	6.63	13.69	83.18	5.224
1977:							
20 January	ND	0.99	66.00	6.34	13.60	83.53	5.212
17 February	ND	1.00	65.00	6.12	14.78	83.33	5.012
7 March	M	1.99	69.12	7.00	18.41	83.29	{ 5.115
7 March	F	2.05	66.23	8.00	13.20		
6 April	M	6.78	64.20	7.00	15.32	84.76	{ 4.883
6 April	F	9.00	65.00	6.50	13.38		
12 May	M	1.29	61.00	6.25	16.79	83.38	{ 5.015
12 May	F	1.38	62.00	6.00	13.48		
22 June	M	3.53	66.08	8.20	13.42	81.12	{ 5.000
22 June	F	3.78	65.18	8.50	11.84		
3 July	M	4.58	61.70	9.76	13.48	80.75	{ 5.021
3 July	F	5.12	62.00	10.12	13.76		
21 August	M	2.12	62.78	8.75	13.06	81.12	{ 5.005
21 August	F	1.89	61.19	7.98	13.78		
11 September	M	1.12	63.75	9.00	11.00	82.50	{ 4.982
11 September	F	2.32	64.86	9.25	12.12		
10 October	ND	4.28	65.12	9.12	15.19	81.98	4.812
15 November	ND	0.92	65.98	9.75	14.12	81.29	5.075
19 December	ND	1.31	66.00	6.40	13.78	84.00	5.065
1978:							
20 January	ND	1.13	65.75	6.34	13.69	83.50	5.060

values corresponding to the large percentage changes. The ash content of the somatic tissues showed irregular fluctuations. Females had higher ash content than males in 1976, but in 1977 males had higher values than females (Table 6 and Fig. 7).

The calorific value of the somatic tissue showed little seasonal fluctuations, except for a fall in October during the two years (Table 6). There were no consistent differences between male and female scallops in terms of calorific values. The total calorific content of the somatic tissues of a standard animal (Fig. 7) paralleled the seasonal changes in dry tissue weight, showing two peak values one in the spring and another in the late autumn. The highest peaks in the spring showed year to year differences, being 7.8 kcal in 1976 and 6.6 kcal in 1977.

*Seasonal changes in dry weight and calorific content of the whole animal without shell*

Seasonal variation in the dry body weight of the standard animal is shown in Figure 6. Maximal body weight

occurred in the spring and then decreased slowly during summer and autumn to minimal weights in winter. Year to year variation has been found in body weights e.g. the highest values (1.74 g) during 1976 was in the month of May while during 1977, it was in June (1.53 g). Smaller peaks have been observed in October and November during the year, after the second spawning in September. The calorific content of the whole body of a standard animal closely parallel the changes in dry weight of the tissue (Fig. 8 a). There was no consistent difference between sexes in respect to calorific content.

#### Immature scallops

The seasonal variation in the dry weight of a standard animal of 10 mm height has been plotted in Figure 9. During the year 1976, separate regressions were used for immature animal (0-18 mm), and the continuous lines in Figure 9 show the dry weight of the standard animal calculated from these regressions. The values did not



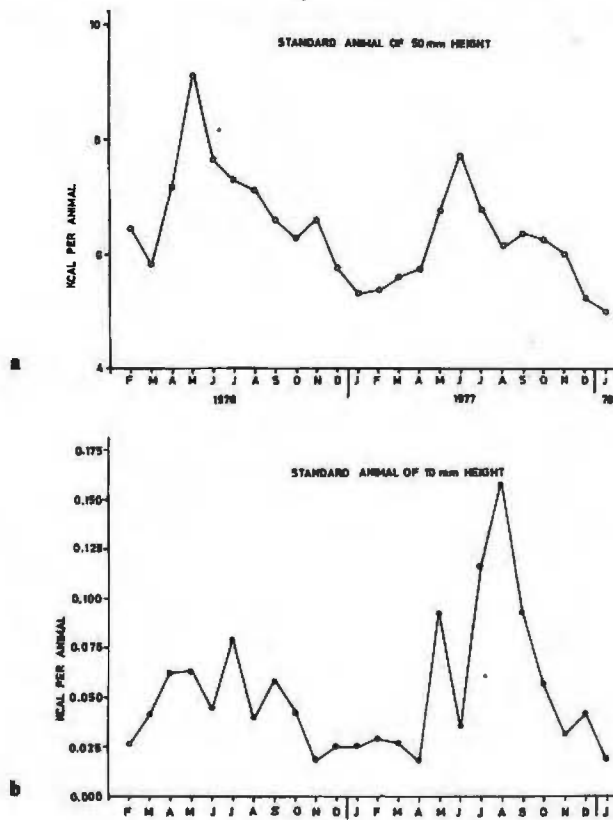


Figure 8 - Seasonal changes in calorific content (kcal/animal) of mature and immature *Chlamys varia* (L.).

show any obvious difference from the values calculated from over-all regressions of mixed mature and immature scallops (dotted lines). The spat showed higher weights in summer than in the winter; the maximum weight of the standard animal differed considerably from year to year; in 1976 it was 15.6 mg and in 1977 it was 31.3 mg (Fig. 9).

No detailed studies on the biochemical composition of the spat were undertaken in the present work, but the calorific values of the spat tissues were determined during every sampling period. The tissues showed little variation in calorific values with respect to seasonal changes except for a fall in October (4.8 kcal/g). The values ranged from 4.8 and 5.2 kcal/g during the two years with slightly higher values during summer months. The calorific content of a standard animal followed the seasonal changes in dry weight of the tissue showing peak values in summer months (Fig. 8 b).

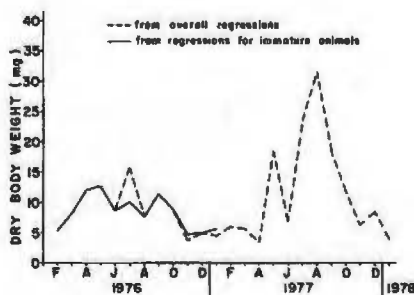


Figure 9 Seasonal changes in dry body weight of standard spat (10 mm).

## DISCUSSION

The allometric relationships between size and weight measurements of black scallops, *Chlamys varia* (L.), have not been published previously in detail. The regressions relating size and whole live weight or shell weight did not demonstrate any regular seasonal differences. The live animal may contain various amounts of water in the mantle cavity which may affect the analysis. Though the shell was cleaned, scrubbed and dried before weighings, some metal deposits might have remained on the shell. When over all regressions were considered for each relationship, the slopes of both the regressions were found to be less than 3 showing that the whole animal weight and the shell weight increase at a relatively lesser rate than the height. Regular significant seasonal differences in shell have been noticed in *Tellina tenuis* Da Costa (Ansell, Trevellion, 1967) and in *Mytilus edulis* (L.) (Boje, 1965), but Comely (1974) did not observe such difference in *Pecten maximus*.

Letaconnous and Audoin (1956) have observed a difference in height weight relationships between young and old *C. varia*. The relationships were found to be isometric in young scallops, but allometry was noticed when the animals grew older. The relationships between height - shell weight and height - breadth were reported to be isometric. The present work does not support their observations, since a true allometry was found in all the relationships cited above and no statistical differences were evident between young and old scallops.

The seasonal comparisons of regressions of dry body weights on heights suggest that there is no significant difference in relative growth rate due to sexual maturity in *Chlamys varia* (Table 2) as was found for mussels (Kuenzler, 1961; Dare, 1975 and Shafee, 1976). Hughes (1970), in *Scrobicularia plana*, and Dame (1972) in *Crassostrea virginica*, have also noticed that the relationships between shell length and dry flesh weight is linear when plotted on logarithmic scales, there being no change in slope associated with sexual maturity. The absence of a significant difference in height - tissue weight relationships with respect to sex in *Chlamys varia* is in accordance with the findings of Haynes (1966) in *Placopecten magellanicus* and those of Ansell (1974 a and 1978) in *C. septemradiata*. The relationships between all linear measurements and tissue weight showed regular significant seasonal differences. Since height was used as a measure to predict field observations, only relationships involving height have been considered in the present study.

How far the reproductive cycle of the scallop influences the tissue weights and biochemical composition of the various body components depends mainly on the timing of gonad proliferation and gametogenesis. The gonadal development of *Pecten maximus* and *Chlamys opercularis* in winter months causes a reciprocal decline in stored reserves in different body tissues; carbohydrate and protein from the adductor muscle, and lipid from the digestive gland (Comely, 1974; Taylor, Venn, 1979). Gonadal weight increase and early gametogenesis stages in *Chlamys septemradiata* and in *Placopecten magellanicus* take place mainly in spring and early summer leading

to spawning in autumn, and therefore, the stored reserves do not appear to make any significant contribution to the developing gonad (Ansell, 1974 a; Thompson, 1977). Lipid, carbohydrate and protein are stored during summer and autumn for subsequent utilization in the winter months for body maintenance.

The reproductive cycle of the Brest population of *C. varia* (L.) falls into two main spawning periods, one in spring (May-June) and another in autumn (September). Gonads begin to develop in March-April and reach maximal weights in May (Fig. 6) for the spring spawning. During this period, food is abundant in the form of phytoplankton (Shafee, 1980) and hence, the simultaneous increase in the dry weight of the gonad and somatic tissues suggests that in spring, gametogenesis takes place without the use of food reserves from the body tissues and depends solely on the food supply. However, the seasonal changes in biochemical composition of the somatic tissues (Fig. 7) shows that the increase in dry body tissue weight is due to accumulation of protein and lipid reserves, while glycogen declines to meet part of the energy requirements of the developing gonad. In the second spawning (September-October), all of the reserves (protein lipid and glycogen) show a decrease while at same time the gonadal tissue gains weight (Fig. 6). It appears that in *Chlamys varia*, as in mussels (Lubet, 1959; de Zwaan, Zandee, 1972; Gabbott, 1976), the loss of glycogen during the reproductive periods is synchronous with gonad development.

Gabbott (1975; 1976) has reviewed the evidence for a glycogen storage cycle in marine bivalves, and remarked on the possibility of glycogen giving five carbon sugars via the pentose phosphate pathway for nucleic acid synthesis as well as the necessary intermediates for lipogenesis. Both of these are essential pathways for the gonad since vitelogenesis takes place in the eggs and DNA and RNA synthesis in both eggs and spermatozoa. Taylor and Venn (1979) have also postulated that the conversion of muscle glycogen into gonadal lipids, in *Chlamys opercularis*, might be possible by following the metabolic pathways described by Gabbott (1976). However, in *Chlamys varia* the decline of carbohydrate reserves alone during spring in the somatic tissue may not fully account for the increase in reserves of the gonad. The development of gonads in early spring could take place mainly by the feeding activities of the scallop and only to a smaller extent by utilizing glycogen reserves in the somatic tissue.

In addition to the two peak spawning periods (spring and autumn) several intermittent spawnings take place in summer in *C. varia* and the gonads of individual animals may be at different stages of development (Shafee, Lucas, 1980). Successive gonadal reconstitution and spawning in summer months may result in a high metabolic demand of *Chlamys varia*. For the second major spawning in early autumn, there is a decline of all reserves in the somatic tissue. In October-November, when the gonads are empty and metabolic activities are presumably low, the reserves are built up again for subsequent utilisation in the winter during which the reserves fall to minimal values.

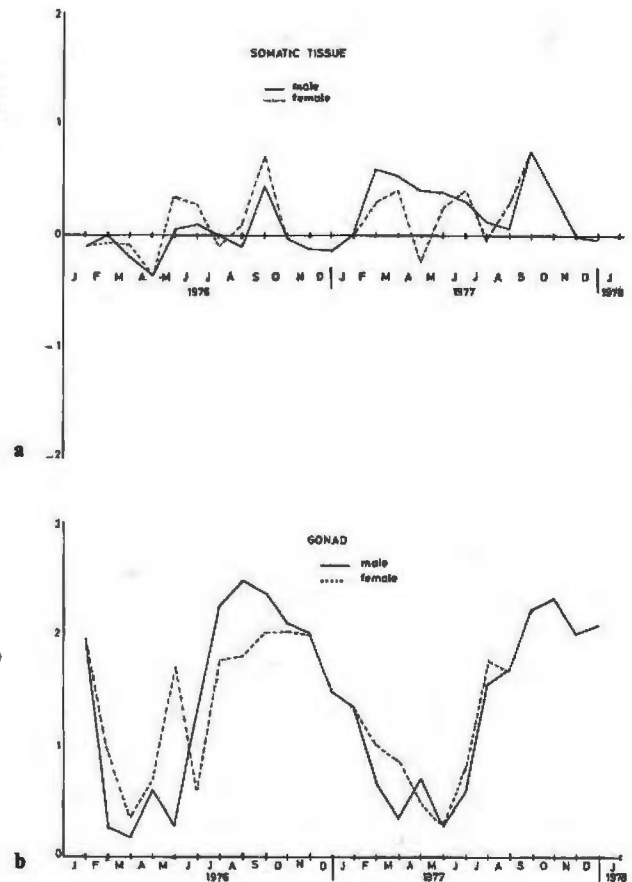


Figure 10

Difference between calculated calorific value (kcal/g) (from biochemical composition) and measured calorific value (kcal/g) (direct bomb calorimetry); the values in y axis were obtained by subtracting direct values from calculated values; a: somatic tissue; b: gonad.

In *Chlamys varia*, energy reserves built up in the previous year do not appear to play a significant role in subsequent maturation of the gonad. However growth of the somatic tissue in the spring seems to influence the gonadal weight increase in the following autumn. The second autumn peak of gonadal weight in 1977 was relatively smaller than that of the previous year and the maximal somatic tissue weight observed in 1977 was comparatively less than in 1976. During the non-reproductive period (October-March) there is no accumulation of reserves in the gonads. The seasonal changes of the whole dry body weight and its biochemical composition resembles those of other temperate bivalves (Ansell, Trevallion, 1967; Ansell, 1972; 1974 b) in accumulating reserves during the spring or autumn, which are later utilised for maintenance during winter when food is not available in sufficient amounts to meet the animal's metabolic demands.

Comparative estimations of the energy content of animal tissues from direct bomb calorimetry and proximate analysis (computation from results of a study of biochemical composition, using appropriate conversion factors for the various components) do not always give similar results (Craig, 1977; Craig *et al.*, 1978; Beukema, De Bruin, 1979). Paine (1971) has reviewed the possible errors resulting from bomb calorimetry. The present calorific values of the somatic tissue of *Chlamys varia* (L.) showed no obvious differences between the two

determinations (Fig. 10 a) but, those of gonadal tissues showed large differences, the direct bomb calorimetry giving lower values than those obtained from proximate analysis (Fig. 10 b). These differences could not be solely due to higher ash content of the gonadal tissues as the difference were apparent in July-September when the gonads were ripe and the ash content was low (see Table 5). Craig (1977) and Beukema, De Bruin (1979) have remarked that the conversion factor for lipids ( $9.45 \text{ cal: mg}^{-1}$ ) as used in the present study, should be replaced by a lower value since the lipid extracted by Chloroform methanol method might contrain impurities. Even when a lower calorific values (Beukema, De Bruin, 1979) of 8.62 was used for lipid, the results from the proximate analysis, differed from the calorific values obtained by direct bomb calorimetry. It is not possible therefore, to give a reasoned explanation for the discrepancy.

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