J. Cons. int. Explor. Mer, 36(3): 240–242. Février 1976.

The glycogen content in winter and summer of oysters, *Ostrea edulis* L., of different ages

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The biochemical composition of adult oysters was determined in January and June, 1974, for five age groups between 18 months and 5 years old. The neutral lipid, phospholipid, free sugar and nitrogen levels were similar in adults of all ages and showed little or no variation between summer and winter. In the summer, the glycogen level was similar in adults of all ages with a mean of 17·1% of the dry flesh weight. The glycogen level in the winter increased with increasing age of oysters; from 4·6% of the dry flesh weight in one to two year old adults to 15·2% of the dry flesh weight in 4–5 year old adults. The latter value is similar to that in the summer (mean 16·4% of the dry flesh weight).

Introduction

In a previous study on biochemical changes during the development of *Ostrea edulis* L. (Holland and Hannant, 1974), young adult oysters, 1–2 years old, were found to have a level of glycogen during the winter which was much lower than the winter glycogen level reported for adults of commercial size, 4–5 years old and kept at the same site in the Menai Strait (Walne, 1970; Gabbott and Walker, 1971). The levels of glycogen during the spring and early summer, however, were similar in both young and older adults. Both young and older adults showed a loss of glycogen during the spawning season, and a similar recovery in the autumn. In this study we have compared the winter glycogen levels and general biochemical composition of adult oysters of different ages, ranging from oysters 1–2 years old to commercial size animals 5 years old, with values for summer, when the phytoplankton levels in the sea are high.

Materials and methods

Adult oysters grown from spat settled in the summers of 1969, 1970, 1971 and 1972 and from a settlement in the autumn (September) of 1972 were kept under similar conditions in trays at the level of low-water of spring tides at Foel, at the South Western end of the Menai Strait. In January and in June 1974, a sample of six oysters was picked at random from each of the five different populations. The shell heights were measured and then the flesh was removed from the shells, freeze-dried and weighed. The shells were heated in an oven at 100°C overnight, cooled and weighed. The six animals from each sample were analysed separately for protein nitrogen, carbohydrate (free sugars and glycogen) and lipid (neutral lipid and phospholipid) content as described previously by Holland and Gabbot (1971) and Holland and Hannant (1973). In addition total nitrogen in a sample of the aqueous homogenate was determined by micro-Kjeldahl digestion in the same way as protein nitrogen.

Results

The mean values for shell height and weight, dry flesh weight and biochemical composition of the five age groups of *O. edulis* in the winter and summer are shown in Table 1. The adults ranged in size from those settled in the autumn of 1972 which had a total dry weight of 8·5 g and were 4·7 cm in shell height in January 1974 (winter) to those settled in 1969 which by June 1974 had a mean total dry weight of 75·0 g and were 8·7 cm in shell height. There was little difference in the level or percentage of neutral lipid, phospholipid, free sugars or nitrogen in oysters between January and June or between the various age groups. In June 1974 the level of glycogen was similar in all adults examined but in January 1974 the percentage of glycogen generally increased with increasing age of the oysters.

Table 1. The shell height and dry weight, dry flesh weight and percentage biochemical composition of adult *O. edulis* of different ages sampled in January (Winter) and June (Summer) 1974. Each value is the mean and standard deviation of separate determinations on six oysters

Year of settlement[1]	1974 sample time[2]	Shell height cm	Dry shell weight g	Dry flesh weight g	Lipid[3] Neutral lipid	Lipid[3] Phospholipid	Carbohydrate[3] glycogen	Carbohydrate[3] free sugars	Protein nitrogen[3]	Total nitrogen[3]
1972 A	W	4·7±0·3	8·3±2·0	0·2±0·1	1·6±0·5	2·0±0·5	4·4±1·7	1·1±0·3	6·0±0·9	7·1±1·4
	S	5·0±0·6	10·4±3·5	0·5±0·2	2·5±0·8	2·1±0·3	18·3±2·7	2·0±0·3	4·2±0·7	7·0±2·2
1972 S	W	5·0±0·7	9·8±3·4	0·3±0·1	2·4±0·8	2·2±0·6	4·7±0·9	1·2±0·5	6·3±0·6	8·0±2·1
	S	5·3±0·4	13·4±1·9	0·4±0·1	2·1±0·5	2·1±0·5	16·2±4·7	2·4±0·2	4·0±0·5	7·1±1·7
1971 S	W	6·0±0·5	19·0±5·0	0·6±0·2	2·3±0·6	2·8±1·1	8·4±0·7	1·3±0·4	5·1±0·6	6·7±1·2
	S	6·0±0·5	15·8±3·2	0·8±0·2	2·5±0·4	1·9±0·6	16·1±1·5	2·0±0·4	3·9±0·9	6·6±1·2
1970 S	W	5·8±0·8	18·1±6·4	0·5±0·2	2·3±0·5	2·1±0·6	7·3±2·5	1·3±0·4	5·0±0·8	6·5±1·2
	S	6·5±0·5	25·2±4·4	1·0±0·2	3·0±0·4	1·8±0·5	18·7±5·2	2·0±0·1	4·4±0·6	6·4±0·9
1969 S	W	7·4±1·0	36·7±9·4	1·6±0·4	3·2±0·7	2·4±0·9	15·2±3·5	1·3±0·4	4·5±1·1	5·3±1·1
	S	8·7±1·4	72·7±35·1	2·3±0·8	2·9±0·7	1·8±0·5	16·4±2·4	2·0±0·6	4·3±0·6	7·3±1·4

[1] A: Autumn, S: Summer. [2] W: Winter, S: Summer. [3] % of dry flesh weight.

Table 2. The glycogen : protein nitrogen ratio in the flesh of adult *O. edulis* of different ages in January and June 1974

Year of settlement	January 1974	June 1974
1972 (autumn)	0·7	4·4
1972 (summer)	0·7	4·1
1971	1·6	4·1
1970	1·5	4·3
1969	3·4	3·8

Table 2 shows the glycogen : protein nitrogen ratio in the flesh of adult oysters of different ages in January and June 1974.

The glycogen : protein ratio in January was higher in the older oysters but in June the ratio was similar in oysters of all age groups.

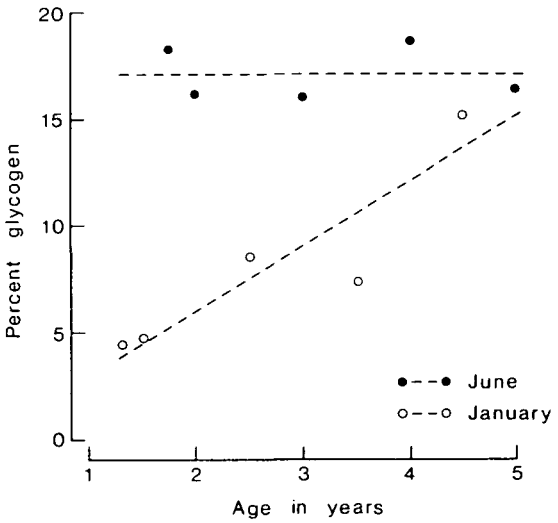

Figure 1. Percentage glycogen in the dry flesh of *Ostrea edulis* in summer (June) and winter (January) for different age groups.

Discussion

Figure 1 shows that the difference between the winter and summer glycogen levels in oyster flesh gradually decreases as the adults increase in age. This assumes that January and June are months which are representative of winter and summer conditions respectively. As the oysters get older there is less of a decline in the winter glycogen : protein ratio until the oysters are four to five years old, when apparently the ratio hardly declines at all during the winter (Table 2). Previously Walne (1970) and Gabbott and Walker (1971) have shown that although glycogen may decrease during the spawning season, the level in large adult oysters is generally the same in the winter and early summer. In contrast young adults (1–2 years old) show a three-fold increase in the percentage of glycogen between January and June (Fig. 1; Holland and Hannant, 1974).

According to Walne (1970) it can be shown that lipid and carbohydrate reserves are accumulated in the summer in some populations of oysters when conditions are good, and that both are lost to a similar extent in the winter when conditions are poor. However, in some other populations, Walne (1970) found no correlation between the changes in the level of glycogen and changes in lipid content. Likewise in

the younger populations of oysters investigated here, although the lipid level was about the same in the winter and summer the glycogen level could vary between the two seasons. A comparatively constant lipid level with seasonally fluctuating levels of carbohydrate (glycogen) has been demonstrated in other populations of *O. edulis* (Russell, 1923, Holland and Hannant, 1974). The precise role of lipid as an energy source in adult oysters still remains to be investigated. Walne (1970) has pointed out that adult oysters can contain half as much lipid (total fat) as glycogen and as the calorific value of fat is about twice that of carbohydrate then the caloric content of the two reserves is approximately equal. However, the importance of the phospholipid fraction (which forms a high proportion of the total lipid in oyster flesh, Table 1) as an energy reserve is unknown. Phospholipid is normally associated with protein in the body structure and energy reserves in the form of fat are normally associated with the triglycerides. In which case glycogen is probably the most important energy reserve in mature adult oysters.

The fall in the glycogen : protein ratio in the young adults during the winter (January) is probably due to utilization of glycogen as an energy reserve when food levels are low. During the winter, Walne (1958) found that there was little or no growth of adult *O. edulis* of various ages at the same site used in this study. It may be that reduction of growth to a minimum allows the older oysters to balance energy expenditure with the low food availability. Hence the glycogen pool would not be required as an energy reserve and could be maintained at a similar level to the summer. However, young or small oysters may have a higher weight specific metabolic rate than older or larger adults. The weight specific metabolic rate has been shown to decrease with increasing body weight in other intertidal bivalves such as *Crassostrea virginica* (Dame, 1972) and *Mytilus edulis* (Thompson and Bayne, 1974). The increased metabolic demand in the smaller and younger adults, compared to the larger and older adults, together with a low food concentration results in the utilization of glycogen reserves during the winter and a fall in the glycogen:protein ratio. This means that the younger adults must be out of energy balance during some part of the winter.

Acknowledgements

The authors wish to thank Dr. P. R. Walne and Mr. J. T. C. Knowles for supplying the oysters and Dr. P. A. Gabbott for criticism of the manuscript.

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