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GLYCOGEN CONTENT OF SOME ORGANS IN TWO MARINE CRUSTACEANS.

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ABSTRACT

Investigations were carried out on the glycogen content of both sexes of two crustacean species, **Portunus pelagicus** and **Penaeus kerathurus**, of different maturity stages.

Marked variations with maturity and sex were detected in the levels of total glycogen in the muscle, hepatopancreas and gonads of the prawn and the muscles of the crab. The pattern of change in the crab hepatopancreas and gonads showed a quite different pattern data as compared with the glycogen levels in those of the above mentioned individuals.

The result leads to the general conclusion that crustacean intermediary metabloism centres mainly as glycogen.

Hypotheses about the metabolic processes in the crustacea suffer from insufficient knowledge about the normal metabolism of the animals, and also from the lack of pure hormone preparations. Detailed and convincing studies on the control of metabolism in crustacea must await the avaliability of pure hormone preparations.

INTRODUCTION

The polysaccharide glycogen is the chief storage carbohydrate in animal muscle, and is the available substrate for rapid glycolysis during animal activity. A glycogen storage disease has been described where the content is much higher, due to the absence of phosphorylase, these cases are characterized by extreme fatiguability, since no rapid glycolysis can be elicited.

Crustacean muscles were among the first to be studied at the beginning of the modern period of research on muscle physiology. In 1928 Meyerhof and Lohmann as well as Boyland (1928) found that after stimulation of crustacean muscles, glycogen disappears and an equivalent amount of lactic acid is formed. In a medium made weakly alkaline by means of secondary

Samples of both crabs and prawns ranged from 20.0-400.0 g 10.0-60.0 g in body weight were collected during the whole experimental period.

Digestive and determination of glycogen in the different tissues were determined according to the method of Hassid and Abraham (1957).

Data obtained was statistically analysed according to Croxton and Cowden formula (1956).

RESULTS

In present work, it was apparent from all the results that the glycogen content (table 1,2) ranges from 4.0 to 44.0 and 4.5 to 47.0 mg glycogen / g tissue dry weight for male and female prawn muscles and 7.5 to 66.6; 10.0 to 52.3 mg glycogen/g dry weight for those of the crabs. The effect of individual animal size and sex on the glyogen content was studied (Fig. 1-6).

Values of total glycogen content in hepatopancreas and gonad in both sexes of the crab vary from 10.0 to 16.0 and 10.8 to 25.5 mg glycogen/g in males; 13.0 to 32.0 and 13.1 to 40.0 in females respectively.

In the prawn, they were 7.0 to 50.0 and 4.0 to 37.0 mg glycogen/g dry tissue male; 9.0 to 60.0; 10.0 to 92.0 mg glycogen/g dry tissue in females for hepatopancreas and gonad respectively. Considering all results, it was apparent that marked variations with maturity were detected in the levels of total glycogen in the muscle, hepatopancreas, and gonad of the prawn and the muscle of the crab.

TABLE 1

Glycogen content in different tissue of male and female Portunus Pelagicus (Linnaeus).
All measurement were made on 5 animals in each group.

Number of experimental	Sex	Total body weight " gm "			mg glycogen / gm muscle			mg glycogen / gm hepat.			mg glycogen / gm gonad		
		Range	mean	± S.d	Range	mean	± S.d	Range	mean	± S.d	Range	mean	± S.d
1	Male	73.0 - 77.0	75.0	1.99	65.0 - 68.0	66.6	1.50	10.0 - 11.0	10.5	0.35	10.0 - 11.6	10.8	0.64
2		93.0 - 97.0	95.0	1.41	13.0 - 17.0	15.0	1.41	10.5 - 14.5	12.5	1.4	10.0 - 12.0	11.0	0.99
3		155.0 - 159.0	157.0	1.41	7.0 - 8.0	7.5	0.40	15.0 - 16.0	15.5	0.35	16.0 - 20.0	18.0	1.42
4		194.0 - 198.0	196.0	1.44	10.0 - 12.0	11.0	0.81	10.5 - 14.5	12.5	1.42	30.0 - 40.0	25.0	3.53
5		257.0 - 261.0	259.0	1.41	10.5 - 11.6	11.0	0.55	12.0 - 14.0	13.0	0.99	20.0 - 23.0	21.6	1.52
6		387.0 - 392.0	390.0	1.42	35.0 - 38.0	36.6	1.22	15.0 - 17.0	16.0	0.98	20.0 - 30.0	25.5	3.32
1	Female	85.0 - 89.0	87.0	1.41	30.0 - 31.0	30.33	0.36	19.0 - 23.0	21.0	1.4	11.0 - 15.0	13.1	1.40
2		130.0 - 134.0	132.0	1.41	53.0 - 54.0	52.3	0.57	26.0 - 27.0	26.5	0.35	15.0 - 18.0	16.6	1.20
3		167.0 - 173.0	170.0	2.44	19.5 - 20.5	20.0	0.49	11.0 - 15.0	13.0	1.32	30.0 - 33.0	31.6	1.50
4		175.0 - 185.0	180.0	4.00	26.0 - 27.0	26.6	0.50	19.0 - 20.2	19.6	0.43	11.0 - 16.0	14.0	2.4
5		210.0 - 220.0	215.0	4.08	9.6 - 10.4	10.0	0.39	25.0 - 35.0	30.0	3.53	15.0 - 17.0	16.0	1.42
6		240.0 - 250.0	245.0	3.50	20.0 - 22.0	21.0	0.99	12.0 - 14.0	13.0	0.99	11.0 - 15.0	13.0	1.4
7		296.0 - 304.0	300.0	2.82	29.6 - 30.5	30.0	0.45	30.0 - 34.0	32.0	1.32	35.0 - 45.0	40.0	3.53

hepat. = hepatopancreas

TABLE 2

Glycogen content as glucose in different tissue of male and female Penaeus kerathurus

All measurement were made on 5 animal in each group.

Number of experiment	Sex	Total body weight " gm "			mg glycogen / gm tissue			mg glycogen / gm hepato.			mg glycogen / gm gonad		
		Range	mean	± S.d	Range	mean	± S.d	Range	mean	± S.d	Range	mean	± S.d
1	Male	5.1 - 6.5	5.8	0.69	42.0 - 46.0	44.0	1.99	45.0 - 55.0	50.0	3.53	35.8 - 40.3	37.0	1.30
2		7.8 - 8.6	8.0	0.41	28.5 - 31.5	30.0	1.50	33.0 - 37.0	35.0	1.49	20.7 - 28.3	25.5	3.40
3		9.0 - 9.6	9.3	0.30	33.1 - 41.0	37.0	3.95	35.0 - 45.0	40.0	3.50	25.0 - 35.0	30.0	3.53
4		10.0 - 10.8	10.4	0.39	38.4 - 42.6	40.5	2.10	40.0 - 47.0	43.5	2.42	30.0 - 35.0	32.5	2.72
5		16.0 - 20.0	18.0	2.0	18.0 - 20.0	19.0	0.99	21.0 - 23.0	22.0	0.99	11.0 - 13.0	12.0	1.40
6		22.0 - 24.0	23.0	0.81	3.0 - 4.0	4.0	0.5	13.0 - 17.0	15.0	1.20	3.7 - 4.5	4.0	0.20
7		25.0 - 27.6	26.0	1.36	6.0 - 6.5	6.0	0.28	17.0 - 18.2	17.5	0.35	4.6 - 5.4	5.0	0.25
8		27.7 - 28.3	28.0	0.30	9.0 - 11.0	10.0	0.99	17.0 - 21.0	19.0	1.32	6.9 - 7.3	7.0	0.099
9		31.0 - 33.0	32.0	0.99	3.0 - 4.0	3.8	0.57	6.3 - 7.9	7.0	0.78	7.5 - 8.5	8.0	0.90
10		33.5 - 36.5	35.0	1.50	14.0 - 16.0	15.0	0.99	15.0 - 25.0	20.0	3.50	10.3 - 14.6	12.0	1.22
11		39.0 - 41.0	40.0	0.99	14.5 - 16.5	15.0	1.04	15.0 - 25.0	20.0	3.32	11.0 - 15.6	13.0	1.45
12		41.2 - 42.8	42.0	0.79	14.2 - 15.8	15.0	0.79	21.7 - 24.3	22.0	0.98	12.3 - 13.6	13.0	0.89
13		43.0 - 47.0	45.0	1.99	14.8 - 15.2	15.0	0.19	20.0 - 30.0	25.0	3.50	12.5 - 13.7	13.0	0.73
1	Female	7.0 - 7.9	7.5	0.52	19.0 - 32.0	25.5	6.5	30.0 - 35.0	32.4	1.89	20.0 - 24.0	22.0	1.4
2		8.0 - 8.9	8.5	0.51	9.5 - 22.0	15.7	6.2	21.0 - 23.4	22.0	0.75	11.5 - 13.6	12.0	0.9
3		11.5 - 12.5	12.0	0.71	24.5 - 27.5	26.0	1.5	30.0 - 42.0	35.0	3.82	18.7 - 21.3	20.0	1.4
4		13.0 - 14.2	14.0	0.64	22.5 - 27.0	24.7	2.2	24.0 - 37.2	30.0	4.37	18.0 - 22.0	20.0	1.45
5		15.0 - 15.8	15.5	0.4	9.4 - 10.0	9.7	0.3	20.0 - 23.0	21.5	1.02	9.0 - 11.2	10.0	0.9
6		15.9 - 16.3	16.0	0.5	46.5 - 47.6	47.0	0.49	55.0 - 65.0	60.0	3.50	35.0 - 45.0	40.0	3.53
7		17.3 - 24.0	20.0	0.53	20.0 - 28.5	24.3	4.2	30.2 - 35.6	32.0	3.70	18.0 - 22.0	20.0	1.42
8		27.5 - 31.0	30.0	1.8	13.0 - 21.0	16.6	4.0	15.0 - 25.0	20.0	3.52	10.0 - 14.0	12.0	1.32
9		31.0 - 33.2	32.0	1.1	35.4 - 36.6	36.0	0.5	35.0 - 45.0	40.0	3.32	15.0 - 25.0	20.0	3.53
10		41.0 - 44.5	42.0	1.8	5.0 - 12.0	8.5	3.5	11.5 - 12.9	12.0	0.32	16.0 - 24.3	20.0	2.43
11		46.4 - 49.5	48.0	1.5	37.0 - 38.0	37.5	0.49	40.0 - 45.0	42.5	1.37	30.0 - 34.0	32.0	1.42
12		49.6 - 50.5	50.0	0.45	3.0 - 6.0	4.5	1.5	8.0 - 9.2	9.0	0.82	15.0 - 25.0	20.0	3.53
13		58.0 - 61.0	59.0	1.5	16.0 - 30.0	23.0	7.0	25.0 - 35.0	30.0	3.53	20.0 - 24.0	92.0	1.8

hepat. = hepatopancreas Muscle = Tissue

The glycogen levels were high during their immature stages (premoult and intermoult stages) but decreased rapidly following the final moult (post moult) stage. On the other hand, the pattern of change with maturity of the concentration of the glycogen in the crab hepatopancreas and gonad showed a quit different pattern as compared with the glycogen levels in those of the above mentioned individuals. It was apparent from observations that the glycogen levels increased rapidly following the final moult.

A comparative examination of the total glycogen concentration between the two sexes within the two species studied showed great variation. The female values were always higher. This difference from the male values seems to be a necessary adaptation for satisfaying the rquirements of both the maturation of the oocyte and egg laying processes.

Marked patterns of change with maturity and sex have been found and the significance of those has been investigated (table 3).

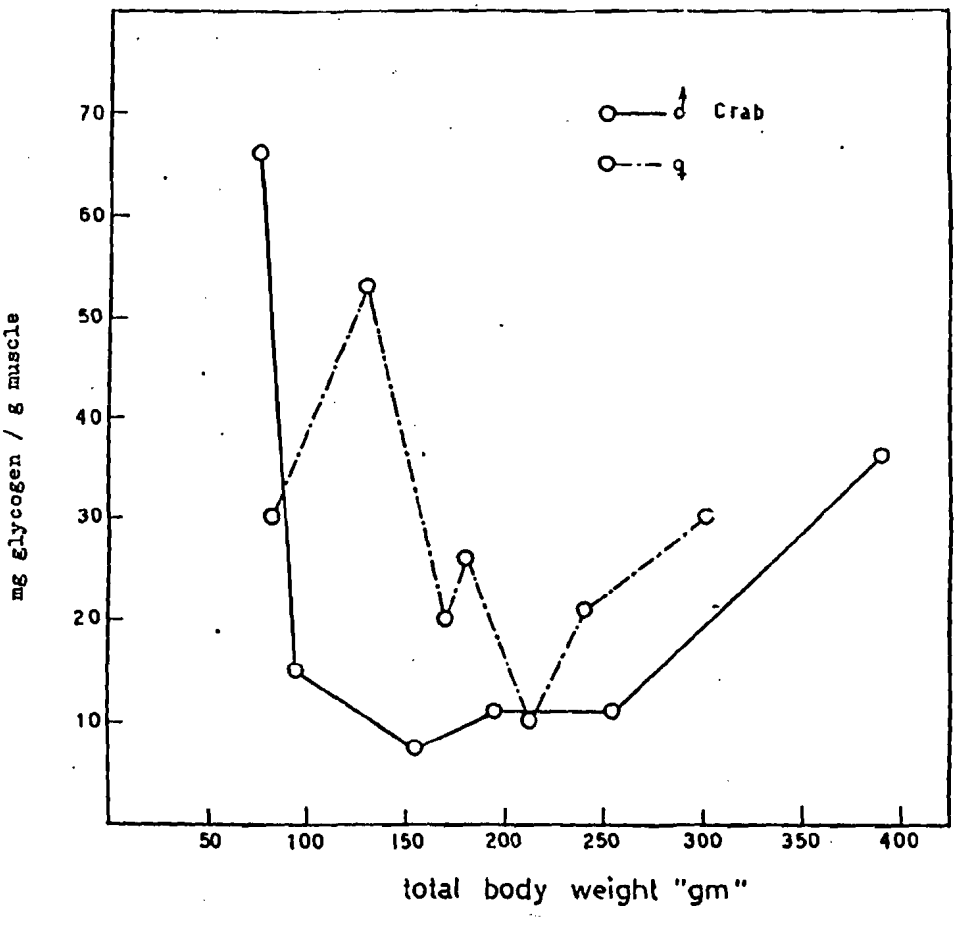

Fig. (1)
Muscle glycogen concentrations of the two sexes of
Portunus pelagicus at their different stages of maturity.

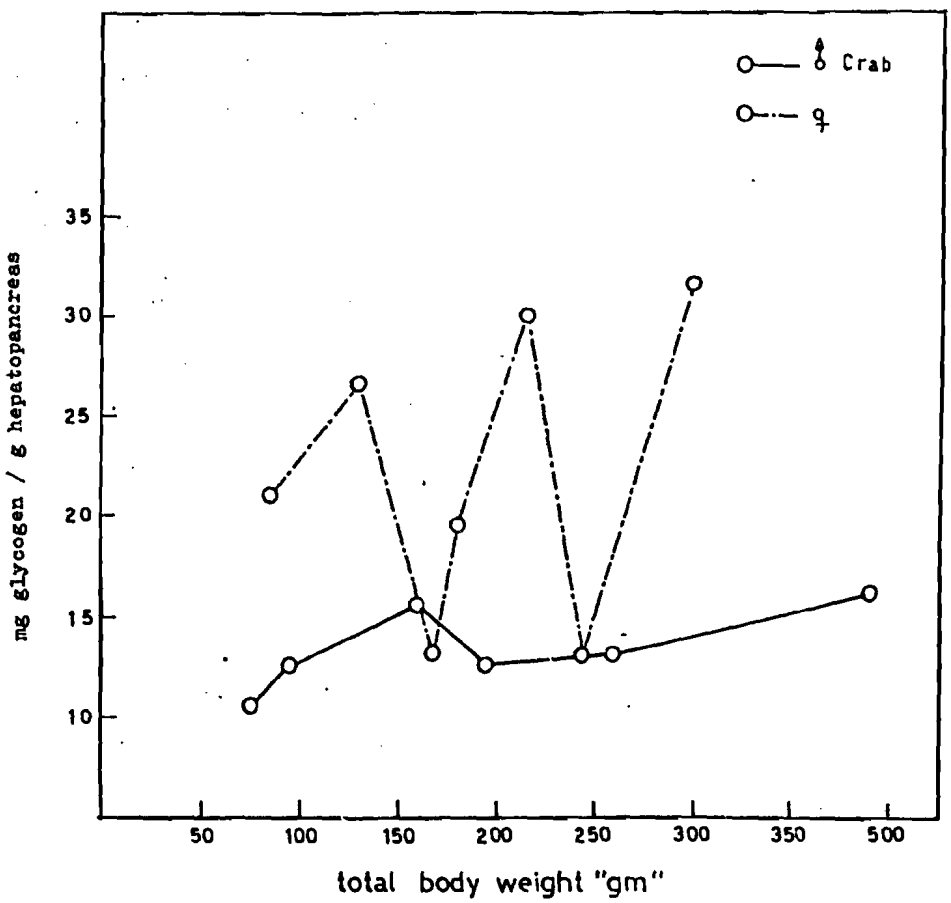

Fig. (2)
Hepatopancreas glycogen concentration of the two sexes of **Portunus pelagicus** at their different stages of maturity.

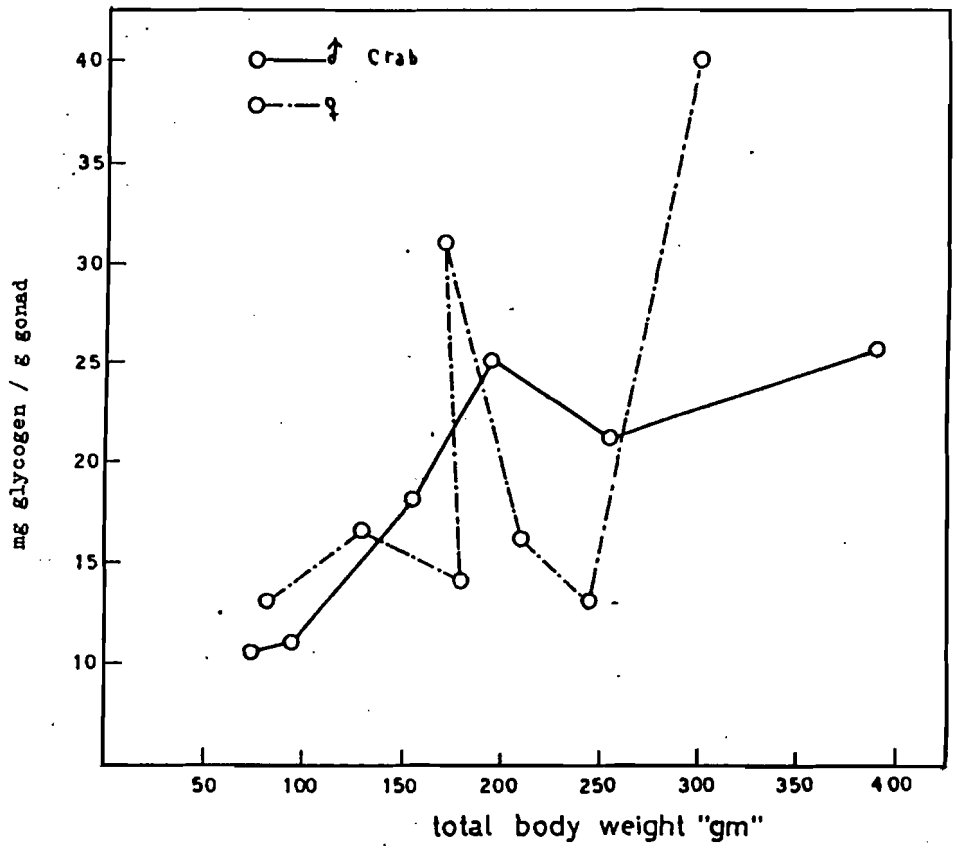

Fig. (3)
Gonad glycogen concentrations of the two sexes of
Portunus pelagicus at their different stages of maturity.

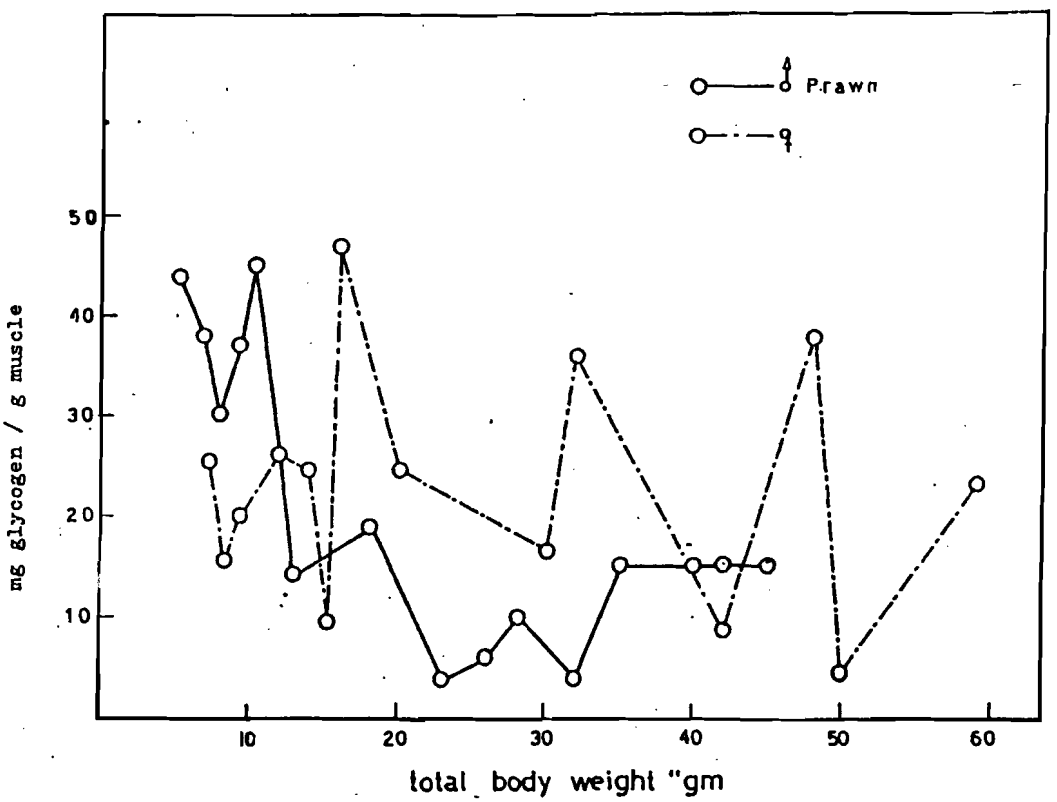

Fig. (4)
Muscle glycogen concentrations of the two sexes of
Penaeus kerathurus at their different stages of maturity.

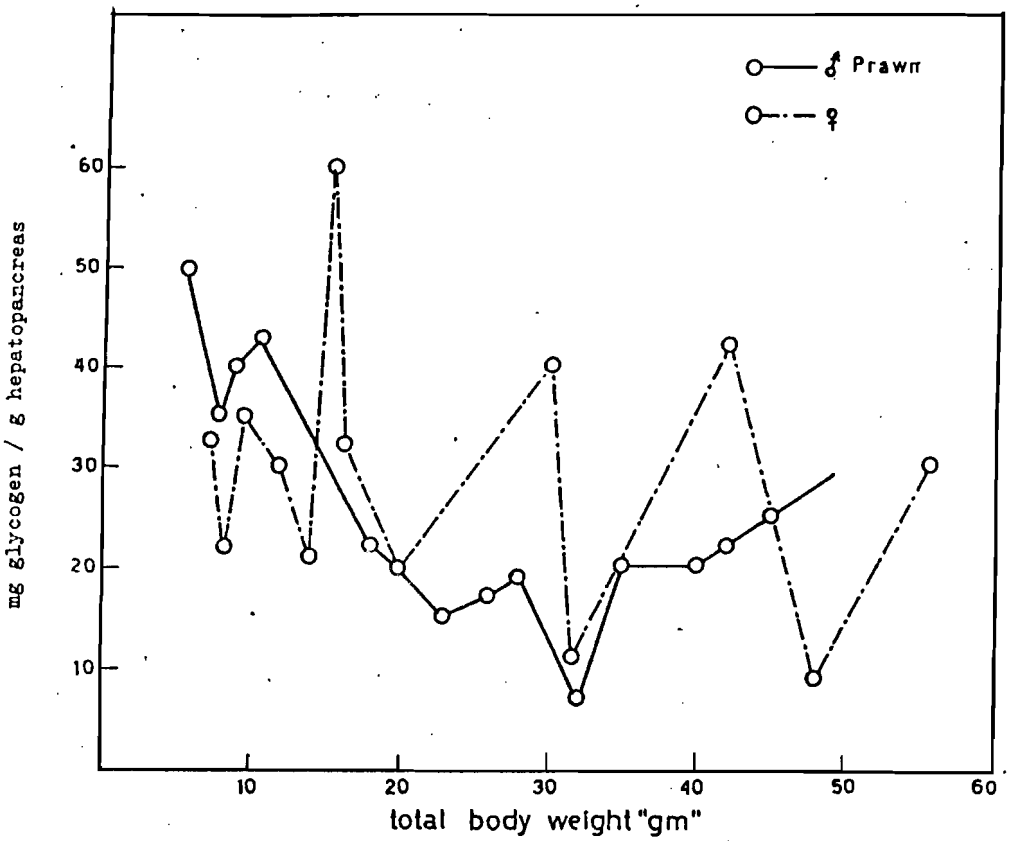

Fig. (5)
Hepatopancreas glycogen concentrations of the two sexes of **Penaeus kerathurus** at their different stages of maturity.

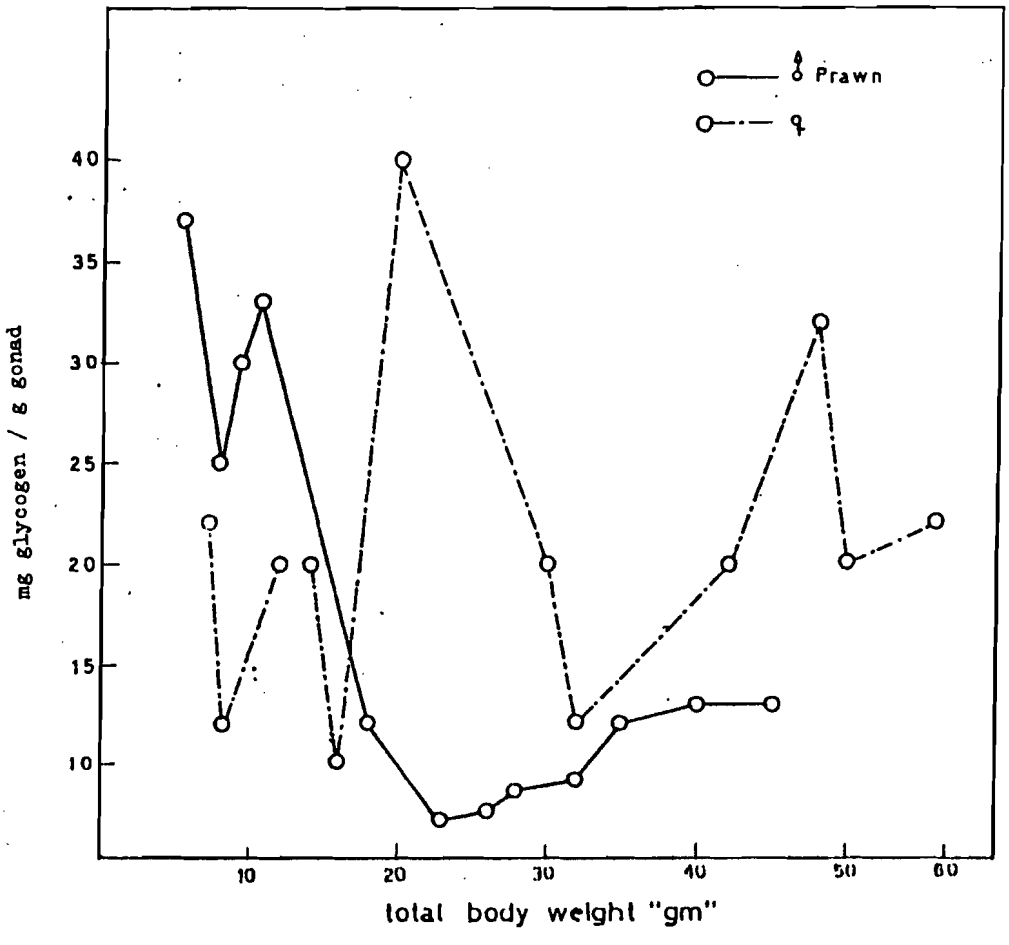

Fig. (6)
Gonad glycogen concentrations of the two sexes of
Penaeus kerathurus at their different stages of maturity.

TABLE (3)

Glycogen content in different tissues of both the crab Portunus pelagicus and the prawn Penaeus kerathurus

Tissue	Glycogen content (mg / g dry tissue)				t
	Male	Mean	Female	Mean	test
In Prawn					
Muscle	3.0 - 46.0	19.56	3.0 - 47.5	23.00	> 0.500
Hepatopancreas	6.3 - 55.0	25.85	8.0 - 65.0	29.72	> 0.500
Gonads	3.7 - 40.3	16.31	9.0 - 45.0	26.15	> 0.200
In crab					
Muscle	7.0 - 68.0	24.62	9.6 - 54.0	27.18	< 0.500
Hepatopancreas	10.0 - 17.0	13.33	11.0 - 35.0	22.16	> 0.025
Gonads	10.0 - 40.0	18.65	11.0 - 45.0	23.47	> 0.400

DISCUSSIONS

A comparative examination of the total glycogen concentration between the two sexes within the two species studied showed great variation. The glycogen content of the females were always higher.

Marked patterns of change with maturity and sex have been found and the significance of those had been investigated.

The muscle of invertebrates acts as a store for glycogen, while higher animales store glycogen and fat in the liver, which keeps the muscle glycogen up to a fairly constant level. Studies of the total content of muscle glycogen of the prawn showed marked variations during development. The mean values in immature individuals were more than that in the mature ones. In other words the muscle glycogen showed a remarkable decrease on reaching the adulthood. Detailed studies on the changes in glycogen content during the moult cycle have been made by Baumberger (1928). Renaud (1949) and Travis (1955), Verrne (1924) and Schwabe et al (1952) have presented evidences that glycogen is utilized as precursor in chitin formation.

The increase in glycogen content observed as the animal approaches a moult was already known from the study of Renaud (1949) on cancer pagurus. Moreover, Schwabe et al (1952) had observed a marked increase in total glycogen, represented by deposition in the hepatopancreas and epidermis, in the transition to the premoult stage in spiny lobsters.

It has been shown also that breeding and moulting lobsters (Boyland, E., 1928) had definitely higher glycogen contents than normal lobsters. The increase in the case of breeding lobsters was possibly due to storage, in order to provide energy for the period during which the animal is less active.

In this work; therefore, it can be concluded that, during the immature stage, there is a gradual transition from carbohydrate oxidation to polysaccaride synthesis as a major pathway of carbohydrate metabolism.

The authors demonstrated a significant rise in hepatopancreas glycogen befor moulting. During the moult cycle of the prawn, the amounts of glycogen increased, at first this increase was moderate, later the increase was stronger, at the end of the moulting cycle, leves continued to fall. The evidence for this was not unequivocal. It may be suggested that at first the glycogen is formed faster in the hepatopancreas then it is withdrawn to the integument, and therefore this organ shows a temporary rise in glycogen levels. Later on as integument secretion increases, glycogen is withdrawn more rapidly from the hepatopancreas than it is formed and the level falls again.

Schafer, (1968) demonstrated also a rise in hepatopancreas glycogen before moulting in **Cancer.**

Adiyodi (1969), mentioned that the sugars present in the hepatopancreas are also found in some abundance in the ovary during early stages of vitellogensis, but vanish progressively in the course of yolk formation. This suggests that the sugars may be utilized mainly in the build up of yolk proteins by the ovary and perhaps also as fuel during that process.

It was found that, in tha female body, carbohydrates are necessary for vitellogenesis and for the formation of the glucosamino glycogen present in the vitelline membrane and the chorion. Vitellogenesis involves the accumulation within the oocyte of carbohydrate, lipid and protein yolk to meet the structural and metabolic needs of the developing embryo. A substantial portion of the yolk is derived from the nutrient reserves of the hepatopancreas and haemolymph. Glycogen which serves as the principal carbohydrate yolk, is usually synthesized in the ovary from glucose and trehalose derived from hepatopancreas and haemolymph (Adiyodi, 1970). In the present investigation, the cyclic changes observed in the profiles and levels of sugars in the hepatopancreas in relation to ovarian development suggest the possibility that the carbohydrate metabolism related to yolk formation may perhaps be under the control not only of the specific reproductive hormones, but also of some of the "metabolic hormones" not conventionall implicated in reproduction.

As yet, little comparative information is available about the involvement of carbohydrates in the male reproductive system of crustacea as in insects because of the difficulty in obtaining uncontaminated tissue samples and

an adequate amount of semen for analysis. Wolvekamp (1960), found that most of the carbohydrates of the reproductive system were present in the testes. Fructose and glucose were the most abundant and made up 83% of the testicular carbohydrates. Fructose was shown to be rapidly metabolized by the spermatozoa, and is therefore unlikly to be involved in their long-term storage in the spermatheca. Glucose and threhalose, together with amino acid, probably serve as an energy source for semen maintenance in both the seminal vesicle and spermatheca.

The evidence on which we can base hypotheses for the source of the increased glycogen in both crab hepatopancreas and ovary remains fragmentary.

Whatever the intermediate steps, the increased hlycogen content of late intermoult crabs till maturity may be derived ultimately either from protein or lipid or both. It would appear that, to make much further progress with these proplems, it will be essential to have full information about the type of cycle and stage of the animals in the cycle.

The results lead to the general conclusion that crustacean intermediary metabolism centres mainly on glycogen, but Kincaid and Scheer, (1952); Nelland & Scheer (1953); Scheer and Scheer (1951 and 1952) have come to quite different conclusions. According to them the primary energy source of the crustaceans they have investigated (chiefly in **Panulirus** and **Hemigrapsus**) is protein rather than carbohydrate.

Vonk (1960) belived also that carbohydrates and to some extent depot lipid are the main substrates for metabolism in crustaceans. However, he admited that it has been argued that at least some crustaceans utilize proteins as a main energy source. Cowey and Corner (1963) have shown that protein is utilized by **Calanus** under starvation conditions (Conover, 1964). Utilization of protein may also occur in **Neomysis** in view of the low level of both glycogen and even depot lipid.

Hypotheses about the metabolic processes in the crustacea suffer from insufficient knowledge about the normal metabolism of the animals, and also from the lack of pure hormone preparations. Detailed and convincing studies on the control of metabolism in crustacea must await the avaliability of pure hormone preparations.

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