

OBSERVATIONS ON THE TRANSPORT OF SUGARS IN
THE TEMPERATE HOLOTHURIAN,
CUCUMARIA FRONDOSA

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ABSTRACT

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Different views have been put forward regarding the function of the perivisceral fluid and coelomocytes in the nutritional transport of echinoderms. To obtain more information in this field an experiment was done with the temperate holothurian, *Cucumaria frondosa*, using carbon labelled glucose, fructose and sucrose. The results showed the main role played by perivisceral fluid in nutritional transport. The different organs such as the alimentary canal, respiratory tree, body wall and gonad showed differences in their uptake.

INTRODUCTION

The roles of the perivisceral fluid and the coelomocytes in the nutritional transport system in different members of the echinoderms have been worked out by other authors (FERGUSON 1962, 1963 and 1968; FARMANFARMAIAN 1963 and 1969; FONTAINE and LAMBERT 1973). However, while considering the role of the perivisceral fluid, some authors (FERGUSON 1962, 1963 and 1968; FARMANFARMAIAN 1963 and 1969) believe that the liquid phase of this fluid plays an important role in the transportation of nutrient materials. In a previous work on a tropical holothurian, *Holothuria scabra* (KRISHNAN and KRISHNASWAMY 1970; KRISHNAN 1971), it was shown that both the perivisceral fluid and the coelomocytes take part in such a function. In the present study *in vivo* experiments were carried out with carbon labelled sugars in the temperate holothurian, *Cacumaria frondosa*, to see the rate of transport of nutrient materials by the perivisceral fluid. The work was also carried out to compare such function in the tropical and temperate forms.

MATERIAL AND METHODS

The specimens of *Cucumaria frondosa* were collected from Strømme near Bergen, Norway, by diving. They were acclimated to the laboratory condition. During the experiments the animals were maintained in continuously circulating sea water with a temperature of 10°C and salinity of 34‰. Before treating the animals with isotopes, they were starved for not less than 24 hours (to avoid loss through excretion) and then transferred to the experimental tanks. The carbon labelled sugars used in these experiments were purchased from the Radiochemical centre, Amersham, England. These isotopes were first diluted in the filtered sea water to a concentration of 5 μ Ci/ml. Each animal was injected with 1 ml of the above mentioned sugars having the following specific activity:

- D-glucose — 1—C—14: 57 mCi per mmol.
 D-fructose — 1—C—14: 58 mCi per mmol.
 Sucrose — C—14 (U) 600 mCi per mmol.

In order to follow the role of the perivisceral fluid, the radioisotopes were injected directly into the coelom of the animal with the help of a microsyringe. After an interval of 1 hour, 1 ml of the coelomic fluid was syringed out and dissolved in 9 ml of the instagel for counting. To see the rate of uptake of these sugars by different organ systems, major organs such as the alimenteray canal, respiratory tree, gonad and body wall were removed simultaneously from those individuals and dried in a hot air oven at 75°C to constant weight. Each set of experiments (with glucose, fructose or sucrose) lasted for 10 hours. The results given are the mean values of duplicate sets.

For counting the radioactivity in the dry tissues, the method given by the Beckman application, was followed. All the countings were carried out with the Packard Scintillation counter, model 2002. In the case of the perivisceral fluid the results of the translocation are presented in counts per 100 g wet weight of the animal:

$$\left(\frac{\text{counts for 1 ml of the coelomic fluid}}{\text{weight for the animal}} \times 100 \right).$$

In the case of the organs the results are expressed in counts per 100 mg dry weight. The results are shown in a semilog graph. Since eye fitting was found more informative, it was used for the perivisceral fluid, and for organs they are plotted using the formula $y = ax + b$.

RESULTS

Fig. 1 shows that all three types of sugars (two mono — and one disaccharide) are translocated, more or less uniformly, from the coelomic fluid. However, the figure also shows clearly that glucose and sucrose are transported much more quickly than fructose. It is also obvious that such a function is completed within the first 4—5 hours for all the sugars.

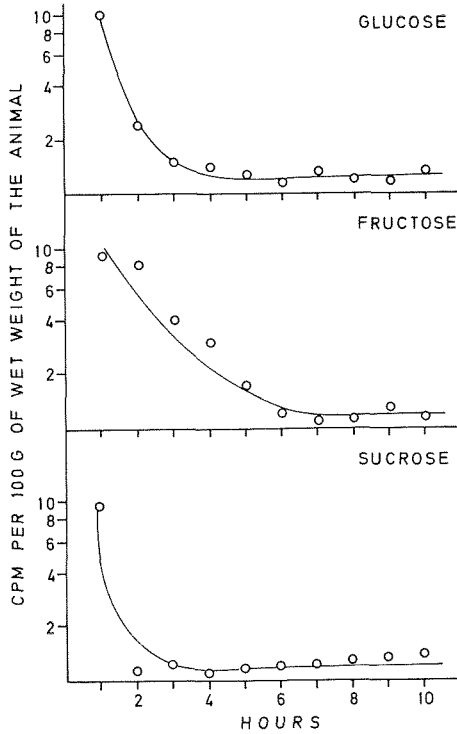


Fig. 1. The rate of translocation of carbon labelled sugars by the perivisceral fluid during 10 hrs. Actual values in Y-axis: 2×10^4 for glucose; 4×10^3 for fructose and sucrose.

Of the four major organs analysed (namely body wall, alimentary canal, respiratory tree and the gonad) for the uptake of the translocated sugars from the perivisceral fluid, the body wall appears to have absorbed a maximum of glucose when compared to other organs (Fig. 2 A); the respiratory tree seems to have taken up mainly fructose (Fig. 2 B); the alimentary canal seems to have absorbed all the sugars in the beginning, but started losing glucose and fructose after some time (Fig. 3 A). In the case of the gonad all three sugars are absorbed in the beginning, but after some time it starts losing all of them (Fig. 3 B). Such diversified results may be due to the varied metabolic stage of the organs.

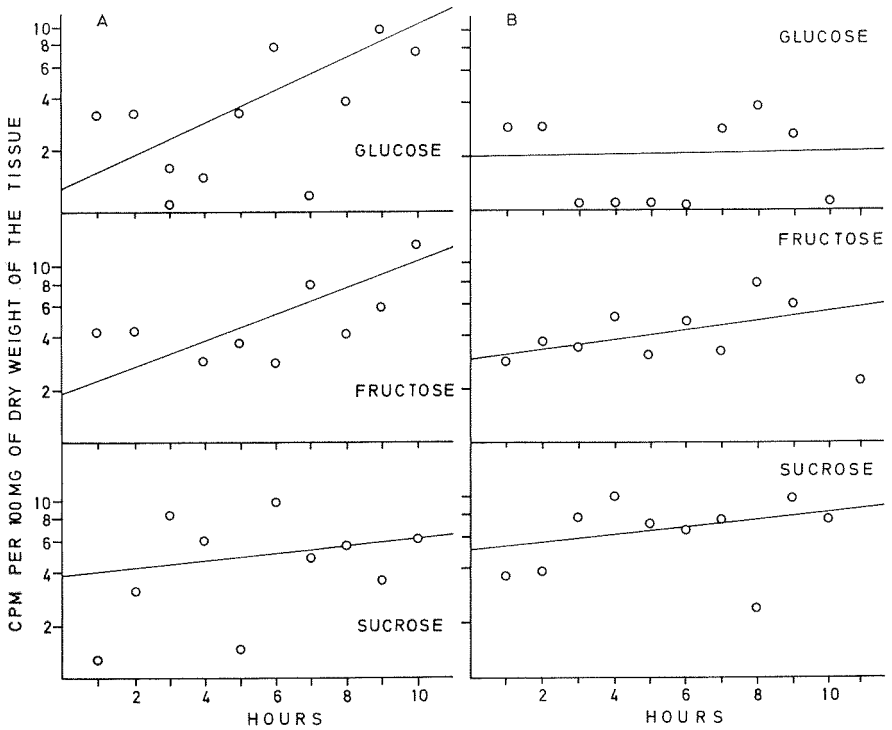


Fig. 2 A. The reaction of the body wall to the C-¹⁴ sugars.

$$Y = 2091x + 0,31 \text{ for glucose}$$

$$Y = 1077x + 0,44 \text{ for fructose}$$

$$Y = 551x + 0,95 \text{ for sucrose}$$

Fig. 2 B. Absorption rate of carbon labelled sugars by the respiratory tree.

Actual values in Y-axis: $x \cdot 10^6$ for glucose, $x \cdot 10^4$ for sucrose and fructose.

$$Y = 979x + 0,20 \text{ for glucose}$$

$$Y = 2189x + 0,29 \text{ for fructose}$$

$$Y = 2736x + 0,52 \text{ for sucrose}$$

DISCUSSION

The results of the present experimental studies confirm the view of FARMANFARMAIAN (1963) and KRISHNAN (1971) that the perivisceral fluid is playing a significant role in the transport of both of the sugar types employed. While presenting the rate of uptake of sugars in the holothurian, *H. scabra*, KRISHNAN and KRISHNASWAMY (1970) found that there appeared to be selective absorption of the sugars by different organs analysed. In *C. frondosa*, experiments with the labelled sugars have shown such selective absorption by the various tissues. However, such selectivity differs from what was observed for *H. scabra*. In the present study there seems to be a loss of the absorbed sugars from the

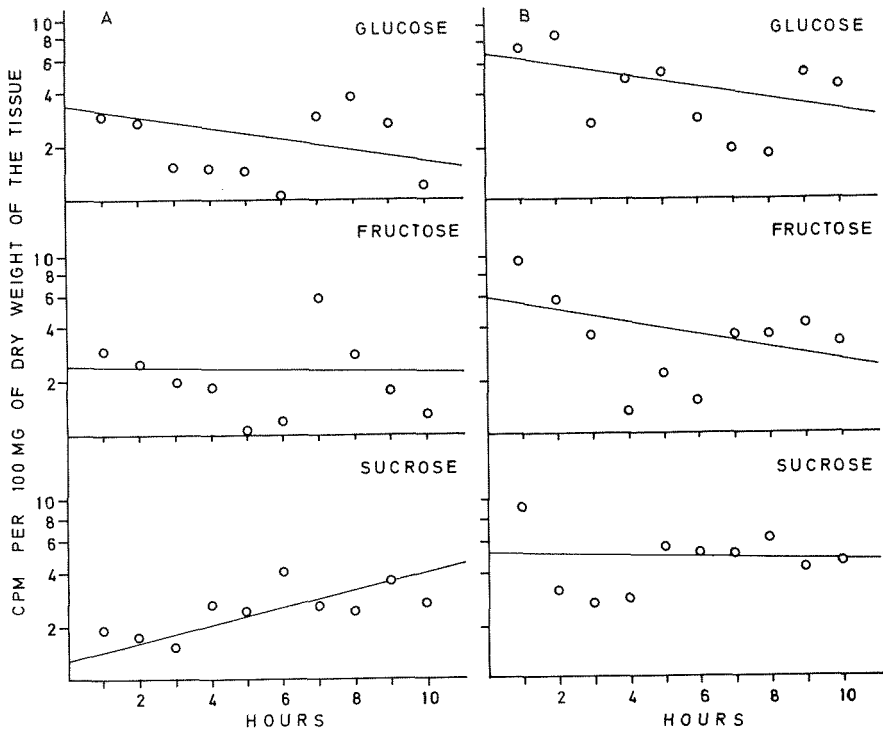


Fig. 3 A. The rate of absorption of C^{14} sugars by the alimentary canal.

Actual values in Y-axis: $\times 10^4$ for all sugars

$$Y = -1713x + 0,32 \text{ for glucose}$$

$$Y = -238x + 0,24 \text{ for fructose}$$

$$Y = 2158x + 0,13 \text{ for sucrose.}$$

Fig. 3 B. Absorption rate of C^{14} sugars by the gonad.

Actual values in Y-axis: $\times 10^3$ for glucose; 5×10^3 for fructose; $3,5 \times 10^2$ for sucrose.

$$Y = -401x + 0,67 \text{ for glucose}$$

$$Y = -1938x + 0,30 \text{ for fructose}$$

$$Y = -239x + 0,18 \text{ for sucrose}$$

alimentary canal. This is true for the monosaccharides glucose and fructose. However, sucrose is shown to be steadily increasing with time. In another holothurian, *Thyone briareus*, FARMANFARMAIAN (1969) reports that the little glucose absorbed (3—17%) in the beginning was later transferred to the required organs through the perivisceral fluid by active transport. This too is true in the case of *C. frondosa*.

While looking into the uptake of sugars by the respiratory tree and body wall, one can easily understand that all those sugars were absorbed steadily. However, the body wall appears to be utilizing more of the monosaccharides than the disaccharide. It is shown in different species of holothurians that glycogen is absent in the body (BENZAZZI-LENTATI

1941; FISH 1967; KRISHNAN 1968). Hence it is tentatively suggested that the body wall may be utilizing the simple sugars available, instead of the glycogen, for its metabolic activity. On the other hand the respiratory tree seems to have more capacity for utilizing sucrose when compared to the other organs. It is quite obvious that this being the most active organ of the body, it is able to utilize all the sugars, sucrose in particular.

The animals taken for the experiments were all in mature condition. It is suggested that since there may not be much synthetic activity in mature gonads, no significant uptake of sugars has been shown by the gonadal tissues. Further, the descending nature of the slope in the regression lines for the three sugars (Fig. 3 B) can be explained as the reabsorption by the coelomic fluid and translocation to other active organs like the respiratory tree and body wall.

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