Biology of the Oyster in Relation to Sanitation*

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OWING to several anatomical and physiological features of the oyster, the sanitary control of the oyster industry presents certain difficulties not encountered in the handling and marketing of other perishable sea foods. An understanding of the biology of this mollusk seems indispensable for an intelligent application of the principles of sanitation to this highly specialized branch of the fish industry. The fact that great quantities of oysters are consumed raw and that, excepting its shell, it is eaten in its entirety, makes the question of what constitutes the oyster's food and how it is taken in of great practical importance. Because the mode of feeding of the oyster consists in straining great volumes of water through the gills and ingesting the microscopical suspended material, the purity of the meat is correlated closely with the organism's activity and the character of the water surrounding it.

The feeding of the oyster is controlled by at least 3 sets of organs: gills, mantle, and adductor muscle. The gill may be regarded as the most conspicuous organ of the lamellibranch body which, besides its primary respiratory function, has become a principal organ of feeding, comparable to a very complex sieve capable of filtering a large quantity of water. The synchronous beating of the ciliae covering the surface of the gill, forces the water through the pores into the epibranchial chamber (spaces above the gill lamellae) and into the cloaca. The rate of feeding is therefore entirely dependent upon the efficiency of the ciliated mechanism of the gill. The latter, however, is affected by physical and chemical changes in the outside environment which exert upon it either a stimulating or depressing influence. The filtering capacity varies with size, shape and condition of the organism, but in all the oysters it is controlled by the temperature. At a temperature of about 25° C. an adult oyster may filter as much as 7 liters of water per hour, the rate decreasing with a drop in temperature and at 7° C. activity ceases.

It is obvious that inhibition of ciliary motion results in a deficiency or complete cessation of feeding. This conclusion, made from the results of experiments, was fully corroborated by the author's observations during 3 years (1932–1935) on oysters in Long Island Sound. Stomachs and intestines examined at bi-weekly intervals were completely devoid of food and even no trace of crystalline style was found in the samples taken during the cold season when the temperature of the water was less than 7° C.

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From the point of view of sanitation it is of interest to determine the efficiency of the oyster gills in removing bacteria from the water. Experiments (Galtsoff, 1928) carried out with oysters placed in water to which a known number of *B. coli* was added, show that only 30 per cent of bacteria are retained by the gills. Apparently these microörganisms are so small that they can pass easily between the cilia and escape back into the water.

The feeding of the oyster is also influenced by the length of time the shells remain open and by the position of the two mantles which, by coming together, may considerably reduce the amount of water sucked in by the gills. Hopkins (1931) has demonstrated in *Ostrea lurida* that it is not so much the existing temperature of the water which determines how long the shell remains open as it is the changes in temperature which control the behavior of the adductor muscle, and are therefore of far greater importance. Falling temperature causes the shells to close, while a rise in temperature is followed by opening. The length of time which oysters remain open depends upon several factors and varies in different localities. From the point of view of sanitary control it is of interest to mention that *Ostrea virginica* may slightly open its shell at 4–5° C. when no current is produced by the gills and consequently no food is found in the intestinal tract.

The oyster possesses a well developed chemical sense which permits the organism to react to changes in the water and detect the presence of small amounts of irritating substances. When a polluting substance is present the oyster protects itself by closing the valves and reducing the number of hours of feeding. Should these conditions prevail for a long time, growth is retarded, the flesh becomes emaciated, and increased mortality ensues. Investigations carried out on the effects of pulp mill pollution (Hopkins, Galtsoff, and McMillan, 1931) showed that death occurred more quickly among oysters which kept their valves open for a longer period of time, those surviving longer which considerably reduced the daily average number of hours during which their shells remained open.

The nutritive value of the oyster meat varies with the seasons and is influenced by the conditions under which it grows. From the nutritional point of view the quality of the oyster is determined by the per cent of solids, glycogen, mineral salts, and vitamin content of the meat. Only the first two factors have been subject to systematic investigation. Normally oyster meat contains about 80 per cent of water, being however, subject to wide fluctuations. Under certain conditions, it is rather difficult to establish a definite standard. Present regulations designed to prevent adulteration forbid putting oysters in water of lower salinity than that in which they were grown. Oysters are very tolerant of changes in salinity. They may thrive as well in water having about 10 parts of salts per 1,000 as in that with salinity ranging between 22 and 27. Moreover, the water content of the meat may vary independently of changes in salinity of the surrounding water. The author's observations show that the water content of oyster meats may increase from 80 to 88 per cent immediately following the shedding of eggs and sperm. As a rule oysters become watery after spawning although the salinity remains constant.

Early in the fall oysters begin to store glycogen, the content of which may reach as high as 12–14 per cent (fresh basis). This process is accompanied by an increase in solids and a corresponding decrease of water in the tissues. At this time oysters have the highest nutritive value. With the onset of cold weather feeding ceases, though the glycogen content remains on a high level throughout the winter. This indicates that all the physiological activities are greatly reduced and that during the hibernating period the organism draws but little on the supplies stored in its tissues. It is remarkable that in spite of the complete cessation of feeding the growth of shell both in length and weight continues.

There is no information regarding the seasonal fluctuations in the contents of heavy metals and vitamins in oyster tissues, though there are sufficient data to show the existence of a definite correlation between the iron and copper content and their geographical distribution (Galtsoff, 1934). In general, oysters from the North Atlantic are poor in iron and rich in copper, while the reverse is true for the South Atlantic and Gulf States, the variation occurring gradually as we proceed along the coast from Rhode Island to Florida. This suggests that the observed changes are not incidental but may be due to differences in the chemical composition of water. Unfortunately our knowledge regarding the iron and copper metabolism in the oyster is too incomplete to justify further speculation regarding the significance of the observed facts.

An understanding of the salient biological features of the oyster may be useful to the public health officer in outlining and executing an efficient sanitary control of the oyster industry. One must bear in mind that the oyster is readily affected by changes in environment, and easily adapts itself to new conditions. In this respect it differs from other sea food and presents more difficulties from the point of view of sanitation.

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EVEN the more magnificent scientific discoveries, especially those of recent years, have not penetrated into our general education, and are entirely disregarded in most discussions of social problems. And yet an imposing accumulation of critical information of wide bearing is at our disposal which might become an active factor in the readjustment of the troubled relations of man were it possible to overcome the obstacles to its general dissemination and acceptance.—James Harvey Robinson, *Humanizing of Knowledge*, 1924.