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Research Seeks to Expand New Fishery[1]

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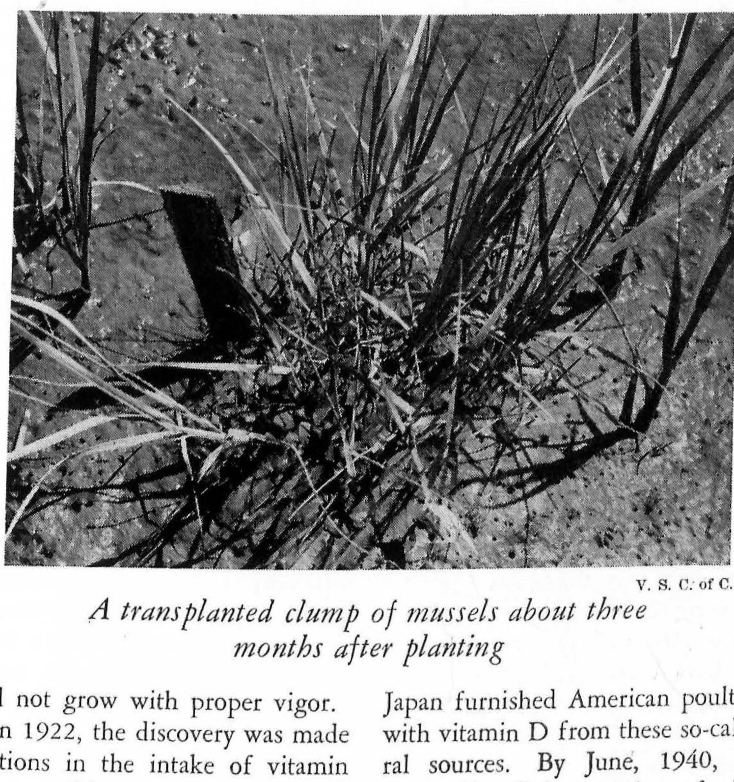
TIME was when poultry farmers gave no attention to the vitamin requirements of their poultry, for the reason that nothing was known of this important subject. As a result, egg laying was subject to great seasonal variations and chicks did not grow with proper vigor.

Then, in 1922, the discovery was made that variations in the intake of vitamin D were responsible in no small measure for this condition. Fish oils and fish liver oils were the first readily available means of meeting deficiencies of this constituent, and in the period from 1922 to the outbreak of the European war in 1939, Canada, Iceland, England, Norway, and Japan furnished American poultry raisers with vitamin D from these so-called natural sources. By June, 1940, however, practically all importation of vitamin D from across the Atlantic Ocean was shut off, and even before Pearl Harbor the Japanese sources were excluded. Only



V. S. C. of C.

A transplanted clump of mussels about three months after planting

[1]Valuable assistance in the preparation of this article has been given by E. I. du Pont de Nemours & Company.

nominal amounts of vitamin D oils were produced in the United States.

Years of investigation had disclosed by 1936 that the edible sea mussel of Holland provided a suitable source of the raw material necessary for the production of a man-made vitamin D. Mussels from the tidewater marshes of Holland had been used commercially as human food for years, so an established Dutch industry was in a position to respond to this new discovery. The part of the mussel that supplied the vitamin D was a sterol. Sterols are fat-soluble, wax-like materials found in variable quantities in practically all forms of animal life. The particular sterol which can be converted into vitamin D by irradiation with ultraviolet light is known as "provitamin D."

During the three years following 1936, the supply of American man-made vitamin D was dependent upon Holland and its established mussel industry for this "provitamin D."

In 1940, the ribbed mussels, *Volsella demissus*, of Tidewater Virginia were discovered by Du Pont chemists to be rich in this "provitamin D." This discovery was followed immediately by the development of a mussel fishery on the "Seaside" of Virginia's Eastern Shore peninsula, the activity centering on the large intertidal marshes where the mussels grow and in the shucking houses along the water fronts of shore towns where the mussels are steamed, shucked, and packed for shipment. This fishery has since constituted the country's principal available "provitamin D" source, and large war demands for eggs and poultry meat have been met by the poultry industry with the help of the previously unexploited Virginia mussels.

Because of the prospective importance of the mussel, the Du Pont company acted through the Virginia Fisheries Laboratory in 1940 to initiate a biological study of this as yet little-known bivalve. To produce the "provitamin D" efficiently and economically, information was needed on the distribution and abundance of mussel beds, the productive capacity of an area of marsh, the effect of digging operations on the growth of mussels, and the time required to grow commercial-size mussels. Considerable progress has since been made on this investigation.

The mussel lives all-but-buried in the soft mud and is dug with a clam pick or similar implement. As in the oyster industry, the bushel is the usual commercial unit. It holds about 600 mussels and is sold by the digger for from 40 cents to $1, depending on the labor situation. The average number of bushels dug per day per man is between nine and ten. The best workers dig as many as sixteen bushels during a single low tide.

Mussels are dug in the marshes and transported on scows to the shucking houses. There, after the mussels are steamed the meats are removed from the shells, washed, packed, and frozen for shipment.

Life Cycle and Habitat of the Mussel

In general, ribbed mussels are found wherever the reeded salt marshes occur. This takes in all the shores of Chesapeake Bay and its tidal tributaries as far up as the salinity is suitable. The most valuable commercial beds, however, are on the Sea Side of the Eastern Shore, in the extensive marshes situated between the mainland and the outer-shore islands. Mussels range northward to Nova Scotia and southward to Georgia, beds of considerable size occurring in the Carolinas, but the center of the commercial supply is in Virginia.

Three principal conditions are necessary for the mussel habitat. First, reeds must be present, to the roots of which mussels attach themselves by secreting a

V. S. C. of C.

A mussel marsh at high tide. The tumps are recognizable by the taller and denser growth of reeds mass of threads. Immature mussels may also be found attached to oysters or other shells, to pilings, and to driftwood. The second important condition is that the bottom in which the mussels are embedded be composed of mud or a mixture of mud and some sand. The third condition pertains to the position or level within the tidal zone. In Virginia mussels are not ordinarily found higher than the upper limit of neap tides or lower than the middle of the entire tidal zone, a vertical range of about two feet.

The mussel population may grow into one of three rather distinct kinds of formations, namely: tump, strip, and mat.

Tump formation. Scattered throughout the soft mud marshes are clumps of mussels which are designated as tumps. They vary in size from a few inches to several yards in diameter, and a single tump may contain several hundred mussels of commercial size. Most of them occur toward the sources of small guts or drains through which tidal waters enter and leave the marshes.

Tumps are the result of vital activities of the mussels themselves. A tentative reconstruction of the development of a tump is as follows: Larval mussels attach themselves to suitable objects in the marsh—ordinarily to reed roots or partly embedded coon oysters. They become covered with the marsh mud until only the posterior or open end of the shell is visible above the mud line. By means of a special ciliary mechanism the mussel draws a current of water into its mouth and extracts microscopic living forms which it uses for food. The feeding process is fundamentally the same as for oysters, although the actual elements of food required may be different. Mud is added to the tump as a result of metabolic activities of the mussels. It is composed of wastes and of debris from the decomposition of the reeds. These materials look like the black mud of the marsh substrate. New strike or attachment of mussels from year to year adds to the number of mussels in the tump and these in turn add to the pile of mud around the group.

In the relatively quiet waters of the Sea Side of the Eastern Shore, tidal currents and waves seem to be insufficient to remove the accumulation of silt in and around the tumps so that they gradually build up. Fertilized by the mussels, they are rich in elements needed for the growth of the reeds. Hence, reed growth on the tumps is constantly richer than that of the surrounding marsh. Tumps may be readily recognized at a distance because of the taller and thicker masses of reeds.

Sides of the shells of the original mussels of a developing tump provide surface for attachment of larvae. These are partially protected by the shells of the larger mussels and by dense reed growth. However, increase in numbers of mussels in a tump is a slow process. The soft mud and waste products of the larger mussels seem to have a smothering effect on the minute mussels. Only a few manage to survive and attain a size sufficient to afford self-protection. Although studies have not progressed far enough to determine definitely the ages of different sized tumps, they are probably measured in terms of many years or even in decades. Individual mussels in a mature tump probably average between five and nine years of age.

Until now, the tumps of the marshes have produced most of the commercially valuable mussels. Relatively few tump formations exist in Virginia outside of the Sea Side of the Eastern Shore, where the industry has been centered.

Strip formation occurs as narrow bands around the margins of shores, where the steeper slope of the intertidal zone causes the mussel zone to be narrow. These zones are subject to swift tidal currents or wave and breaker action which prevents silt from accumulating. Thus, the mussels occur in small, compact groups or clusters, each group containing up to several hundred small mussels, firmly embedded in hard-packed mud, held together by roots of the reeds. Several clusters may grow together to form more extensive areas of tightly packed small mussels. In general, strip formation is favorable for the preservation of young mussels, with plentiful opportunity for attachment in the existing groups and freedom from the smothering silt of quiet, soft marshes. Strip formation is found discontinuously around the entire Chesapeake Bay shore as well as on the Sea Side.

Crowding rarely allows many mussels to reach a mature size and enforces a comparatively slow growth. Mussels necessarily project above the substrate, and the larger ones, projecting farther, are more subject to attack by various natural enemies such as shore birds and crabs. Many mussels are literally squeezed out of the clumps by growth pressure and are thus left without protection.

There are conspicuous differences in the average sizes attained by tump and strip mussels. In tump formation, the size class that has the most numerous mussels is that ranging in length from 9 to 10 cm. (roughly 3.5 to 4 inches) and estimated to be from five and one-half to eight years of age. The corresponding size group of strip mussels is the 3 to 4 cm. class (about 1.2 to 1.7 inches) in their second or third year of growth. The length range of mussels used for commercial purposes is from about 3.5 to 4 inches. With the present methods of processing, mussels below two inches are too small to be used profitably.

Mat formation does not differ materially from strip formation except that it is composed of continuous and extensive

Drawn by J. G. Mackin

Cross section of a tump. The mussels live almost buried, with only the open end of the shell visible above the mudline. To the left, above the tump, is an oyster. Snails cling to the reeds

A scowload of mussels, taken in a Sea Side marsh, being pushed toward an open-water channel. In two days these men gathered more than fifty bushels of mussels

carpets of tightly packed small mussels. This growth form occurs to a limited extent at various scattered localities, but extensively only near Chincoteague on the Sea Side. A square yard of mat formation may contain more than 5,000 small mussels, none of them large enough to be used commercially.

Problems of the Industry

As in all fisheries the basic problem to be considered is that of the extent of natural production in relation to the demands of the industry. It was early recognized by the Du Pont company that the existing supply of mussels might soon be exhausted. As a result, the company assisted largely in initiating and carrying out biological studies on mussel culture. It seemed desirable to make an estimate of the probable time lapse before restrictions or regulations would be required to prevent complete exhaustion of the commercial beds. It was necessary to know whether natural production could keep pace with commercial utilization. If not, methods of mussel culture comparable to those used successfully by the oyster industry would need to be discovered and practiced.

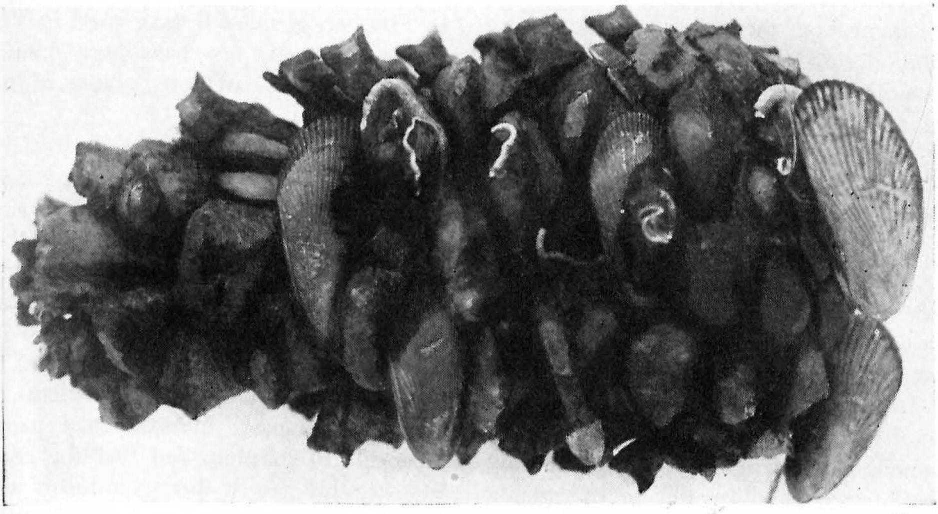
The problem of discovering a practical method of culture necessitated a careful study of the reproductive processes, growth, and life habits of the mussel. This study is still in progress but is far enough advanced to warrant a discussion of the results obtained up to this time.

Early in the investigation it became clear that natural reproduction and growth of mussel tumps was disappointingly slow, and that if the industry were geared down to the level of the natural supply and hence to the level of natural replenishment it would always remain a minor affair. The first two years of the industry witnessed the digging of upward of 80 percent of the choice marshes of the Sea Side and it became increasingly difficult for diggers to find "easy" tumps with large numbers of commercial-size mussels. Furthermore, it was soon discovered that dug-over tumps would recover only slowly, if at all.

There remained two possibilities: that of working out methods of mussel culture which would step up production to a level approximating commercial needs, and that of increasing the production of provitamin D by synthetic means. With respect to the first prospect, two important conditions are favorable. First, there is no lack of space in the marshes, since the natural tumps, although numerous, are estimated to occupy less than 1 percent of the soft marsh favorable to tump growth. If methods could be evolved to utilize the 99 percent of unused area, or even any significant part of it, the problem would be solved. Second, certain more or less closely related bivalves, including oysters and clams, have been cultured for many years. From this experience suggestions could be drawn that might be of value in dealing with the ribbed mussel.

In addition to extensive surveys, morphological studies and growth experiments, two principal approaches to the problem of increased production, have been followed. The first has been an effort to produce conditions in the soft marshes favorable for an increase in the amount of "strike," that is, the numbers of microscopic, free-swimming larvae that have settled down or struck on the bottom where there is a suitable surface for attachment. Different surfaces for attachment have been tried with varying degrees of success. In nature, "strike" is heaviest in crevices and narrow angles of shells that are protected from enemies, silting, and other adverse conditions. Types of culch that have shown promise are corn cobs wired to stakes, coon oyster clumps, brooms made of pine needles, and pine cones.

However, the securing of "strike" has so far failed to lead to the successful



Moore

Cemented pine cone used as culch, to which mussels have attached outcome desired. Two factors have contributed to the failure, one being the fact that ribbed mussel larvae, after attaching, apparently either fail to survive or move off the culch. The second factor is failure of culch to accumulate larvae during succeeding years.

It was expected that culch would form the nucleus of new tumps, and, from the evidence, it is quite probable that coon oysters may be used to accomplish this purpose. However, the development may prove to be too slow to be commercially practical.

A second approach to mussel culture has possibilities. It will be recalled that the strip formation mussels are too small to be used commercially and are widely distributed over large portions of the shores of Tidewater. It was conceivable that these mussels, if transplanted from their hard substrate to the soft marshes, might grow well in the new environment. Various experiments with such transplants have been carried out during the past two years. Questions bearing on mortality of transplanted mussels, rate of growth of transplants, and best methods of transportation are being investigated.

In general, the clumps of mussels are dug out of the hard strips with long-handled shovels, care being taken to retain reeds and hard mud around the clumps. These clumps are transported by scows to the marshes, floated onto the transplant area at high tide, and dumped overboard in rows marked out by stakes. After the tide recedes, workmen go into the marsh and set the clumps into orderly rows with the mussels correctly oriented and set part way into the soft mud.

A certain percentage of the transplant mussels die for various reasons, chief among them being crab predation, silting, and rough handling during transplantation. Silting, as previously observed, is deadly to very small mussels in the tump-bearing marshes. Blue crabs, possessing a voracious appetite and powerful crushing claws, can wipe out whole areas of transplants in a few days time. Ultimate success or failure of the culture experiments depends on control of losses occasioned by these two mortality factors.

With respect to the possibility of synthetic production or production from other sources, scientific investigations by the chemists have disclosed that a "provitamin D" similar to that in mussels can be produced from a packing-house product, cholesterol, and, as a consequence, the "provitamin D"' from Virginia mussels may not turn out to be the first choice. Furthermore, the biological chemist and the animal nutritionist continue to explore the field of sterol chemistry for ingredients that were unknown yesterday but can be vital necessities tomorrow.

Looking to the future, the possibilities are that the poultry industry will continue to depend on production both from natural sources and from synthetic processes. The relative extent of the use of these sources will probably depend upon comparative costs.

During 1940-43, approximately 400,000 bushels of mussels were taken in Virginia. Relatively few have been obtainable during the past year because of the shortage of labor.

Digging mussels is not an attractive, easy job. However, the industry has proved to be helpful to watermen during slack periods when oystering and other long-established fishery industries are seasonally closed. Such a supplementary fishery will again be needed with the return of peace.

It is to be hoped that the problems of the ribbed mussel industry may prove amenable to solution, and that the commonwealth's newest fishing industry will mature into a soundly based and dependable source of revenue for all concerned.