

(not counting local and home consumption) to the enormous weight of 500,000 pounds, and the cash receipts for salmon in Restigouche County that year amounted to more than \$40,000, besides which some \$5,000 was expended by anglers; this result was almost entirely brought about by artificial propagation. A new hatchery of size sufficient to produce five million young fish annually will no doubt soon be erected by the Dominion Government upon this river.

A somewhat similar record might be given of the river Saguenay. Some years ago anglers and net fishers of this river said it was useless to lease from the department, as the scarcity of salmon was such as not to warrant the outlay. A hatchery was built, and this state of things is now wonderfully changed; so much so, indeed, that in 1878 salmon, from the great numbers which were taken at the tidal fisheries, became a drug in the market, selling often as low as three cents per pound, and angling in the tributaries was most excellent.

Some one hundred million young salmon have been artificially hatched and distributed in the waters of the Dominion during the last few years, and new government hatcheries are constantly being erected.

Yours, &c.,

FRANK TODD,

*Fishery Overseer, Saint Croix District.*

**FOOD OF THE SHAD OF THE ATLANTIC COAST OF THE UNITED STATES (ALOSA PRÆSTABILIS DE KAY); AND THE FUNCTIONS OF THE PYLORIC CÆCA.\***

**By E. R. MORDECAI, M. D.**

1. The small size and the arrangement of the teeth would suggest that the food of this fish is easy of prehension.†
2. The gullet is capacious.
3. The stomach, as is well known, consists of a conical, and gizzard portion. The tissues of the former do not differ from those of the stomach of an ordinary fish. The latter is a powerful muscular apparatus, terminating in a very constricted pyloric orifice.
4. The pylorus opens into an intestinal tube neither remarkable for its length nor breadth.
5. The pyloric cæca are fusiform sacculi, varying in number, by my enumeration, from sixty to a hundred—according to the development of the fish.

They enter the intestinal canal. The points of communication are marked by depressions in the mucous membrane of the wall of the viscus. Sometimes six or eight cæca will be found to open into a single depression.

\* Reprinted from a pamphlet entitled: Food of the shad of the Atlantic coast of the United States, (Alosa præstabilis De Kay); and the functions of the pyloric cæca. by E. R. Mordecai, M. D., Member of the Academy of Natural Sciences of Philadelphia. — Philadelphia: King & Baird, Printers, 607 Sansom St. 1860.

†The teeth are very minute.

Below the pylorus the intestine is expanded for an inch and a quarter of its length. It is into the inferior wall of this *basin* that the largest, longest, and the greatest number of these appendages enter.

The cœca vary in length, by actual measurement, from an inch to three inches and a half; and in circumference, from that of a small probe to that of a number six catheter. When the fish is in good condition, they are separated from each other, and supported by delicate layers of fat; the cellular tissue of which is abundantly supplied with vessels, that expend themselves on the walls of the cœca. The blind extremities of the sacculi gravitate freely in the abdominal cavity.

Such, in part, is a rapid anatomical sketch of the organs of digestion. What is the food of the fish? and what are the functions of the cœca?

As the shad of the Western Atlantic makes its appearance first off the coast of Georgia, it occurred to me that could specimens, *fresh-run* from the sea, be obtained from this locality immediately after the appearance of the fish, that an opportunity would be offered of discovering from the contents of the stomach more in relation to its habits than was known.

On the 2d of February of the current year, two shad, which were fortunately procured from Savannah, Ga., were examined at my office in Mobile.

The stomach of the first contained nothing except a small quantity of brownish mucus, which others have described.

But I was astonished to find the cœca greatly elongated and distended. They were of a flesh color—evidently due to their contents, viz: a homogeneous-looking fluid, which, when squeezed through the cœcal orifices into the intestinal canal, was found not to differ materially, under the naked eye, from the brownish mucus alluded to above. To my mind the functions of the cœca were apparent.

The gizzard-stomach of the second specimen, in addition to the brownish mucus, contained a minute quantity of solid matter. This was immediately mounted on a slide and subjected to a lens of low power suitable for examining vegetable tissue entire.

I was amazed at the beauty and perfection of the objects displayed—minute cylindrical stalks, and differently shaped and colored fragments of algæ, gemmed with the pearly calcareous shields of infusoria! Many of the shells, having altogether escaped the effects of the action of the stomach, preserved their integrity—bi-convex loricae predominating.

A Bailey would know and name them at a glance.

They are to be seen of all sizes, from the fully formed disc to that presenting under the same power a mere point.

An algologist might readily determine the species to which the fuci belong.

The question relative to the food of *Alosa præstabilis* is answered.

Shad feed and fatten on marine fuci, and on the microscopic organisms that are parasitically attached. Both are necessary to the economy of the fish. How beautiful the adaptation! The succulent vegetable mat-

ter, held and macerated in the conical division of the stomach, passes gradually into the gizzard, where it is in time thoroughly disintegrated by the powerful walls of this muscular apparatus, aided by the sharp points and edges of the broken shells of the infusoria. Reduced to chyme—the brownish mucus of some observers—it passes the small pyloric orifice, is changed by admixture with the proper secretions, which meet it at the threshold, and is immediately *sucked* up into the cœca, that distend to receive it.

In these receptacles the liquid food, prepared in the ocean, is stored away to nourish the fish in its long passage, five or six hundred miles perhaps, to the headwaters of rivers, where the ova are to be deposited and receive impregnation. Thus we may explain how it is that a fish coming to us in superb condition from the sea, with nothing apparently in its intestinal canal but a little discolored mucus, can make this ascent, execute the functions necessary for the reproduction of its species, and descend to its feeding grounds in the deep.

In the absence of food the fish feeds on the nutritive contents of the cœca; either by forcing a certain quantity of the fluid into the large intestine, or, and this is far more likely, by absorption immediately from the cœca—each of these appendages being provided with a sphincter, or valvular arrangement, to prevent the involuntary passage of its contents into the general reservoir. The action of gravity on the free extremities of the loaded tubes would materially assist this retention.

Something like this, there is little doubt in my mind, takes place in the other species, and genera, provided with cœca, that run from the sea to spawn. These useful appendages varying in number, and size, according to the *habits* of the fish, and the presence or absence of food in the fresh-water streams which they ascend.

Some finding, although precariously, appropriate food, a part of the fortuitous excess of to-day is stored away for to-morrow's scarcity.

The adult shad from *its* habits during the season for spawning (for the fatness of the fish and the apparent emptiness of its alimentary canal have long been subjects of wonder) requiring an abundant supply of food for *long* voyages, has a great number of receptacles.

The number varies in individuals of the same species; less than seventy and more than ninety-five having been carefully counted by me in the specimens examined. And this difference seems to be directly in proportion to the size, and, there is good reason to believe, the age of the fish. It may be thus explained. In the young adult shad some of the cœca are rudimentary.\* They are gradually developed with the growth of the fish until a fixed number is reached for the species.

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\* Since this paper was read before the Academy, I have found some of these organs in a rudimentary state in the young adult of *Labrax lineatus* (striped bass, rock-fish), and in specimens of the species of *Dioplites* (another of the perch family) generally known as "trout" at the South. ●

Preparations proving these ichthyological points are in my possession.

Let us take a British enumeration of these organs in different families, having different habits, and requiring different food. "While there are six in the smelt (*Salmo eperlanus*), there are seventy in the salmon (*S. salar*). In like manner, though there are eighteen in the anchovy (*Clupea encrasicolus*), there are twenty-four in the herring (*C. harengus*), and fourscore in the shad (*C. alosa*). In some, as in the cod, says the same authority, they consist of several large trunks, ramified into numerous small ones.

The herring and anchovy, though closely allied to the shad, are of small size, and do not go far beyond brackish water to spawn. Hence their cœca are few and small. The salmon, a fish of large size, has fewer receptacles than the shad; for the former can obtain, from day to day, suitable food in the fresh waters it frequents. But the adult shad, from the nature of its food, is dependent upon that, in the liquid state, which it brings with it from the ocean; and consequently its pyloric appendages are numerous and long.

In the cod, as was stated before, the cœca consist of several large trunks ramified into numerous small ones. Now, as this is exclusively a salt-water fish, the arrangement here would seem to be at variance with the opinion expressed concerning the uses of these organs. But, compared with the shad, the cod is of enormous size, and, though a salt-water fish, it is highly probable that, for the most part, it migrates from its feeding grounds to perform its reproductive functions in *securer* oceanic localities than those in which it fattens.

It is the shad, however, which occupies our attention.

The distance from shore at which this fish can obtain its appropriate food may be inferred from the botanical nature of the algæ on which they feed; and perhaps the shells of the infusoria may assist the search. As a guide, the statement of Forbes should be regarded.

"The British marine plants," says that author, "are distributed in depth or bathymetrically in a series of zones or regions which extend from high-water mark down to the greatest explored depths" (for plants).

There are no waters more fertile in algæ than those of the Gulf of Mexico; and none in which the minute organisms, that fasten on marine plants, are more numerous and varied. A cold aqueous belt, of vast area—bounded on the south by the gulf-stream—almost isothermal with that which washes the shores of Georgia and the Carolinas—extends along the coast from the mouth of the Mississippi to Cape Sable.

Here may be found several species of *alosa*. One, from its size and physical construction, and as an article of food, rises considerably above insignificance. It is frequently caught in the headwaters of the rivers of Alabama, where it spawns. But the shad of the Atlantic, a fish affording, from its gregarious and prolific nature, a valuable food for man, does not naturally exist in the Gulf of Mexico. Yet there is much reason

to believe that in this sea it could obtain, in great abundance, the peculiar food adapted to its wants.\*

Once successfully introduced, in numbers sufficient to sustain the species against the natural causes of destruction, it must become abundant. For the temperature of the gulf-stream opposing, according to recent experiments, an irremovable barrier to its exit, its oceanic range, on the western side of Florida, would be limited to the body of cold water, the boundaries of which have been described.†

Many of the rivers that pour their contents into this belt would seem to be as well adapted to the functions of reproduction as any the shad naturally frequents. Let us take for comparison the Ockmulgee—one of the branches of the Altamaha, a river of Georgia—and the Flint River, a tributary of the Apalachicola, which flows through western Florida into the Gulf of Mexico.

These streams have their origin in the same State, and spring from a geographical range which is geologically the same. At one point they almost touch. Now the Ockmulgee, like its sister tributary, the Oconee, teems with shad; while in the Flint River they are unknown. Yet they are in juxtaposition, and their waters, for the practical purposes of this deduction, are homogeneous. One makes its way to the Atlantic Ocean, where shad *abound*; the other to the Gulf of Mexico, where they do *not exist*.

But be the possibility of its successful introduction into the Gulf what it may, such, as has been shown, is the food of this fish; and such, with deference to the opinions of others, are the functions of the cœca.

These assertions rest on—

1. The examination of twenty-five or thirty shad obtained from Savannah, Ga, at different times, from February 2d to March 15th, of this year (1860). In three specimens only were the stomachs entirely empty, and in these the cœca were greatly distended.

2. Nineteen stomachs with their contents dried, and glued to glass with Canada balsam. In all of which are to be seen the fuci and shells of infusoria, and in *one* numerous cylindrical stalks of algæ are plainly to be recognized by the naked eye.

3. A part of one of the cœca opened, and flattened out on a slide, the dried contents resting on the mucous membrane. With a glass of higher power, sparkling points of the calcareous discs, which have escaped the action of the gastric juice, may be seen, here and there, in the thinnest parts of this specimen.

4. A parasite from the mucous surface of the above cœcum, identical with one taken from the conical stomach of the *same* fish.

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\* Since this pamphlet was printed I have discovered in the stomach of a species of *Alosa*, very numerous in the Gulf of Mexico, fucus and shells identical with those found in the Atlantic shad.

† See a paper by Mr. Wm. Gessner, of Milledgeville, Ga., in August No. of the Cotton Planter and Soil, p. 256, Montgomery, Ala., 1858.

5. A section of the intestinal canal, cut from a point below the opening of the cœcum nearest the termination of the alimentary tube, spread on glass. It exhibits on its mucous membrane an inspissated matter of a somewhat darker brown color than that of No. 3, and the débris of microscopic shells, small enough to pass the pylorus, but too large to enter the mouths of the cœca.

6. A wet preparation of the gullet, stomach, cœca, and intestine.

7. A preparation in ether of the cœca, their orifices, and the intestinal expansion in which they open.

8. Several dried stomachs (some of the last obtained) unopened, but supposed to contain the fuci and infusoria described.

The most important of the specimens have been placed in the hands of Lieutenant Holt, U. S. A., who has kindly undertaken to deliver them to Dr. Walter F. Atlee, of Philadelphia, to be presented by him, with this monograph, to the Academy of Natural Sciences.

[An abstract of this paper will be found in the December number (1860) of the Proceedings of the Academy of N. Sciences of Philadelphia, *appended* as a continuation of the report from the Biological Department of the Academy for May, 1860. By reference to this report it may be seen that the statements made in relation to the *contents of the stomachs and the cœca* were abundantly verified by members of the Academy in the specimens mounted for microscopical examination which accompanied this paper.\*

Before the shells of the minute organisms can be easily recognized, the solid contents of the stomach should be thinly spread on glass and thoroughly dried, in order to remove the liquid matter which renders these small objects obscure. With specimens thus prepared from fish fresh run from the sea during the spawning season, examined under a bright sunlight, the investigations detailed in this paper may be easily repeated.

MOBILE, ALA., *October 25, 1860.*]

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#### THE MICROPYLE OF THE EGG OF THE WHITE PERCH.

By JOHN A. RYDER.

[Letter to Professor S. F. Baird.]

I have found the micropyle of the egg of the white perch; it measures .0075 millimeter or  $\frac{1}{3333}$  inch in diameter. Average diameter of egg,  $\frac{1}{34}$  inch; of oil sphere,  $\frac{1}{100}$  inch.

WASHINGTON, D. C., *May 17, 1881.*

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\* As the vegetable matter in the stomach of the fish is in a disintegrated state, a lens, generally, is required to determine its nature.