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I therefore conclude that shad choose (or are impelled) to lay their eggs in the highest daily average temperature, a condition which would be realized about or soon after sunset, when the warmer water of the flats is intermingling with the colder channel water and establishing a balance. This suggestion is supported by the fact (at least on the Albemarle Sound and Potomac River) that the greatest number of ripe shad are taken off the edges of the channels.

It is but a step further to infer that fish so sensitively organized as to recognize the highest average of heat on its daily recurrence would readily perceive those tempered areas below creeks, which are relatively warmer. It is not impossible that they would detect an increase in heat here so slight that the ordinary thermometer would fail to record the advance. The air temperature during the run of the shad being on the increase, the creeks are naturally warmer than the river channels. The degree of heat increases from that of frosty mornings in the springtime to the hot days of June, or the time when tree foliage is full grown. The creeks, being sheltered from winds, absorb the sun's direct rays in a relatively greater ratio than the deeper waters of the river proper. The heat is imparted to the water volumes of the creeks on the flood tide and to their mud flats (and conserved) on the ebb tide.

Let the cause be what it may, it can not be denied that those river areas which are traversed by creek currents are the fields of preëminent adaptation for the natural spawning of shad.

The reason for not attempting an application of my observations to the Susquehanna spawning-grounds is that I am less familiar with the localities and have not made full studies of the charts in relation to the recorded receipts of eggs, the details of which form no part of the general office files at Washington. Apparently the large egg-production there (equal or perhaps superior to the amount obtained on any other of the rivers named) is in no way dependent upon creek currents. Since, however, the largest and most regular production of eggs on the Potomac is derived from the gill nets which are operated below and in the currents of creeks, viz, those at Moxley Point and White House, I can but infer that similar relative conditions are in force on the Susquehanna to effect such a great yield of eggs from the gill boats there. That the colder water in the channels and the warmer water on the contiguous flats or bars afford there the corresponding conditions seems altogether probable. The water from the two areas, commingling by gravity in the early part of the night would undoubtedly establish at about that time the temperature of highest daily average. The numerous deep channels and vast expanses of flats seem to be sufficient to account for the large egg-production below Havre de Grace.

6.—A PRELIMINARY REPORT ON THE AQUATIC INVERTEBRATE FAUNA OF THE YELLOWSTONE NATIONAL PARK, WYOMING, AND OF THE FLATHEAD REGION OF MONTANA.

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INTRODUCTORY.

The immediate impulse to the investigation of the aquatic invertebrate fauna of Wyoming and Montana, here reported in a preliminary way, was supplied by the ichthyological work of Dr. David S. Jordan, in the Yellowstone National Park, in 1889, and of Prof. B. W. Evermann, in Montana and Wyoming, in 1891.

The waters of Yellowstone Park had been reconnoitered by Dr. Jordan for the special purpose of ascertaining precisely which of them were destitute of fish and what was the cause of their barrenness. This having proved to be topographical in every case—some physical barrier to the entrance of fishes from below—it seemed possible to stock these waters permanently with valuable game-fishes, and thus greatly to increase the attractiveness of the Park to a considerable class of travelers. Preliminary to this, however, it was evidently desirable that a full knowledge should be had of the variety and abundance of the lower animal life of these fishless waters, since upon this the fishes introduced must chiefly depend for food. To this practical end it was the wish of Hon. Marshall McDonald, United States Commissioner of Fish and Fisheries, that my own investigations made in 1890 should be immediately directed; but with the understanding that the opportunity thus afforded for a general zoölogical survey of the waters of Yellowstone Park should be improved to the best of my ability.

My associate in 1890 was Prof. Edwin Linton, of Washington and Jefferson College, Pennsylvania, who, although specially charged with another duty, that of a study of the parasites of fishes in these waters, rendered me constant and invaluable service in my own special field.

In 1891 it was my general purpose to coöperate with Prof. Evermann in an exploration of the waters of Montana and Wyoming, to be made with reference to the location of a fish-hatchery; but in this, as in the preceding year, I made every effort to become as thoroughly acquainted with the animal life of the waters which I examined as the brief time spent in each locality would permit.