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DEPARTMENT OF COMMERCE

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HUGH M. SMITH, Commissioner

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By ERNEST DANGLADE

Formerly Field Assistant, U. S. Bureau of Fisheries

APPENDIX V TO THE REPORT OF THE U. S. COMMISSIONER OF FISHERIES FOR 1918

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By Ernest Danglade, *Formerly Field Assistant, U. S. Bureau of Fisheries.*

INTRODUCTION.

During February, 1917, the Bureau of Fisheries and the Florida Shell Fish Commission made an investigation of a series of oyster areas on both the east and west coasts of Florida with regard to a reported destruction of oysters by a parasite, which later proved to be a polyclad turbellarian, or flatworm. As early as March, 1916, Dr. R. E. Coker stated, in unpublished field notes, that a worm, known locally as the "leech," was reported to occur occasionally on some of the oyster bars in the vicinity of Tampa, and sometimes to cause within a very short time an enormous mortality among the planted oysters, and that the fear of the pest served to deter the oyster planters from extending the cultivated areas. In the latter part of December of the same year T. R. Hodges, State shell fish commissioner of Florida, submitted to the Bureau a number of oysters, taken from the beds near Cedar Keys, affected with the so-called "leech." The oysters, which had been packed in ice, were alive when received in Washington, and contained from 2 to 3 flatworms each; however, the worms were dead, probably having been frozen in transit. The attacks of this parasite on oysters in these two localities, Tampa and Cedar Keys, are the only ones that had ever come to the attention of the Bureau.

The writer was informed by R. E. Gibson, an oyster dealer and planter of Tampa, Fla., that the worms, or so-called "leeches," had been observed attacking the oysters on some of the oyster bars in the Tampa Bay region at more or less regular intervals during the past 20 years, and particularly during the oyster season 10 years ago. The worms would disappear entirely from the beds for a period of 2 or 3 years and then reappear, the reoccurrences apparently running in cycles. Compared with the attack of the season 1916–17, the previous infestations and mortality were said to have been less extensive and harmful.

On the east coast of Florida a similar outbreak of the worms was observed 10 years ago at three or four points on Indian River. The principal infected localities in that body of water were Indian River Inlet, Bethel Creek, and Orchid. After a very serious and damaging attack, from which some oyster bars were practically depleted or greatly reduced in productivity, the trouble ceased and has not occurred there since. The oyster bars in the meantime have recovered their normal condition.[a] It is interesting to note that the destruction of oysters by turbellarians was reported by David G. Stead

[a] This information was furnished by E. F. McDonald, a practical fisherman of Port Orange, Fla.

from New South Wales in 1907.[a] His notes regarding the discovery of their injurious effect upon oysters are of interest:

A few years ago I found that this worm was known to a few of the oyster farmers of Georges River, who had repeatedly observed it amongst oysters on various leases, and that they distinguished it under the name of "wafer." As this name appears to be fairly suitable, I propose for the future to use it in speaking of this worm. Though, as I say, the wafer has been known to certain lessees, no definite connection between the oyster and this worm has been shown to exist, and no satisfactory evidence has been brought forward to show that the latter was to be added to the already long list of oyster pests. However, in the light of recent evidence, I think it will be found that this is a pest; that it is at times to be seriously reckoned with, and that it will be found to be fairly widespread in our oyster-producing waters.

At the end of July this year [1907], J. W. Swainson, of Georges River, handed to me for determination a number of examples of the wafer, which, he said, was very plentiful on his leases at that time. No visit was made by me for the purpose of investigating the matter. During the early part of September Fisheries Inspector Latta brought in a specimen of an oyster (from a lease in the Hawkesbury River) which was in the last stage of destruction by one of these flatworms, and which contained the worm itself. This specimen had been handed to Mr. Latta by J. Izzard, who had stated that the worm was very plentiful on his leases at Bar Island and Pelican Island, and that apparently it was destroying the oysters. Upon this it was so arranged that I made a short visit to the locality in question, for the purpose of obtaining more definite information. At Bar Island I found the wafer present in large numbers, and some were found actually at work between the valves of the oysters. Large numbers of gaping shells of oysters only recently killed were to be seen on all hands, while the same was apparent on Pelican Island (which is submerged at high water). In view of the very positive evidence obtained at the time, it is only fair to assume that at least a part of these—if not all, probably a very large percentage—had succumbed to the attacks of the wafer. I must here point out that although the common oyster worm (Polydora or Leucodore) was only too abundant on portions of these leases, none of the recently dead and gaping shells which I examined showed the least sign of its attacks or of the attacks of the common "Drill" or "Borer" (Urosalpinx), although I found the latter (previously unrecognized from this locality) to be fairly plentiful.

It is of interest to mention that at the time of my visit the oysters were all "opening very badly"; that is, they were in poor condition and were likely to remain so until the advent of a freshet in the river.

OCCURRENCE OF THE TURBELLARIAN IN 1916–17.

The distribution of this turbellarian in sufficient abundance to attract attention from oystermen, during the oyster season, 1916–17, appears to have been confined to the western coast of Florida, between Cedar Keys on the north and Tampa Bay on the south, a distance of about 110 miles. It was stated that the southern limits had probably extended, at some of the earlier periods, as far south as Cape Sable, making an approximate range of 300 miles.

In the vicinity of Cedar Keys, Port Inglis, and Tampa the greater number of the oyster bars, especially in the more saline districts, were infested and had suffered to a greater or less extent. The conditions were so bad that, for a time, the industry appeared to be seriously threatened. The loss, as reported, ranged from 10 to 20 per cent of the stock on some beds to the destruction of one entire bar. A planted bed of 35 acres in Tampa Bay was attacked by this worm and the mature and young oysters alike were said to have been completely annihilated. The bed had been planted just two years and had given promise of excellent returns.

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[a] David G. Stead: Preliminary Note on the Wafer (*Leptoplana australis*), a Species of Dendrocoelous Turbellarian Worm, Destructive to Oysters. Department of Fisheries, New South Wales, November, 1907; pp. 1–6. (No other references to turbellarians attacking oysters have come to the writer's attention.)

At Port Inglis and Cedar Keys the destruction during the season was estimated to be about 30 per cent. One or two localities, however, revealed a mortality as great as 90 per cent, but the excess should not be attributed to the turbellarian, since many of the empty shells or "boxes" contained spat which had set before the depredations of the worms had occurred, the mortality of these oysters being due evidently to other causes. When the devastation was at its height the affected oysters, as a rule, contained from 1 to 3 worms, although as many as 8 or 10 are said to have been taken from a single oyster. During the early part of the season about 100 oysters per barrel contained worms, but by February, the time of the examination, the trouble had abated to such an extent that not more than 1 or 2 worms were taken in 20 barrels of stock. It is worthy of remark that on the Port Inglis and Cedar Keys bars no small oysters were found or reported containing worms, nor did any of the empty shells of the small sizes show any malformations indicating that a defensive struggle had taken place.

DESCRIPTION OF THE FLATWORM.

Although this pest is known to the oyster dealers, planters, and shuckers of Florida as the "leech," it is an animal of very different type, belonging to the branch of wormlike animals called platyhelminthes, class turbellaria, and order polycladida.[a] Since the general character and habits of this turbellarian compare closely with the similar pest found in New South Wales, and described by Dr. Stead, the name "wafer" would be a more suitable and less misleading one for common use.

The worm is almost flat, more or less circular in outline, and measures from about one-half to three-quarters inch in diameter. It has occasionally been observed, when feeding, to be so distended that it would cover half the body of the oyster. When disturbed it usually rolls up into a sort of a tube, the margins then becoming curled and very irregular. The upper surface is drab to dark-brown in color, sometimes nearly black, and at times finely stippled with darker spots; the central portion, posterior to the eyes, is, as a general thing, of a lighter shade than the remainder of the surface; when taken from an alcoholic solution and allowed to dry, a whitish mucus coating is observed. The lower surface is whitish to cream color. The worm, when removed from the oyster, is soft and slimy, and on very moderate pressure breaks up or runs into a jellylike mass, apparently without much structure. When placed in alcohol of about 75 per cent strength it becomes firm and somewhat leathery.

PHYSICAL CONDITIONS.

The turbellarians were found to thrive in only those localities where the salinity of the water remained comparatively high, and not in areas where decided changes in density caused by freshets occur at certain seasons. The temperature is also an important factor in their activity and even their existence. If the water is chilled considerably below the normal it may cause their complete disappearance or

[a] Harry K. Harring, of the Bureau of Standards and custodian of Rotatoria, U. S. National Museum, is engaged in a study of the turbellarian, which will probably prove to be a representative of a new genus.

perhaps death. During the early part of February, 1917, there was a decided fall in the temperature throughout the greater portion of the State and many orange trees, early gardens, and much vegetation in general were killed; also many small fishes, crabs, and oysters on the shallower reefs were destroyed. Following this extreme, the worms practically disappeared from the oyster beds, and relief was expressed by those engaged in the oyster industry. Just about this time local rains reduced somewhat the salinity of the water, which was also an unfavorable condition for the worms.

Speaking of the turbellarian in New South Wales, Stead says: "Judging by my present data, they appear to be most plentiful during dry weather (and particularly while mild or high temperatures prevail), when the water of our estuaries is of greater density."

Dry, warm weather appears to be the most favorable condition for this enemy. The months of their greatest activity on the oyster bars are stated to be August and September, and if the weather continues warm, October, November, and December may be included.

The character of the oyster bottoms and the depth of water on the bars or reefs do not appear to have any direct influence on the depredations committed by the worms, since they were found active and damaging at all depths and on all kinds of bottoms, such as sand, firm mud, or shells.

THE ATTACK AND RESULT.

It is not known how the worm gains admission within the valves of the living oyster, and we were not fortunate enough, while examining the beds, to obtain any data along this line. It is probable that the soft, velvety creature may flatten itself into a very thin wafer-like form and slowly work its way between the partially opened valves without producing a reaction on the part of the oyster. Some oystermen, who have observed the habits of the parasite, are of the opinion that the entrance is made along the ventral margin or gill side, about halfway between the hinge and tips rather than at the tips themselves, since this is near the point where the worm is usually found. The first reaction of the mantle of an infected oyster takes place at this mid-portion of the shell. (See figs. 1 and 2.) It is possible that entrance is made during the larval or immature stage of the worm, at a time when admission could be more easily gained, and development completed within the oyster.

Regarding the method of attack the following remarks are made by Stead:

> METHOD OF ATTACK.—After gaining an entrance between the valves of the oyster, the wafer proceeds to wrap itself round the upper part of the oyster, as close to the great adductor muscle (which so powerfully keeps the two shells shut) as it can get. It then proceeds to pour out a great amount of thick, stringy, slimy mucus, which perhaps has the effect of partly digesting the body of the oyster, so as to prepare it for absorption by the wafer. Certainly in those which have come under my notice, the adductor muscle, usually the hardest part of the body of the oyster, is, after being attacked by the wafer, quite soft, although smelling quite fresh.
>
> One aspect of the case which is very puzzling is, as to how the worm gains entry between the shells of the oyster without the latter "closing down" on it; as, if it did, the wafer would surely be nipped in two.

The worm is usually found on the right side of the body of the oyster, near the heart, between the adductor muscle and the anterior

end or hinge. By carefully opening an infested oyster and removing the right valve, the worm may be observed as a thin sheet, closely adherent to the meat, and more or less covered with a slimy mucus. (See fig. 3.) It was stated by the oyster dealer,[a] who was interested in this subject, that he had found the worms in about the same relative position mentioned above, but on the reverse side or between the meat and lower valve, so that it was necessary after taking off the upper valve to turn the oyster over in order to see the worm.

It was not determined how long the oyster can successfully withstand an attack or whether it is able to recover after an invasion. It is the opinion of some dealers that the oysters are killed within two or three days, but this is evidently too brief a period, at least for the majority of cases. An examination of many of the oysters showed plainly, both in the meats and shells, that a hard, continuous, and defensive struggle for existence had taken place. The oysters, which were alive when opened, were poor, watery, and shriveled, to a degree depending upon the duration of the plague. Being robbed of its juices and its vitality probably reduced by secretions of the worm, starvation and death would ultimately follow. Up to this time no odor of decomposition was observed.

When carefully examined, the meat and shell often reveal the successive stages of the battle between the feasting turbellarian and the helpless oyster. With a slow but continued loss of its life juices and consequently contracting meat, the mantle gradually withdraws from the margins, particularly along the ventral side, and leaves a dark or blackened border or band of shell substance. (See fig. 4.) As the struggle continues, a thin ridgelike deposit of the shell substance may form along the gill side about one-half inch from the edge of the shell, and extend from the hinge to the tips. (See fig. 5.) At times a second or inner ridge is secreted. (See fig. 6.) The oyster, now being reduced to a smaller space by additional loss of its juices, has thus accommodated itself to a still smaller shell cavity. These ridges are doubtless a mechanical consequence of the shrinkage of the oyster; they indicate that the attack is persisted in and that considerable time elapses before death ensues. The ridges and other deposits are composed of regular shell material—calcium carbonate, and conchiolin; nacreous and crystalline layers are both present. (See figs. 7 and 8.)

CONCLUSIONS AND RECOMMENDATIONS.

1. Although oysters may be able to resist a brief invasion of the turbellarian, it does not appear that they possess the means to ward off an assault in harassing numbers, if long continued.

2. After the turbellarian has once gained admission within the oyster, there appears to be no method of combating the enemy. The defensive ridges deposited by the oyster afford only a temporary relief.

3. It is recommended that a careful working or cultivation of the beds in the infested district be carried on systematically, and that new, air-dried cultch and fresh seed stock be used when possible. All marine grasses and other objects under which the turbellarian

[a] Mr. Williams, Cedar Keys, Fla.

may secrete itself or deposit its eggs should be removed from the vicinity of the bars.

4. When it is desired to select a new area for planting and cultivation, it is advisable, other things being equal, to choose those localities where the water has sufficient depth to prevent overheating in summer, and also where the salinity may not attain too great a degree, as off affluents.

EXPLANATION OF THE FIGURES.

[All figures are two-thirds natural size.]

Fig. 1. Left valve, showing a thin deposit of shell substance along the ventral margin from hinge to tips, and covering nearly one-half of the inner surface of the shell. The deposit had curled and peeled somewhat before the photograph was taken. The shell is empty. (Taken from Cedar Keys, Fla., Feb. 10, 1917.)

Fig. 2. Both valves, showing the results of the struggle between the oyster and the worm. Notice the shell deposits, particularly along the ventral margins. Parts of the meat are still clinging to the shell at the muscle scar. The worm had escaped. (Taken from Cedar Keys, Fla., Black Point Bars, Feb. 12, 1917.)

Fig. 3. Left valve with the meat, and the turbellarian *in position* near the adductor muscle. Notice the shriveled condition of the oyster, and the retreat of the mantle from the edges of the shell. The worm had contracted to about one-half of its spreading capacity. (Taken from Port Inglis, Fla., Feb. 10, 1917.)

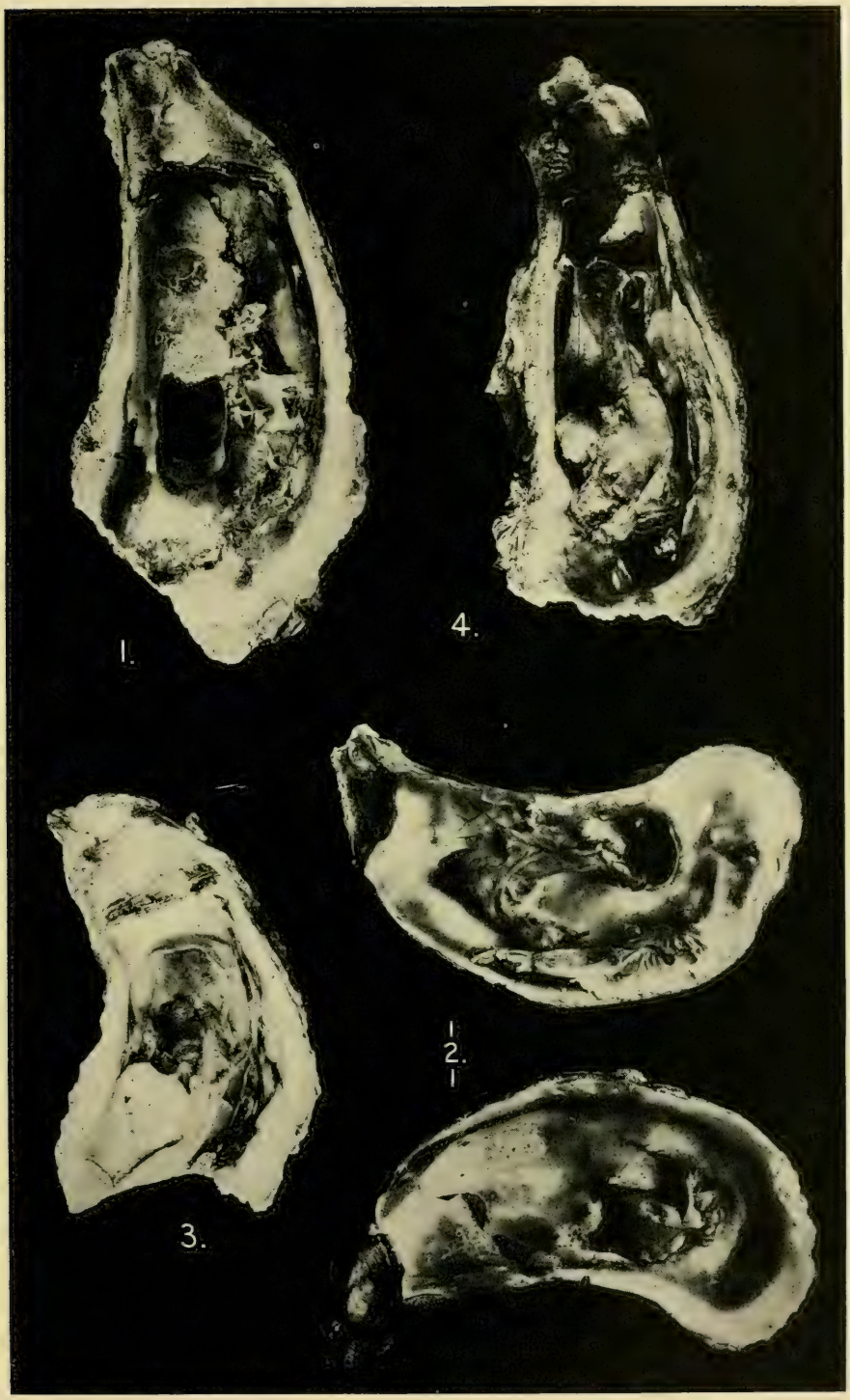
Fig. 4. Left valve with oyster showing the gills. Notice the "ridges" near the hinge and along the ventral margin. The oyster was shriveled and dead. The worm had escaped. (Taken from Port Inglis, Fla., Feb. 10, 1917.)

Fig. 5. Left valve, showing that the space occupied by the oyster was reduced, before death, about one-half. Notice the "ridge," beginning at the dorsal margin, then crossing adjacent to the hinge to the opposite side and extending to the tips. (Taken from Cedar Keys, Fla., Feb. 10, 1917.)

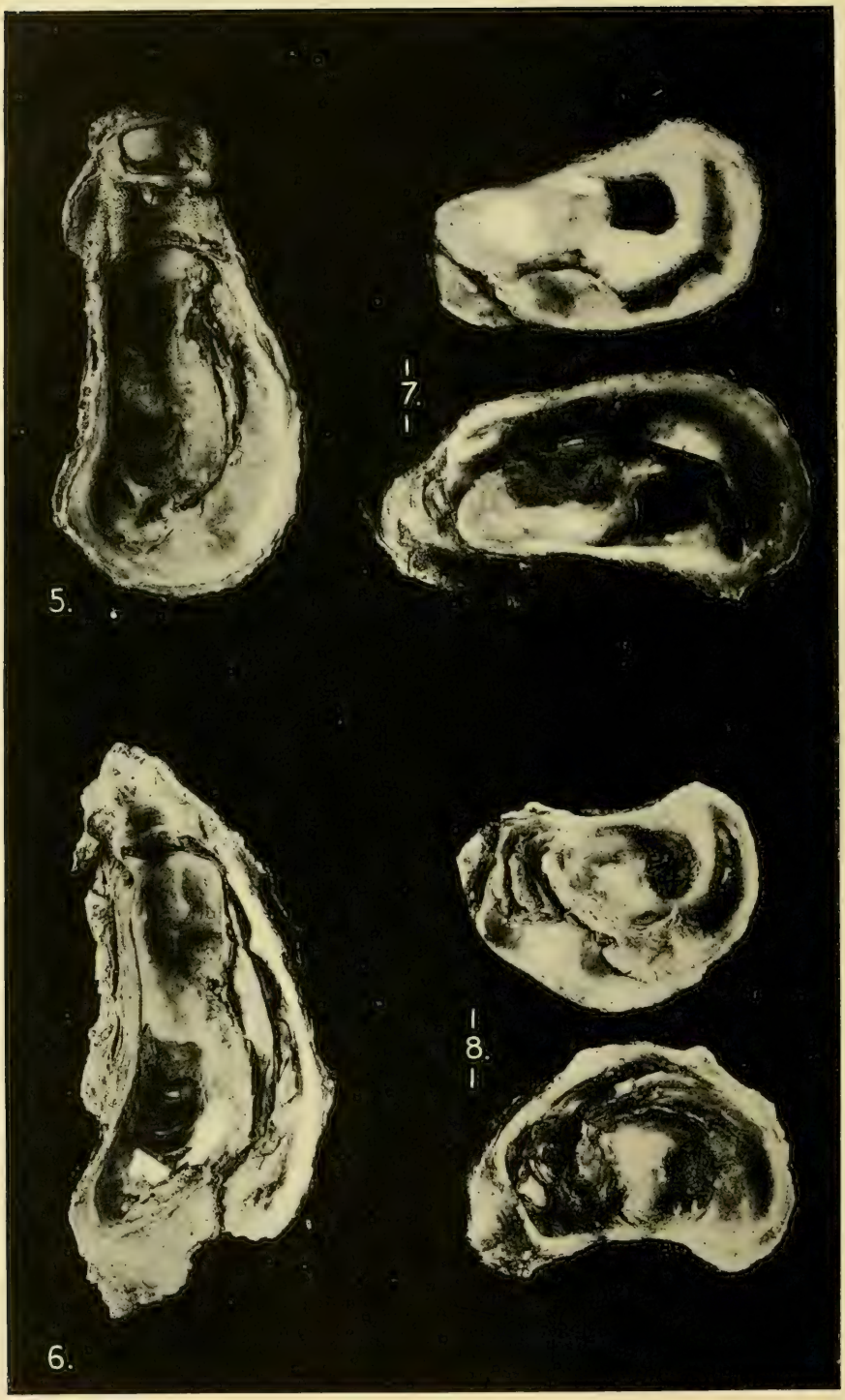
Fig. 6. Left valve, showing the reduced space occupied by the oyster just previous to death. Notice the two "ridges" or successive stages of retreat along the ventral margin, and the spreading out or fan-like condition at the tips. (Taken from Cedar Keys, Fla., Feb. 10, 1917.)

Fig. 7. Both valves, showing shell deposits of conchiolin and calcium carbonate. (Taken from Cedar Keys, Fla., Black Point Bars, Feb. 12, 1917.)

Fig. 8. Both valves, showing deposits of conchiolin and calcium carbonate. (Taken from Cedar Keys, Fla., Black Point Bars, Feb. 12, 1917.)



OYSTERS AND SHELLS, SHOWING THE RESULTS OF ATTACK BY FLATWORMS.



EMPTY SHELLS OF OYSTERS, SHOWING MALFORMATIONS RESULTING FROM ATTACKS BY FLATWORMS UPON THE LIVING OYSTER.