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SOME CASES OF NARROWLY RESTRICTED PARASITISM AMONG COMMERCIAL SPECIES OF FRESH WATER MUSSELS

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The U. S. Bureau of Fisheries has now carried on for some six years an investigation of methods of propagating fresh-water mussels.

The work has gone on beyond the experimental stage and operations have been conducted upon a scale that it is hoped will appreciably increase the supply for commercial purposes.

While certain species of mussels have been successfully dealt with by the methods first adopted, difficulties have been experienced with other species. In a paper read before the American Fisheries Society in 1912 I showed that I had been able to propagate the Warty-back Mussel on the catfish and that apparently they could not be reared on other species. From my studies of natural infection it looked to me at that time as if other cases of restricted parasitism would be found. The subject of natural infection has been made the object of special study at the Fairport Station and some considerable data published showing the species of fish on which the various mussels have been found. The data thus obtained have in some cases pointed conclusively to definite results while in others the interpretation was less obvious.

The identification of the larvæ (*glochidia*) when imbedded in the tissues of the host is uncertain in some forms, and accidental infections of a temporary nature undoubtedly occur. This makes necessary some method of proving out. In practice I have taken the indications obtained from observation of natural infections as a guide and made a test of the suspected species, comparing other species as a control. As the object of the investigation is to find a method of propagation, such a test meets the ultimate requirements.

The results obtained from these artificial infections are frequently very definite, giving conclusive support to the indications obtained from natural infections.

The following cases are concrete illustrations of this: Last May I undertook a series of experiments to determine to what extent the common fishes could be used in artificial propagation of certain mussels of the family Lampsilinae (Ortmann). The species were the Mucket, *Lampsilis ligamentina* Lam.; the Fat or Lake Mucket, *Lampsilis luteola* Lam., and the Yellow Sand Shell, *Lampsilis anodontoides* Lea.

The glochidia of these species were brought in contact with some sixty fish of 12 different species in each experiment. The infections with each species of mussel were kept separate so that I had three separate experiments. These I carried on under as nearly identical conditions as possible, so that they were practically parallel. The results summarized show what usually occurs in such an experiment. The glochidia took hold more or less on every fish, dropping off of some species in from 1 to 4 days without development, in other remaining on to the full period, which was three weeks in each of these cases. The muckets and fat muckets remained the full period on the basses (*Centrarchidæ*); sea basses (*Serranidæ*), and perches (*Percidæ*). They dropped off of the catfishes (*Siluridæ*), the sheepshead (*Aplodinotus grunniens* Raf.) and the gar (*Lepisosteus platostomus* Raf). The yellow sand shells remained on the gars, and dropped off of all the other species. We have here rather striking results. Chances of error were largely eliminated, from the fact that the experiments were carried parallel. As a further check I have repeated tests where there seemed to be any possibility of doubt.

The mucket and lake mucket are indicated as mussels having an extensive range of parasitism on several genera of fishes, while the yellow sand shell, a closely related

species, is parasitic upon a single genera of fishes far removed genetically from the hosts of the others.

My experiment will illustrate how a study of natural infections was of assistance. The gar would not have been included in this test ordinarily, as it is commonly thrown away as a nuisance. I had found it infected with glochidia which I identified with some uncertainty as *L. anodontoides*. On this account when the opportunity came to infect with the yellow sand shell I made a special effort to bring in the gars with the other fishes.

The natural infections which I collected first on July 17, 1912, were upon the long-nosed gar (*Lepisosteus osseus* Linn.).

The following year infected gills of the alligator gar, (*L. tristoechus* Bl. and Schn.), were sent to the laboratory from Indiana by Mr. Ernest Danglade. These were identified as the glochidia of the yellow sand shell. As I used the short-nosed gar (*L. platostomus*) in my experiments, we have a pretty clear indication that any of the three species of gar is a suitable carrier for this mussel.

Definite results in a similar manner were obtained with the Missouri niggerhead (*Obovaria ellipsis* Lea). Natural infections of doubtful identification had been found on the sturgeon (*Scaphirhynchus platorhynchus* Raf.). This was an especially difficult case because the infections in question were of an appearance and dimensions corresponding to those of a group of glochidia which are much alike, viz.: *Lampsillis ventricosa* Bar., *L. fallaciosa* Simp., *L. higginsii* Lea., *Obovaria ellipsis* Lea., and *Quadrula pustula* Lea. In the experiments the glochidia of *O. ellipsis* remained and passed through the parasitic stage on the sturgeon while they were promptly shed by the black bass, sunfish (*Lepomis pallidus*), sheepshead (*A. grunniens*), white crappie, black crappie, and channel catfish. It will be noted that the sturgeon did not retain glochidia in the other experiments.

The butterfly shell (*Plagiola securis* Lea.) I have found in several instances of natural infection on the sheepshead (*A. grunniens*). In artificial infections I obtained development upon the sheepshead as expected and immediate shedding by the black bass, the black crappie, and the bluegill sunfish. Mr. Surber (1913)* reported the host as unknown. Two other species of *Plagiola* have been reported on this fish and one of them, *P. donaciformis*, seems to be very common here at Fairport on the sheepshead, so that we apparently have three species of one genus confined chiefly to one host, together with other species of paper shell mussels which are at present considered of little value.

The three fish, the gar, the shovel-nosed sturgeon, and the sheepshead or grunter, which we find to be the carriers of these mussels have held economically quite different positions. The sheepshead and shovel-nose are now esteemed food fishes, although it is not many years ago that the latter was considered worthless. The gar at present is well known, and as I intimated above is considered a nuisance and, worse than that, a positive menace to the welfare of other fishes. The discovery then that it is practically the sole host for one of the most desired of shells is perhaps not agreeable. As a rule, however, we have to take nature as we find her, and for those who expect always to find a *raison d'etre* for each creature, this nursing of the yellow sand shell by the voracious gar will satisfy the belief that things are as they should be.

These results open up interesting problems as to details in the ecological relations of the associated species and the nature of the specific reactions which control them. These are applicable to all cases of specific parasitism and have been solved for some. It is of practical importance to those interested in mussel propagation that at least an answer be found for some of the questions of this nature raised here.

*Surber, T., 1913: Notes on the Hosts of Fresh Water Mussels. Bul. Bureau of Fisheries.

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A NEW RECORD IN REARING FRESH-WATER PEARL MUSSELS

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Last May, Mr. A. F. Shira, of the U. S. Bureau of Fisheries at Lake Peppin, Minnesota, shipped to the Biological Laboratory at Fairport, Iowa, a number of gravid mussels of the species called "fat mucket" *Lampsilis luteola*, Say. This mussel has a reputation for bearing pearls and is of economic importance for its mother-of-pearl used in the manufacture of buttons, etc.

At the time, I was engaged in a series of experiments to determine to what extent the common fishes could be used in artificial propagation of certain members, including this species, of the family Lampsilinæ (Ortmann). On May 21, 1914, I took the glochidia from these mussels and infected a dozen different species of fish; of these, six species proved susceptible and carried the young mussels through their metamorphosis. As the young mussels began to be shed by the fish, I placed a number of infected black bass (*Micropterous salmoides* Lac.) in a floating crate made for the purpose of catching the young mussels as they fell off. The crate I devised to meet a number of difficulties that had been experienced in attempts to raise mussels under observation. In aquaria, either balanced or with running water direct from the usual habitat of the mussels, they do not thrive. The majority are apparently eaten by predacious worms, or those which do not fall prey to their enemies, stop growing, apparently owing to some lack of nutrition.

Among European investigators who have attempted to grow young mussels are M. Brown, W. Harms and Karl Herber.* The latter this year reports having carried the

*Brown, M.: 1889, Die postembryonale Entwicklung der Najaden.
Harms W.: 1909, Postembryonale entwicklungsgeschichte der Unioniden.
Herber, Karl: 1913, Entwicklungsgeschichte von *Anodonta cellensis* Schröt. Zeitschrift Wiss. Zool., Bd. 108.

juveniles to a size of 3 mm., the largest which has been recorded so far as I know.

Having had about the same indifferent results as other investigators in such attempts, it seemed to me that a promising line of attack for a solution of the problem would be to find some way which would depart from the natural habitat only so far as the necessity of mechanical control demanded. In our situation, where we take the mussels from the Mississippi, the most practicable solution that offered itself to me was a floating crate containing baskets of sufficient size to hold the fish and made of small enough mesh to retain the microscopic mussels.

A crate thus held at the surface accommodates itself to the frequent rise and fall of the river, is convenient of access and removes the young mussel from many of its enemies at the bottom. Another advantage of a surface location is that the precipitation of silt is at a minimum. The crate was constructed from a floating fish car to which were added barrels to give greater buoyancy. Four baskets of rectangular shape were made to fit inside. These consisted of a frame work of galvanized iron attached to a galvanized iron bottom tray. On the frame was stretched copper cloth of one hundred mesh to the inch.

Two or three weeks after obtaining the plant of young mussels from the bass, I found evidence that they were thriving in the crate. A small sample of sediment from the bottom revealed some half dozen or more, and at various intervals during the summer, I readily obtained specimens, making observation on rate of growth and preparing material for anatomical studies. At the last observation in September, the young mussels were about an inch in length (twenty-five millimeters). This compares very favorably with the length of 3 mm. secured by Karl Herber.

For comparison, I put some of the rapidly growing mussels from the crate in an aquarium of running water and compared their growth for a period of three weeks with those growing at the same time in the crate. I

found the rate in the aquarium one-third as fast as in the crate. The rate in the crate was a constantly increasing one, and in the aquarium apparently decreasing. The growth of one inch gives us an actual observation on the growth for one season and removes some uncertainties as to what young mussels may do the first summer.

At this writing, without a study of the records, I am unable to give the percentage of survivals from the original plant, but an estimate of the number gave two hundred living and rapidly growing mussels. All examined had byssi of about six inches length attached to some base in the basket. Each juvenile had the anterior end buried as commonly seen in adult mussels and none were suspended in the current as some have supposed the condition to be with byssiferous forms.

In this experiment we have succeeded in carrying mussels under cultivation, we may say, through what are apparently the most critical periods in the life history, namely, the parasitic and early juvenile stages. Just what bearing these results will have in practical artificial breeding of mussels, is still a question, but the information gained is of obvious value. Early in the investigation of the subject Lefevre and Curtis suggested the feasibility of raising mussels to this more hardy stage and then distributing them. A point in favor of such a method would be that results could be quite definitely measured. By the method of infecting fish and letting them go at large, results are not as readily ascertainable. The planting of mussels according to a definite plan, in favorable locations, might have a distinct advantage over the natural distribution by fish. The assumption of an advantage in the more artificial method would be based upon results with the analagous rearing of fish, young lobsters, oysters, etc. This phase of the subject requires investigation. The raising of young mussels in a floating crate can doubtless be perfected and adapted to many species. I fully realize that the result obtained is only a beginning, but it is at any rate a start.