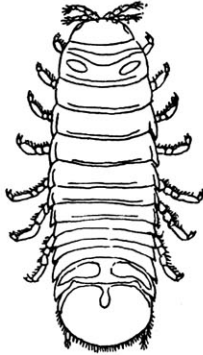


XI.—SUPPLEMENTARY NOTES ON DESTROYERS OF SUBMERGED WOOD IN NOVA SCOTIA.—BY M. MURPHY, D. SC., *Provincial Government Engineer, Nova Scotia.*

Much has been said and written about the destructive habits of the *Limnoria Lignorum*, or "gribble," as it is usually called by the fishermen in Great Britain. It is one of the most destructive creatures, attacking all woodwork below tide mark. Although its ravages have gone on for centuries it was only made known to naturalists by Dr. Leach in 1811. The living specimens which I place before you this evening have been just taken from their burrows in a piece of a submerged pile from a wharf in Halifax Harbor. The piece of pile was sawn off two feet below the surface during low water at spring tide. It was immediately placed in a bucket of sea water and brought to my office. On its removal from the water the outer soft layers of wood were found to have been burrowed into cells about one quarter of an inch in depth, just deep enough to protect the workers without covering them. I picked them from their burrows with the point of a writing pen, letting them drop into the bottles where you now observe them. You may notice that they are quite active, that they dart forward or backward with equal swiftness and that they are capable of moving rapidly in the water.

I tried to get them photographed in the water, but without success. Fig. 1, on the following page, is reproduced from a drawing by Prof. J. Smith. Fig. 2 is from a photograph by Notman. Their length is 4.3 m.m. breadth, 1.6 m.m.; color in water, light greyish. They are no doubt identical with the *Limnoria Lignorum*, White, and are the same species of crustacean as that first brought prominently into notice by the celebrated Robert Stephenson, who found it rapidly destroying the wood work at the Bell Rock light-house erected by him on the coast of Scotland. Unlike the *Teredo*, this creature is vegetarian and lives on the wood which it excavates, so that its boring operations, as remarked by Dr. Baird, provide it with both food and shelter

***Limnoria lignorum***

Enlarged ten diameters.

Fig. 1.

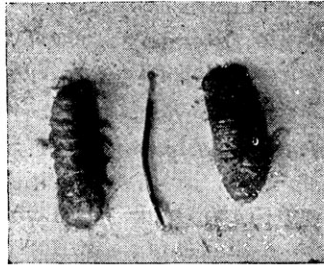
Photograph of *Limnoria* and
Annelide.

Fig. 2.

The *Limnoria* is aptly described in Chambers' Encyclopædia thus:—"It is only about the sixth of an inch in length, of an ash grey color, with black eyes which are composed of numerous *ocelli* placed close together. The head is broad. The legs are short. The general appearance resembles that of a small wood louse, and the creature rolls itself up in the same manner if seized."

It is found boring in submerged wood along our coast from Florida to Halifax, N. S., and the Gulf of St. Lawrence. It occurs above low water mark, but does not usually live far below that line. It has however been found by Professor Verrill at a depth of ten fathoms in Casco Bay, and was dredged by the United States Fish Commission at a depth of $7\frac{1}{2}$ fathoms in Cape Cod Bay, Mass., in the summer of 1879. It is abundant, according to European authors, in many localities on the coast of Great Britain and in the North Sea. *L. uncinata*, Heller, from Verbasca in the Island of Lesina, Adriatic Sea, appears to be the same species, as the differences pointed out by Heller do not really exist, but were doubtless suggested by the incorrect figures that have been published representing the uropods with rami

composed of two or more segments. *Limnoria* is said also to occur in the Pacific Ocean, and from its habits might be expected to have a wide distribution.

In my paper on the ravages of the *Teredo Navalis* and *Limnoria Lignorum* in Nova Scotia, on piles and submerged timber, (see pp. 357-376, vol. V, Trans. N. S. Institute of Natural Science, 1881-2), I brought this subject more prominently before you. My remarks this evening are intended to supplement that paper with such information as I have since obtained respecting this insignificant in appearance, yet destructive little isopod. For here in Halifax Harbour where they are so destructive as to destroy the piling of our wharves, or at least most of them, in a period of eight or ten years, and have in seven years destroyed the piles of the wooden railway bridge across the Narrows of our harbor, involving an expenditure of many thousands of dollars, there are not many questions of greater local importance to the Engineer than that of devising some means whereby their attacks may be arrested or prevented. The *Limnoria* has also been charged with the grave offense of attacking the gutta percha of submarine telegraph cables, with damaging tarred ropes, used for mooring boats, and with the destruction of fishermen's weirs, as well as that of destroying all sorts of timber.

We can only remedy these destructive operations by a precise knowledge of the causes that produce them, such knowledge as may enable us to check or at least to mitigate some of these undesirable consequences.

In the Bay of Fundy where the water is clear, free from silt and transparent, the *Limnoria* is active and very destructive. Up the Bay where the tide during the ebb digs deep into the muddy flats thus discoloring the water and making it mucid there is no *Limnoria*.

In the Annapolis Basin they are active; at the head of the bay, where the water is muddy, they are not to be found. In like manner in Halifax Harbor where the water is clear they are active. At such places as are polluted by a discharge of sewerage into the harbor there are no *Limnoriæ* to be seen. We account

for their absence in such localities as we have named, by reason of the muddy or unclean water leaving a deposit of silt, in their cells or burrows, and in this way sealing them up so as to destroy the tenant or make the cell uninhabitable. It is further noticeable that any piece of timber partially covered by mud, slime or algæ is exempt from these attacks, although timber in the same place not so covered is being destroyed by them.

From these observations one might infer that some external application such as cement, lime bitumen or coal-tar, if repeated as required, would arrest their ravages if not end them. These conjectures, of course, require confirmation, though they seem not improbable. I may mention, however, that a solution of lime will not kill the *Limnoria*, immediately. I have had them in a glass containing a strong solution of lime for two days and some of them then seemed active.

One method which is used to avert their destruction is to cover the piles or submerged wood-work with copper or zinc sheeting; but this covering is so expensive that it is not generally employed. It is an important practical problem to determine some cheap, ready and effective method or some means whereby we can approach nearest to a cheap and practical method of preventing the ravages of this little pest.

In Nova Scotia we suffer more from the ravages of the *Limnoria* than we do from the *Teredo*, not because the crustacean is more destructive than the mollusc, but because the habitat or region of the *Limnoria* covers the littoral waters where most of our wooden structures are to be found. Wooden wharves or wooden bridges along the Bay of Fundy and from there along the Atlantic coast as far as Whitehaven, suffer from the *Limnoria* while the location of the *Teredo* is further east and north. The zone of the *Teredo*'s operations begins about Musquodoboit Harbour. From there to Whitehaven the work of both borers may be traced; and in some intermediate places both may be observed at work on the same stick. There is no neutral ground between them. Their domains overlap for a few miles, each of the little borers becoming less abundant as we advance farther

into the territory of the other. The reason that these destructive creatures cannot thrive on the same ground is quite apparent. The *Teredo* enters the wood in the embryonic stage through an aperture having a diameter of one-quarter to half a millimetre only, which enlarges little by little until it reaches a diameter of five millimetres or more. This diminutive entrance protects it from its enemies the Annelides. If the opening is enlarged by the exterior burrowing of the *Limnoria*, the *Teredo* becomes a prey to its enemies and cannot exist. Both borers may be found on the same pile at work at the same time, but such are not the fittest conditions provided by nature for their growth and development.

Since the researches of Quatrefages and Kater and the report of the Dutch commission on the *Teredo* and its depredations, nothing more reliable as to fecundation of eggs, development and expulsion of young, has been added. Quatrefages tells us that the eggs pass through a series of modifications, such as is met with in the examination of all animals, that in the third phase of development the bivalve shell is formed, the foot appearing on the outside, that the embryo possesses the faculty of locomotion, and that the development is very rapid, four days only being required for the acquisition of full equipment for living in wood. Kater observed them in large numbers on the surface of wood towards the end of June and by the 15th of July he found them in the interior, in the form of perfectly developed *Teredos*.

They enter the wood thus in small openings which, as we have before remarked, are necessary for their protection as well as, probably, for their growth and manner of sustenance. With such information before us and with the knowledge, from my own observations, that they seldom, if ever, pass from one piece of timber to another, I was led to think that a pile made of boards with a thick coating of tar, or white lead, between them, to protect the inner leaves from the attachment of larvæ or the penetration of the fully developed *teredo* itself, might arrest their depredations, or perhaps, prevent them from entering further than the outer covering.

Reasoning thus and wishing to try the experiment suggested, I had four piles constructed from hemlock and spruce boards. They were formed, first, by a core 4 x 4 in., and then by boards prepared through submergence in a bath of coal tar, then securely fastened, one by one, until the built pile attained the dimensions of 12 x 12 in. The piles were then hooped and shod with iron, and were driven, close to the Little Bras d'Or bridge, at one of the outlets of the Bras d'Or lakes (tidal waters) Cape Breton. These piles, so formed, could well stand driving under a 16 cwt. pile hammer. They were placed in position in November, 1889, and examined in September, 1890. The teredos had completely riddled the outer board and in some instances had entered the next board to it.

In July, 1891, they were again examined, when they were found to have penetrated to the third board, the two outer boards having been destroyed and the third perforated. I exhibit a section of the pile. You will notice that the outer board is completely eaten away, scarcely any part of it being thicker than a leaf of packing paper. You can by merely an impress of the fingers rub it off in small leaflets. Still, it is evident that it was partially, if not totally, destroyed at the point where the entry was made to the second board before the entry was effected. In like manner the second board was destroyed before an entry at assailable points to the third was effected.

In the same place, not 100 yards from where these experiments were tried, creosoted piles obtained from Messrs. Eppinger & Russell, Brooklyn, New York, have been driven for over five years, and there is not yet the slightest sign of a teredo having entered any one of them. Essential oil of creosote impregnated into such woods as are adapted to the purpose and treated in such manner, as is being done by Messrs. Eppinger & Russell, will, in my opinion, assure a long duration.

The Tereido requires a clear, pure, salt water. It has often been remarked, that piles placed in dirty muddy water or in the neighbourhood of sewerage discharge are exempt from its attack. From these observations one is led to believe that where there is

no current a strong application of a solution of common lime applied in the months of June, July and August, whilst the expelled ova are undergoing development, might prove effective.

In such places as the Bras d'Or Lakes or in land-locked harbours where the lime would not be immediately carried away by a current, the experiment might be worth trying. An application of a barrel of lime dissolved in about eight or nine barrels of water and poured around the piles of a wharf might be tried, or a stronger solution if considered desirable, or still better, if forced around each pile through a hose and nozzle with an ordinary force pump.

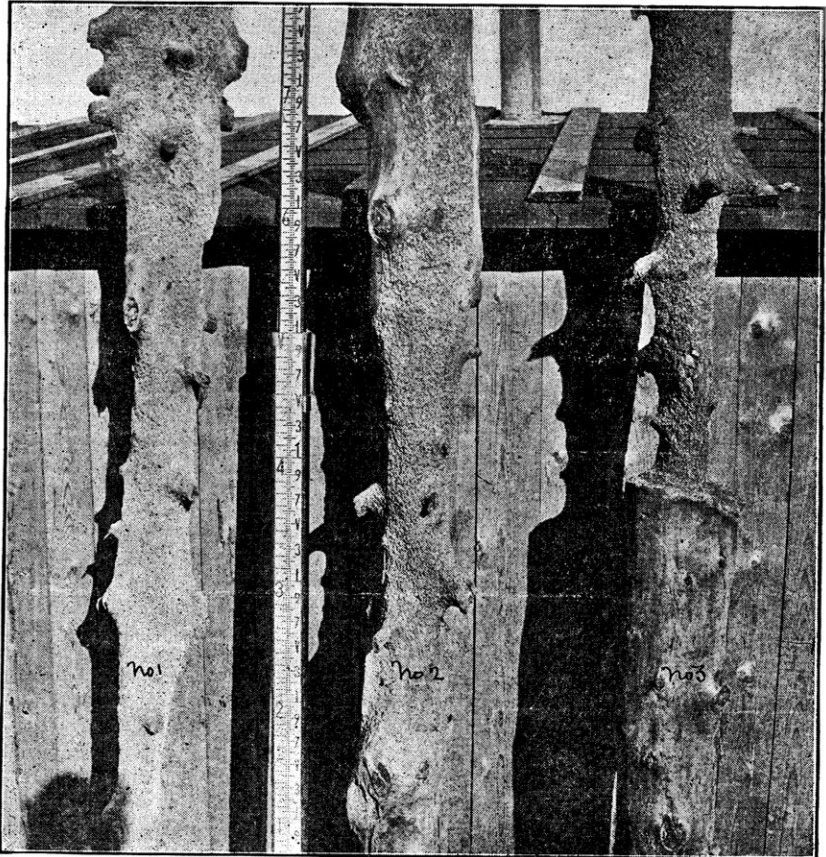
I conclude with some notes on the effect of current on the ravages of *Limnoria*, communicated to me in January, 1892, by Mr. W. B. McKenzie, C. E., of the Intercolonial Railway Office, Moncton, N. B. His observations were made on piles of the Intercolonial Railway Bridge across the Narrows of Halifax Harbor, and are as follows:—

“Hemlock piles driven seven years ago, with bark on, into a hard gravel bottom with boulders, in salt water, 55 ft. in depth, where the tide rises 6 ft. and the surface velocity is $2\frac{1}{2}$ miles per hour, were found to be worm-eaten from the surface of the ground upwards about ten feet, as shown on the accompanying photograph (reproduced in Plate II.) No. 1 pile appears not to have entered the ground but probably rested on a flat boulder. No. 2 pile penetrated $1\frac{1}{2}$ ft. No. 3 pile penetrated $3\frac{3}{4}$ ft. The rate of destruction averages $\frac{4}{10}$ of an inch per year, reducing the diameter of pile $\frac{8}{10}$ of an inch per year. As it has heretofore been asserted, and is a generally accepted opinion that the *Limnoria* works at extreme low water only, or thereabout, the discovery was surprising that, in this case, no damage of any consequence was done at this point, but that its operations were confined to the bottom part of the pile, being greatest at its ground line and decreasing upwards for a distance of about 10 feet.

“I can only account for this on the hypothesis that the current being about $2\frac{1}{2}$ to 3 miles per hour at the surface, the *Limnoria* found it easier and more convenient to work down near the bottom, where the current was probably much less.

“In large rivers (to which the “Narrows” may be compared) the bottom velocity is much less than the surface velocity. Du Buat gives an approximate rule for finding the mean and bottom velocity thus:—If a be the surface velocity, b the bottom velocity and y the mean velocity, all in inches per second, then $b = (\sqrt[3]{a} - 1)^2$ and $y = \frac{1}{2}(a + (\sqrt[3]{a} - 1)^2)$. According to this, if the surface velocity at the “Narrows” is $2\frac{1}{2}$ miles per hour, the bottom velocity will be 0.85 miles per hour and the mean velocity 1.54 miles per hour.

“I think we may conclude that in a current having a bottom velocity of about 3 miles per hour, the operations of the *Limnoria* would be much retarded, if not wholly prevented.”



Illustrating Dr. Murphy's Paper on "Destroyers of submerged Wood in Nova Scotia."