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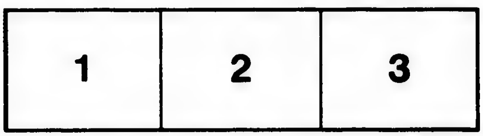
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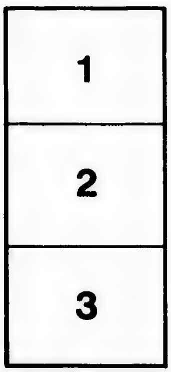
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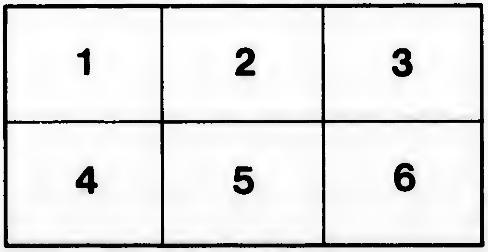
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THE

TEREDO NAVALIS

AND

LIMNORIA LIGNORUM

IN

NOVA SCOTIA,

BY

MARTIN MURPHY, C. E.

Provincial Engineer.

Reprint from the " Transactions of the Institute of Natural Science," Nova Scotia, 1881 – 2.

HALIFAX, N. S.:
WM. MACNAB, STEAM BOOK AND JOB PRINTER, 12 PRINCE ST.,
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teenth, and the last two between the twenty-second and twenty-third, or between the twenty-third and twenty-fourth hæmal spines, in other words upon the twenty-third or twenty-fourth centrum, (I have specimens of both befor[illegible]), in this case the last interhæmal spine is very short and [illegible] not reach the extremity of its posterior hæmal spine.

72. The Lophius has no ribs.

In conclusion, I would mention that the foregoing paper when read, was illustrated, by the disarticulated bones of the skull, &c., as well as a skeleton of a Lophius, together with the disarticulated bones of the skull, and a skeletal head and shoulder-girdle of a codfish (Gadus morrhua).

Art. VII.—On the Ravages of the Teredo Navalis, and Limnoria Lignorum, on Piles and Submerged Timber in Nova Scotia, and the means being adopted in other Countries to prevent their Attacks. By Martin Murphy, Esq., *Provincial Engineer.*

(Read Monday evening, 13th March, 1882.)

Among the questions which interest the engineer in the Maritime Provinces of the Dominion of Canada, there are none of greater importance than the means whereby the ravages of the Teredo Navalis can be checked or prevented. I think I may say that here, as in many other instances, where the operations of nature interfere with the designs of man, we can only remedy these difficulties by a precise knowledge of their causes, a knowledge which may enable us, if not to check, at least to avoid, some of the evil consequences. We know that innumerable boring animals establish themselves in the lifeless trunk of the piles and other submerged timbers of our wharves, piercing holes in all directions into their interior, like so many augers, penetrating the timber in every direction, until they actually destroy its solidity, and dissolve its connection with the ground. But however efficient these borers may be, science comes to the rescue, and means are being successfully adopted in both Europe and America to not only resist, but to effectually destroy their attacks.

I need not allude to the universal knowledge of the danger to be apprehended, arising from the growth and development of the Teredo within the bearing timbers which support our railway bridges; to the annual loss to both the Dominion and Provincial Governments arising from their destructive powers upon our public road bridges, wharves and breakwaters, to satisfy the most sceptical that a study of this subject is worthy of the deepest scientific interest; and that a minute knowledge of the extent and mode of formation of those belonging to our own shores must be of paramount importance, were it only with reference to the preservation of timber from their attacks. For although efforts are being made to replace our timber bridges by iron, still, when it is remembered that owing to our great extent of sea coast, to the many indentations of the sea, or harbours which run far inland, and that are necessarily crossed over tidal water, and that timber is within easy distance, and labour, skilled in fashioning it into desirable form, is always available, it may yet be a long time before all the timber bridges in this country will be superseded by more permanent materials. The same remarks will more fully apply to the wharves and breakwaters of the Maritime Provinces of Canada; for until timber in this country becomes much more expensive than it is at present, it will be more economical to adopt in many situations the class of wooden structures, or stone and wood, as at present existing.

These facts suffice to show that the reasons so far given for the necessity of investigating the ravages of the Toredo, and the other destructive species of its class, are in themselves a subject well worthy of investigation; and the author of this paper would respectfully solicit the aid of the President and members of this Institute, many of whom are much more conversant with nature and its fauna and flora than he could pretend to be, the object in view this evening being more to explain what is being done by Engineers to prevent, or at least to lessen, the evil consequences of their attacks, than to discuss the several species of molluscs which perpetrate them.

Let us now return from this digression to the consideration, first, of the abode of the Teredo in Nova Scotia.

From a series of investigations for the purpose of this paper, the author is led to believe that the Teredo Navalis, or the Teredo Norvegica, exists all along the shores of this Peninsula. The zone or area of its active operations is, however, confined along the shore bounded by Northumberland Strait, St. George's Bay, Strait of Canseau, Chedabucto Bay, and all round Cape Breton Island. South and West of these places its attacks are not very remarkable, the Limnoria Lignorum being more conspicuous for its depredations along the Atlantic Coast, from Chedabucto Bay to Cape Sable and along the shores of the Bay of Fundy. It is very remarkable that in Nova Scotia the haunts of the Teredo, where its ravages are greatest, indeed where its destruction is very noticeable, are confined to bays, harbours or estuaries that are frozen over from four to five months of the year. From Cape Sable to Cape North, 370 miles, we have a much greater diversity of climate than is due to latitude alone. The influence of the gulf stream on the southwestern promontory gives a milder and more tepid atmosphere, with harbours open all the year round. The influence of the ice floes in the Gulf of St. Lawrence on our northern and more eastern coast, has quite the opposite effect. Here where our harbours or rivers are sheltered from agitation of the sea, they are frozen over, and here is seemingly the place where the Teredo appears to live, thrive and destroy.

At Shediac I have seen a spruce stick, that had been driven as a fender pile to the wharf one year previously, completely honeycombed so that it floated to the surface. I saw living teredos in it from 4 to 6 inches in length. I am sorry I did not know enough at the time, to notice the shell or pallets which distinguish the species.

At Pictou the Teredo is very destructive on both sides of the harbour, almost every piece of submerged timber bears traces of its ravages.

The specimens of its borings obtained from Pictou, which I place before you, leave no doubt that it is the work of the Teredo.

At the Pine Tree Gut, about six miles from New Glasgow, and eight from Pictou, where the railway crosses the tidal estuary, the Teredo has attacked the piles of the railway bridge, which we shall hereafter refer to.

At the marine slip, Strait of Canseau, distinct traces of the work of the Teredo are quite visible.

At Sydney, C. B., every wharf suffers by their depredations, except the pier of the Sydney and Louisburg Railway, which is an example of how their attacks can be prevented. I shall hereafter refer to this structure.

At Louisburg, and at Margaree, they are also quite active, so that I think we may fairly assume that they are to be found in the other harbours intermediate between those places.

Returning to the Strait of Canseau, and proceeding westwardly towards Halifax, we are in the region of the Limnoria Lignorum, and although traces of the Teredo may be found at the ship yards and marine slips all along our shores further south, yet they are neither numerous nor destructive. The wood eating Limnoriæ now become the active agents of destruction. Myriads of them are visible on the piles of our wharves, and on every piece of submerged wood within the zone of their attack. From Whitehaven to Halifax, at Mahone Bay, Lockeport, Shelburne, Yarmouth, St. Mary's Bay and at Digby the attacks of these little borers are vexatiously conspicuous. A pile at the old yacht club house in Halifax Harbour, 12 inches in diameter, was reduced to 6 inches in seven years. Along the Atlantic shore they destroy timber over its submerged surface within the limits of its workings at the rate of about one inch per annum. Specimens from Digby, which I submit, show a much less degree of destruction. Those four specimens of piles, taken from Digby wharf, 13 years submerged, were, when driven, 10, 12, 13 and 15 inches respectively, they are now 6½, 5, 7 and 6 in the order in which they are first named. Along St. Mary's Bay, Annapolis Basin, and Minas Channel, inlets of the Bay of Fundy, the average rate of destruction seems to be about the same as at Digby, namely, about one-half inch on the exposed surface per annum, or about one-half as much as at Halifax, and some other places on the Atlantic coast. In 1877 one of the piers of the Victoria bridge, which crosses Bear River near its confluence with Annapolis Basin, toppled over, owing solely to the borings of the Limnoria Lignorum. It had been constructed about 10 or 11 years, and was erected thus:

1st. Cribs were built of logs, floated to the site of the piers, and there sunk by stone.

2nd. Around the submerged crib-work a single row of piles was driven at a distance of three feet apart centres.

3rd. On the rectangular single row of piles the piers were erected, which then, stilt-like, supported the whole weight of superimposed pier and superstructure.

Many of the piles suffered so much from the attacks of these crustacea, that several of them floated away with the tide, causing the pier to tilt over and carry the bridge superstructure with it into the stream below.

At the lowest spring tides known for that year, I visited the lower trunk of the pier which still remained standing, with the view of having it renewed. Every pile was eaten at the level of low tide to about three inches from the former surface, until its section became so reduced as not to be able to support the superimposed weight above. The timber consisted of spruce, hemlock and pine,—the attacks seemed to be just the same on each, irrespective of kind. I would here mention that the same remarks apply to hardwood, such as black maple and oak.

I will now briefly advert to the animals themselves.

Dr. E. H. Von Baumhauer, Commissioner to the Centennial Exhibition from Holland, in papers published in the "Popular Science Monthly" for August and September, 1878, gives, through the translation of Mr. Andrews, the following very full and interesting description of the habits and workings of the Teredo Navalis, as extracts from the "Archives of Holland" or extracts from the report of the Dutch Commission, on the subject under your consideration.

"Teredos penetrate wood naturally by very small openings in a direction perpendicular to the surface (Figs. 12 and 15–C); then they generally turn about in order to follow the direction of the woody fibres, usually upward, but sometimes downward. Although they do not enter into the earth or mud, one generally finds the first traces immediately above the line of the mud in which piles are driven; it is at this point that piles destroyed by the teredo generally break off.

"When the teredos are lodged in a piece of wood, one recognizes them by very small holes on the surface, and the extremely delicate tubes which project from them (Fig. 12, e, d). These are the siphons, only one of which shows at first, the other appearing later. These siphons are generally kept outside the wood in the water, but the slightest touch causes the animal to retract them. One of them is shorter and larger than the other, but they both seem to serve for the expulsion of the fæces, which largely consist of particles of wood reduced to a very fine powder. It is known that the teredo does not perforate wood for nourishment, but only to procure a suitable abode; the woody substance detached in the boring, passes through the intestinal canal, and then is expelled in the form of a very fine white substance by one of the siphons, generally, according to M. Vrolik, by the shorter, but sometimes by the longer. The long siphon appears to serve principally for the introduction of food, which consists of infusoriæ diatoms, and other inferior animalculæ which the sea-water brings with it into the siphons. It is nevertheless still uncertain whether the matter expelled through the longer siphon comes directly from the intestinal tube, or is at first introduced from outside with inflowing water to be expelled again after a short sojourn inside.

"The Teredo requires for respiration a clear, pure water. It has often been remarked that piles placed in dirty, muddy water, near drains, for example, are protected thereby. The water should have, moreover, a certain degree of saltness; the teredo cannot live in brackish water: that is a point to which we shall return later.

"The Teredo continues to grow in the wood; while the gallery which it forms presents near the surface a diameter of only one quarter to half a millimetre, it enlarges little by little, until it reaches a diameter of five millimetres and more; as regards his length, and consequently that of the tube which incloses him, we have sometimes found it to be thirty to for[illegible] centimetres. He never goes upward more than half way between the flow and ebb of the tide; although the teredo is thus, for a short time, partially above the water, yet it appears that the wood holds a sufficient amount of moisture to sustain his life temporarily.

"The researches of Kater have still further shown, what had already been remarked by Sellius, that the Teredo can hibernate in the wood, and that it is those individuals, thus preserved, which in the spring go through with all the phenomena of reproduction —i. e., the formation of eggs, fecundation, development, and expulsion of the young.

"The part of the external integuments which constitutes the mantle deposits a calcareous matter, forming an interior lining to the gallery in the wood (fig.12. f.) Between this calcareous casing and the body of the animal there remains a space sufficient to prevent any inconvenience, at least during the act of respiration, for it is possible that when the Teredo absorbs water, which serves for respiration, his body is distended, and fills exactly the calcareous tube. The form of this tube, secreted little by little, corresponds exactly with that of the gallery, which has been slowly perforated in the wood; it has the appearance, also, of a series of rings placed one against the other. As the animal progresses a new ring is added to those which existed before, so that when the tube is closed at its extremity by a calcareous film, its length represents the total length of the animal. (fig. 12; b to c) Among the segments of the tube, those which are nearest the surface of the wood are the oldest and hardest; in the interior of the wood, where the gallery ends (fig. 12, g), the calcareous ring, newly formed, is at first soft, flexible, and of slight consistency; later, it becomes solid, and closes up the tube, as has been remarked by Sellius.

"The calcareous tube, once formed, constitutes for each Teredo his own abode, where he isolates himself from his companions, and has nothing to fear from their close proximity. One never sees a Teredo pierce the tbue of another. The tubes make their way side by side, and cross each other in every direction, but, be the wood ever so worm-eaten, there always remains a woody wall, often very thin, it is true, between two adjoining tubes."

I think this description by the Dutch Commission is so full and comprehensive, that it leaves but little to add to the mode of sustenance and attack of the animal, which is all I shali advert to here. Suffice it to say, that the characteristics so explicitly described are largely if not fully applicable to the species of Teredo inhabiting our shores.

Let us now return to a review of the habits and attacks of the Limnoria Lignorum, so destructive from Chedabucto Bay westerly and along our Atlantic coast and the shores of the Bay of Fundy.

The piece of pile alluded to taken from the old Club house wharf at Halifax, was sent to me by Mr. Peter Archibald, C. E., Resident Engineer of the Intercolonial Railway. It had been in the water seven years,—was 12 inches in diameter when placed there, and was reduced to six inches by the action of the Limnoria. I received it just as it was taken out; one could observe with the naked eye the crustacea then living. I had it placed in sea water, and sent to Notman's Photographic establishment here to be photographed. The operator found no difficulty in obtaining a negative of the piece of wood which I produce, and enlarging it about four diameters. It was very difficult, however, to find a single perfect specimen; they all died when about one day from their abode in the harbour, and owing to their diminutive size, they had so shrivelled up as not to be recognizable. Fortunately, Rev. Dr. Honeyman had a specimen which I obtained, and which is shewn enlarged about four or five diameters; it is procured from the same neighbourhood. Two views are shewn, the dorsal and ventral.

Owing to the vrey able and comprehensive description of the Limnoria Lignorum given by Professor Baird, in his Report of the sea fisheries of the south coast of New England in 1871–72, we are able to place this wood borer in the order of its species as one of the crustacea. At page 379 Dr. Baird says:

"Of Crustacea, the most important is the Limnoria Lignorum. (p. 370 Plate VI, fig. 25) This little creature is grayish, and covered with minute hairs. It has the habit of eating burrows for itself into solid wood to the depth of about half an inch. These burrows are nearly round, and of all sizes up to about a sixteenth of an inch in diameter, and they go into the wood at all angles, and are usually more or less crooked. They are often so numerous as to reduce the wood to mere series of thin partitions between the holes. In this state the wood rapidly decays, or is washed away by the waves; and every new surface exposed is immediately attacked, so that layer after layer is rapidly removed, and the timber thus wastes away and is entirely destroyed in a few years. It destroys soft woods more rapidly than hard ones; but all kinds are attacked except teak. It works chiefly in the softer parts of the wood, between the hard, *annual layers*, and avoids the knots and lines of hard fibre connected with them, as well as rusted portions around nails that have been driven in; and, consequently, as the timbers waste away under its attacks, the harder portions stand out in bold relief. When abundant it will destroy soft timber at the rate of half an inch or more every year, thus diminishing the effective diameter about an inch annually.

"Generally, however, the amount is probably not more than half this; but even at that rate, the largest timbers will soon be destroyed, especially when, as often happens, the Teredos are aiding in this work of destruction. It lives in a pretty narrow zone, extending a short distance above and below low water mark. It occurs all along our shores from Long Island Sound to Nova Scotia. In the Bay of Fundy, it often does great damage to the timbers and other wood-work used in constructing the brush fish-weirs, as well as to the wharves, &c. At Wood's Hole it was formerly found to be very destructive to the piles of the wharves. The piles of the new Government wharves have been protected by broad bands of tin plate, covering the zone which it chiefly affects. North of Cape Cod, where the tides are much greater, this zone is broader, and this remedy is not so easily applied. It does great damage, also, to ship timber floating in the docks, and great losses are sometimes caused in this way. Complaints of such ravages in the Navy Yard at Portsmouth, New Hampshire, have been made, and they also occur at the Charlestown Navy Yard, and in the piles of the wharves at Boston. Probably the wharves and other submerged wood-work in all our sea ports, from New York northward, are more or less injured by this creature, and if it could be accurately estimated, the damage would be found surprisingly great.

"Unlike the Teredo, this creature is a vegetarian, and eats the wood which it excavates, so that its boring operations provide it with both food and shelter. The burrows are made by means of its stout mandibles or jaws. It is capable of swimming quite rapidly, and can leap backward suddenly by means of its tail. It can creep both forward and backward. Its legs are short and better adapted for moving up and down in its burrow than elsewhere, and its body is rounded, with parallel sides, and well adapted to its mode of life. When disturbed it will roll itself into a ball. The female carries seven to nine eggs or young in the incubatory pouch at one time.

"The destructive habits of this species were first brought prominently to notice in 1811, 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. Since that time it has been investigated, and its ravages have been described by numerous European writers. It is very destructive on the coasts of Great Britain, where it is known as the "gribble."

If we contrast the destructive powers of the two most remarkable wood borers inhabiting our shores we find a great diversity in size, form, mode of operation, mode of existence and attack.

The Teredo, as we find it, is from four to six inches long, and about $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. The Limnoria is about 1-16 to 1-8 of an inch in length, and about one half that thickness. The Teredo is long and vermiform; the Limnoria is short and ovate. The Teredo bores to make itself a house. The Limnoria bores for existence. The Teredo lives on the infusoria of the water; the Limnoria on the substance of the wood itself.

The Teredo attacks from the outside, and penetrates into the heart of the timber; the Limnoria attacks from the outside only, and rarely more than one half an inch, until the cells are destroyed by the water, when it renews its efforts and destroys again.

From these facts it will be seen that the preventive measures to be taken in order to counteract the attacks of these two classes of borers, should be quite different. For instance: the means to be devised for the preservation of wood from the attacks of the Teredo in the harbour of Pictou should be entirely different (preventively considered) to those which should be employed in the harbour of Halifax. To arrest the destruction going on by the Limnoria Lignorum, one means must be used so as to permeate every pore of the wood internally; the other need only to be applied externally, so as to fill up the half inch cavities or cells visible on the outside of the timber, or both destroyers may be warded off by a metallic covering, so as to prevent them from attacking the wood at all.

That the Teredo existed in Europe, in a geological period earlier than our own, does not admit of a doubt. At Belfast, Ireland, 12 feet under the surface in a blue argillaceous soil beneath a series of strata of shells, in the London clay, in the Eocene formations at Brussels, and also near Ghent, fossil wood containing the remains of the Teredo has been found.

An idea prevails that the Teredo was imported from abroad through vessels coming from the East Indies to Europe; but this is said to be an erroneous impression. The same idea prevails here, that it was imported from the West Indies through the same means, and it may be found equally fallacious. It is obvious that the Teredo in Nova Scotia does not seek the most southern and warmest haunts.

One of the circumstances favoring the ravages of the Teredo is said to be saltness of the water; it is not found in brackish water here; and owing to the narrowness of our Peninsula (not more than 100 miles at the most) the small consequent water sheds, and the small volume of water poured from them into our harbours, we cannot say much on this point. I have, however, nowhere observed the Teredo active near fresh water.

The Teredo finds himself exposed to the attacks of an annelide which is constantly found wherever the Teredo exists. His eggs and embryos are met with in the midst of those of that mollusc.

Kater has remarked that the adult annelide leaving the muddy bottom where he has hibernated, and in which the piles are driven, climbs along the surface of the wood toward the opening made by the teredo; there he sucks away the life and substance of his victim; then, slightly enlarging the aperture, he penetrates and lodges in place of the teredo. All the early writers on this subject state that they have found this annelide in wood at the same time with the teredo. It is remarkable that a similar annelide, and perhaps the same, has been found in the cavities hollowed out in stone by the pholades.

We have an annelide in Nova Scotia that hibernates in winter as represented, and is busy in our mussel beds in summer. I cannot say whether it is the species or not alluded to by M. Andrews. I have not heard of its being found in the cells of the teredo.

Experiments in the preservation of wood from the attacks of the Teredo.

The trials made by the Commission may be placed under three principal groups:

1. Coatings applied to the surface of wood, or modifications of the surface itself.

2. Impregnation of wood with different substances, which modify the interior as well as the surface of the wood.

3. Employment of exotic woods, other than ordinary woods of construction.

Coatings applied to the surface of wood. The methods belonging to this group; which have been examined by the Commission, are the following:

1. Method invented by M. Clawren, and kept secret by the inventor.

2. Metallic paint, invented by M. Clawren, and likewise kept secret.

3. Method of M. Brinkerink, consisting of a mixture of Russian talc, resin, sulphur, and finely powdered glass, applied hot

on wood previously roughened by a toothed instrument; this application was two millimetres thick.

4. Method of M. Ripurjk, analogous to the preceding.

5. Paraffine varnish, obtained by the dry distillation of peat, from the factory of M. M. Haages & Co., at Amsterdam.

6. Coal tar applied cold on the wood in several successive layers, or applied hot on wood whose surface had been previously carbonized. Some pieces were treated as follows: Holes were first bored in them and filled with tar; then plugs were fitted closely to the holes and driven in with sufficient force to make the tar penetrate the wood; other pieces still were painted over with a mixture of tar with sulphuric acid, or sal ammoniac, or turpentine, or linseed oil.

7. Painting with colours mixed with turpentine and linseed oil, among others, with chrome-green or with verdigris.

8. Singing or superficial carbonization of the wood.

The pieces of wood thus prepared were placed in the water at the end of May, 1859, and the first examination, made toward the end of September of the same year, showed that neither of these methods afforded any protection from destruction by the Teredo. There was one partial exception, and that was the piece of wood treated according to No. 6; these showed only traces of the Teredo here and there. But at a later examination, in the autumn of 1860, when the wood had been exposed a year and a half, these were also found to be equally severely attacked by the Teredo.

The results of these experiments strongly convinced the Commission that no exterior application of any nature whatever, or modification of the surface merely, would give any efficacious guarantee of protection against the teredo. Even supposing that one or another of these means would prevent the young teredo from attaching themselves to the wood, yet the constant friction of the water or ice, or any accident, might break the surface of the wood sufficient to give access to the teredo.

This seems a proper place to mention a practice in general use in Holland for warding off the teredo; this consists in covering wood with a coat of mail made of nails. This operation is very costly; for, to really protect wood in this way, it is important that the square heads of the nails join exactly; for insuring the best results, the armoured piles are exposed in the open air for some time before being placed in the water, that rust, forming on the surface of the iron, may close up the interstices inevitably remaining between the heads of the nails. But this precaution is not infallible, as the Commission examined piles more than once, in the course of its investigation, which had been several years in the water, and whose surface was entirely incrusted with rust more than a centimetre thick, but which were, nevertheless, eaten in the interior by the teredo.

Impregnation of wood with different substances. The Commission examined in this category the following methods:

1. Sulphate of Copper.
2. Sulphate of Protoxide of Iron (Green vitriol).
3. Acetate of Lead.
4. Soluble Glass and Chloride of Calcium.
5. Oil of Parafine.
6. Oil of Creosote. This is, as is very well known, a product of the dry distillation of coal tar, separated by distillation from the more volatile parts, which serve for the preparation of benzole and naptha, the residuum being pitch. Experiments had already been tried abroad, as well as in Holland, with this substance, and from the beginning of their experiments the Commission paid especial attention to this very important method of preparation.

Wood of various kinds, prepared with creosote oil, at the works of the Society for the Preservation of Wood, at Amsterdam, was placed in the sea in the month of May, 1839, at Flessingue, Harlingin, and Stavoren, the pieces of oak, pine and red fir, were found intact, while those unprepared were perforated. In the month of October, of the same year, the pieces of creosoted pine and fir at Harlingin showed a perfect state of preservation. At Harlingin the treated and untreated pieces were fastened together; the teredo penetrated the latter, but had not touched the creosoted wood. The same was true of the creosoted wood at Stavoren, when visited in 1859.

At Nieuwendam in March, 1859, three pieces each of oak, pine, and red fir, all creosoted at Amsterdam, were exposed in the sea. They were examined in September of the same year. They had been fastened together by cross pieces of unprepared wood; it was found that the teredo had penetrated, at the juncture of these cross pieces, even into the creosoted wood, and that sometimes he stopped immediately beneath the surface; at others he penetrated to a depth of several millimetres; in the oak, he worked his way into the interior through those parts of the surface which were not in contact with the unprepared wood.

Experiments with creosote oil were recommended in July, 1860, with ten pieces each of oak and red fir, following the plan indicated in paragraph 5; the localities chosen were Kieuwe-Diep and Stavoren; in the latter place the pieces which remained intact the previous year were again placed in the water after their surface had been removed by the adze. Still later in August, 1861, a further trial was made at these same places, with pieces of pine, beech and poplar, sent to the Commission by Mr. Boulton, and prepared at his works in London. All these pieces were examined toward autumn in 1862, 1863 and 1864; while the unprepared pieces, placed near the others as counter-proof, were found each year filled with teredos, one could not discover any traces of the teredo in the creosoted pieces except in the oak creosoted at Amsterdam; in cutting these it was found that the creosote had penetrated them very imperfectly. A third examination in 1864, showed that all the pieces prepared by Mr. Boulton, and which had been exposed in the sea since August, 1861, were entirely intact; the most careful examination could not show the slightest trace of the worm, even in the pieces withdrawn from the water in 1862 and 1863, and each time scraped to a depth of several millimetres and again placed in the water. They resisted the attacks of the teredo perfectly.

Conclusions. By way of recapitulation, the result of the experiments, tried by the Commission during six consecutive years, were as follows:

1. The different coatings applied to the surface of wood, with the design of covering it with an envelope on which the young

teredo cannot attach itself, offer only an insufficient protection; these coverings are likely to be injured either by mechanical means, such as the action of the water, or by being dissolved by the water. Just so soon as a point of surface of the wood is uncovered, be it ever so small, the teredo, still microscopic, penetrates into the interior. Covering wood with sheets of copper or zinc, or with nails, is a too expensive process, and only protects the wood so long as they form an unbroken surface.

2. Impregnation with inorganic, soluble salts, generally considered poisonous to fish and animals, does not protect wood from the attacks of the teredo.

3. Although we do not know with any certainty if among exotic woods there may not be found these which will resist the teredo, we can affirm that hardness is not an obstacle which prevents the mollusc from perforating his galleries; the ravages observed in wood of guaiacum and mamberlak prove this.

4. The only means which can be regarded with great certainty as a true preservative against the injury to which wood is exposed from the teredo, is the oil of creosote; nevertheless, in employing this means care is necessary that the oil be of good quality, that the impregnation be thorough, and that such woods be used as will absorb oil readily.

The conclusions arrived at by our Commission are confirmed by the experience of a large number of engineers in the Netherlands, and also in England, France and Belgium. M. Crepin, a celebrated Belgian engineer, expresses himself thus, in a Report on experiments tried at Ostend, under date of February 5, 1864:

"The result of our experiments now seems decisive, and we think we can draw from them this conclusion: that soft woods, well prepared with creosote, are protected from the attacks of the teredo, and are in a condition to assure a long duration. The whole matter, in our opinion, is reduced to a question of thorough impregnation with good creosote oils, and the use of such woods as are adapted to the purpose. It has been found that resinous woods are impregnated much better than other varieties."

Mr. Fourtier, a French engineer at Napoleon-Vendu, in a report dated March 3, 1864, makes a resumé of experiments conducted by himself in the port of Sables d'Olonne, in the following words:

"These results fully confirm those established at Ostend, and it seems to us difficult to refuse to admit that the experiments at Ostend and Sables d'Olonne are decisive, and prove in an incontestable manner that the teredo will not attack wood properly creosoted."

"Under date of Haarlem, April 20, 1878, Prof. Von Baumhaur, writes to Edward R Andrews, of Boston: 'I have deferred answering your favor of the 22nd of February, until I had corresponded with the chief engineers of the Waterstaat as to the results obtained in their experience in the use of creosoted timber in all our marine works, in large quantities, and during some tens of years. They all unanimously agree that the teredo will not penetrate timber thoroughly impregnated with creosote: but that, to obtain the best results, the work must be thorough, as they had observed that the teredo had destroyed piles only superficially infected.'

"Fir, if the sap be first withdrawn in a vacum and then treated with hot oils under a heavy pressure, can be most thoroughly creosoted; but oak is more difficult. Still, I have often seen heavy oak piles where the creosote had entered into the very heart."

In a paper read by Mr. Burt, before the Institute of Civil Engineers, London, upon the nature and properties of timber, with a description of the methods then in use for its preservation, after reviewing John Howard Ryan's, Sir William Burnett's, and Payne's process, then in use, he proceeds to say:

"One hundred parts of coal tar contain, when submitted to distillation, 65 parts of pitch, 20 of essential oil (creosote), 10 of naptha, and 5 of ammonia. The oil produced from this distillation is the creosote of commerce, now so extensively used for preparing timber. The preservative properties of this material appear to be threefold.

First. It prevents the absorption of moisture in any form, or under any change of temperature.

"Secondly. It is noxious to animal and vegetable life; thereby repelling the attacks of insects and preventing the propagation of fungi.

"Thirdly. It arrests the vegetation or living principle of the tree, after its separation from the root, which is one of the primary causes of dry rot, and other species of decay.

"The attention of the author of the paper referred to, was first called to this subject in 1841, in consequence of having practiced the process, to some extent, for Mr. John Braithwaite (M. Inst. C. E.), on the Eastern Counties Railway. The works, in that case, were of the most primitive and incomplete description; nevertheless they answered the purpose, and the sleepers, prepared at Heybridge, eleven years ago, are as sound and perfect as the day they were laid down, although they are of Scotch fir, and not of very good quality. Since that time; being extensively engaged in preparing timber, many improvements have been made in the machinery and apparatus, and in the method of preparation.

"Creosote is at present used for preparing timber, either under pressure in strong closed cylinders, or by placing the timbers in open tanks, and keeping the solution up to a temperature of 120° to 150° until the required quantity is absorbed. Creosote has the property of crystallizing when the temperature is below 35°, and it becomes a hard compact mass of salts. It was in consequence of this peculiarity, and the difficulty of using it in the winter season, that peat was resorted to; and was done in the first instance by making a common fire-place at one end of the reservoir, and running a flue under the bottom. This system was, however, exceedingly dangerous, because the oil came in contact with the heated iron plate, and the temperature could not be raised beyond 70° or 75°, or only just sufficient to enable the work to be continued conveniently during the cold weather. The experiment was then tried of allowing high pressure steam to blow into and upon the creosote in the reservoir; by this means the temperature was raised as high as was required, and it has continued to be used. Where a steam engine is used for working the pressure pumps, the waste steam can be employed to heat the creosote, by passing it through a coil of pipe laid in the bottom of the reservoir. This mode of heating was first adopted at Mr. Bethell's works at Battersea, and it answers admirably.

"The cylinder now used in the ordinary process is similar to a steam engine boiler, 6 feet diameter, and from 20 feet to 50 feet long. Formerly the end or charging doors were made in a variety of ways, some to open inwards, some to slide in air-tight grooves, and others similar to the cover of a gas retort. Nothing, however, answers so well as to have the cover of the full size of the cylinder, with proper fastenings, and all the joints accurately turned and fitted together, for the pressure on so large an area is enormous, and the heated oil is so exceedingly subtle, that great care is necessary to prevent leakage. Small trucks run on rails inside the cylinder and carry the load. These formerly ran out upon a long switch, and were then turned into a siding and unloaded. A different plan is now adopted, by making the inside lorries run out upon another larger and stronger truck of the ordinary gauge, so that by this means they can be run on to any of the adjacent sidings, to be unloaded without shifting a second time.

Since 1853 the process then described by Mr. Burt, as creosoting under pressure in strong cylinders, has become the favorite one to adopt to resist the attacks of the teredo. The same process, with slight modifications, is carried out to this day, both in Europe and America.

The Dutch Commission speak most favorably of it.

English engineers, such as Hawkshaw, Burnett, and others, speak of it from time to time in the Reports of the Transactions of the Society of Civil Engineers, in a very favorable manner. American engineers generally recommend its adoption.

But no better example could be desired of the efficiency of creosote to prevent the attacks of the teredo, than we have in the Harbor of Sydney, Nova Scotia. Here the teredo is seemingly as destructive, if not more so, than at any place on our coast, and here, about ten years ago, a coal-loading pier was erected sufficiently large that three ocean-going steamers could load coals at the same time. The pier runs out into the harbor; it was erected entirely of pine timber, creosoted in Great Britain, and sent out here. It has most effectively withstood the ravages of the teredo, whilst all other piles in the neighborhood had to be renewed twice.

Not satisfied with reports about its permanency, so far, I requested that the Sydney and Louisburg Coal and Railway Company would have an examination made for the purpose of this paper. I have to-day a telegram from Mr. D. J. Kennelly, Q. C., managing director of that Company, in which he says: "Creosoted pier absolutely sound; ten years erected. Timber not creosoted twice renewed."

One of the objects of this paper is, firstly, to point out the necessity which exists for a creosoting apparatus to be placed in Nova Scotia, somewhere in the region of the Teredo's most active operations; and, secondly, that experiments be conducted by some responsible parties, as to the best means to adopt to arrest the ravages of the Limnoria Lignorum.

Considering the interests at stake and the great annual loss to the Department of Public Works, Canada, from these destructive animals, one would think that something should be done in the public interests, by at least investigating the matter, and with the view of proper remedial measures being taken so far as practicably possible, to mitigate or prevent their ravages in the future.

ART. VII.—SHORE BIRDS OF NOVA SCOTIA. BY BERNARD GILPIN, A. B., M. D., M. R. C. S.

(Read April 10th, 1882.)

IN studying the immense flocks of what are called Shore Birds, which yearly appear during July, August and September of each year upon the flats of the Bay of Fundy, St. Mary's Bay, the Tuskets, and Digby Basin, in Nova Scotia, we must consider them as migratory birds, breeding, with few exceptions, in the Polar regions, and now returning with their young to warmer latitudes, reaching even the Gulf of Mexico, and thus passing our

[illegible] from November, [illegible] 1876, in crib at Pier [illegible] North River, twenty- [illegible]

FIG. 14.—Spruce submerged two years in Coal Mining Company's wharf, Middle River, Pictou, N. S., four feet below low water.

FIG. 14.—This cut was made from a *Teredo navalis*, taken from a pile exposed two sea-ons (1876 and 1877) at Horn Island, Gulf of Mexico. When first taken from the wood it was eighteen inches long.

FIG. 15.—Hemlock from Yacht Club wharf, Halifax Harbor, N. S., attacked by Limnoria Lignorum. Enlarged 4 diameters.

FIG. 16.—Photograph of piece of spruce pile from Halifax Harbor, N. S., containing living Limnoria and Mussels.