INSECTS DESTRUCTIVE TO BOOKS.*

BY WILLIAM R. REINICK.

"The man who marks a borrowed book,
And makes the ends and corners look
Dog-eared and ragged and infirm,
He is an insect and a worm."

ELLA WHEELER WILCOX.†

It will be impossible in this lecture to go into details regarding the various series of experiments that have been made and studied in order to obtain the results, which I will speak of this evening, on account of the limit of time. Some of my remarks will appear to some researchers to be the words of one lacking an understanding of the groundwork of science, but in reply to those who doubt, I can only say, investigate along the same lines and the results will amply repay you for your time and labor.

Paste-eaters.—The statement previously made by me to the effect that the paste used in binding was often eaten by the larvæ of insects hatched from eggs that were originally in the flour, has been questioned on the ground that the heat necessary to boil paste, 212°, would have killed all life. How this challenge could have been made by anyone who had experimented on the vitality of eggs under adverse conditions is beyond my comprehension. They confuse the life that has hatched with the life within the egg. Heat no doubt would destroy the greater portion of the life that had hatched, but not always, as in the case of certain bacteria, who from their known power to withstand a high degree of heat, are popularly called heat-lovers. They have even stood the high temperature of steam for a number of hours. But aside from the imago state of the insect, the egg, in which the embryo passes through its various stages, has been overlooked, and experiments properly conducted will prove them capable of withstanding a temperature very much above that which the scientist of today has knowledge.

Anyone caring to investigate the life in the paste may easily do so in the following way: Boil the flour in the usual manner, adding the glue for the binder, and after allowing the mass to cool, let it stand in a dark, damp place. After it has become sour, it will be found that nature will again produce the same forms from it as she did when it was in the form of flour. Naturally, to give conclusive evidence, care must be taken to see that no insects are allowed to gain access to the paste from the outside, so as to avoid any possibility of their laying their eggs in the substance.

Bindings: Wood Bindings.—Books that are bound with wood covers are always subject to the borings of the insects that lived on the species of trees from which the boards are made, especially if the atmosphere is saturated with moisture, this being due to the porous nature of the wood. Take the point of a needle, touch the wood, and you find that it gives, showing that it is composed of cells containing gases. They are not only subject to attacks from without, but also from within; *i.e.*, larvæ hatching from eggs that were deposited in the tree

before it was made into lumber. The early stages of a number of species of wood-destroying insects take quite a long period to evolve.

The insects destroying wood bindings are species of *Bostrychidae* and some of the *Scolytidae*. One species of *Cerambycidae* has been named as causing trouble, and as a large proportion of the species of this family are wood-borers, other species will likely be found to tunnel these covers.

Bindings: Leather Bindings.—The so-called dry rot of leather bindings said to be caused by the fumes in the air, especially where gas is used for lighting purposes, is also found to take place with leather-bound books that have not been exposed to such chemicals. Investigation will prove that instead of gases being the destructive agency, minute forms of life alone are the cause.

Another subject for future research is the cause of certain round holes, as though made by shot, often found in books bound in sheepskin. A careful examination of bindings showing these peculiar shot-like holes failed to show any galleries leading into or along the back of the books, which the *Coleoptera*, the insects named as committing these ravages, would make; and careful observation will reveal that instead of the holes being made by beetles, that a species of *Trichina*, a parasite which at present causes great losses to sheep-breeders, is the source. The skins, even after going through the various processes of tanning, still contain the same basic principles as in the primo state.

FIG. 1

Book from British Guiana. The volume is bored through by a species of *Coleoptera*.

Bindings: Printed Cloth Bindings.—These bindings, on account of the oils and greases used in their manufacture, are subject to the ravages of those insects which have use for such substances.

Species of *Blattidæ* and *Gryllidæ* are fond of these bindings.

Printing Inks.—While investigating the various printing inks, Mr. Thomas A. Bradley, President of the Security Bank Note Company, of Philadelphia, called my attention to the fact, that the working clothes of the employees of his company, if left hanging in a dark place for a time, were found to have been gnawed by the larva of some species of insect, and that the most striking part was, only that part of the clothing which had been stained with ink was eaten. Most inks contain one or more acids in their composition, and as they are claimed to be poisonous and therefore should kill, one would say that the parts of the goods discolored by the inks should be exempt from these attacks, instead of proving attractive. A French author writes of a book in which the insects had eaten the portion of the paper which had received the impress of the ink, showing that they were after something besides the paper, paste or binding.

To prove this, I took a piece of parchment—sheepskin and imitation—and a quantity of the finest grade of engraver's black printing ink, made a circle of ink in the centre with diagonal lines running from this to the corners and sides and a one-eighth inch border all around the edges. After the ink was dry, I placed a piece of each kind of parchment in a tin can with twelve roaches, adding water from time to time for drinking purposes. At the end of two weeks an examination of the parchment showed that the roaches had eaten all of the edges, had then followed the diagonal lines, eating mostly the portions so marked, and then the circle, showing that they knew the value to them of the acetic acid which was in the ink.

I hope that other experiments will be made along the same lines to ascertain if the various dyes, though often of the same color, are more secure from the inroads of insects than others, on account of containing certain chemicals in their composition. *Blatta orientalis* was the species used in making these experiments.

CONDITIONS FAVORABLE FOR THE PROPAGATION OF BOOK PESTS.

Darkness.—The majority of libraries generally keep a large number of their books upon stacks placed in a dark portion of the building, badly ventilated, and the only light available as a rule is from gas jets or incandescent lamps, which are only lighted when needed. This darkness (the necessary condition for the starting of all life), the more or less damp air which is found in these surroundings, the gases of various kinds in the air, and the fact that the books most seldom called for are kept in these locations, all combine to give favorable conditions for the propagation of these small forms of life without much chance of their being disturbed during the evolution of their life-cycle.

Gases.—It is known that quite an amount of poisonous gas is given off by the gas used for lighting purposes, and also from the breath of readers, and that if the room is not properly ventilated, a quantity is constantly floating in the air. As plant life is known to live upon this gas, so will the lower forms of life be found to exist to a greater or less degree upon them.

In the earlier stages of the earth's history, when the chaotic conditions were in full play and harmony, every form of life was crude and drawn to the grosser matter that surrounded it for its energies and principles of growth. From the sun emanates the rays that have acted on the earth's surface and its interior, generating various elements known to science to-day to the extent of some seventy elements. By the action of these heat rays in associating the waters of

the earth with these elements were generated gases, and these gases are the energies upon which the lower organic life lives.

Man's body is a laboratory of life. While man uses intelligence in regards to poisons, the instinctive power of the little insect is used with greater care. Doctors will prescribe poisons and the patients take them without question, but the little insect uses its instinct to know what not to touch, and of those that it does partake, knows just how much to eat.

UNFAVORABLE CONDITIONS FOR THE INCREASE OF THESE INSECTS.

Light.—This, with cleanliness, are the two most important factors in preventing the ravages of insects among books, and will also prevent another sort of damage to books, which is the various kinds of fungi which start to grow upon and in the books a short time after they have been placed in a damp, warm atmosphere.

The lessening of the destruction of books by insects, that have been kept on shelves in badly-ventilated and badly-lighted libraries, after having been transferred to a new building having good ventilation and light, is ably illustrated by the experience of Mr. Ernest J. Reed, Librarian of the Oahu College, Honolulu, Territory of Hawaii. He stated in a letter to me that before the books were moved to the new building, the whole collection was constantly being riddled by various species of boring insects, but that since moving to the new quarters they are comparatively little troubled by pests. From an examination of samples of books I have received from him, I wonder how anyone was able to read the books with any degree of satisfaction, as many had hundreds of tunnels running through them, some had large cavities eaten in them, and others looked as though a mis-

FIG. 2

Volume from the Hawaiian Islands. The cloth cover is almost entirely eaten, exposing in the strawboard the tunnels of *Calorana Mexicana*, a species of *Coleoptera*.

chievous boy had taken a pair of scissors and tried to see how many strips he could cut each leaf into; in others the cloth binding was almost entirely eaten off, exposing the galleries made by the beetles in the cardboard covers. (Illustrations Nos. 1 and 2.)

Books will also be found to have forms of life living upon them which at present cause much speculation as to what substance they feed upon, and the insects commonly known as book-lice, belonging to the family *Psocides* of the order *Corrodentia*, are examples. In turning over the pages of books or looking over papers which have been kept in a dark location for a long while, one with a keen eyesight will often see little specks of life run to a crevice to hide or get away from the rays of light. On account of their whitish gray color and an ability to run with a speed which is amazing when the size of the insect is considered, it is only the keen observer who will spy them as they scamper across the printed page. Though so small, they will be found to be the cause of a great deal of damage to books.

Many investigators think that the greatest damage is committed by the larger forms, whereas, as a rule, the smaller species, in proportion to their size, consume many times the amount of food as compared to that of the larger insect. I especially noticed this in making the experiment on artificial parchment herein mentioned, where twelve roaches, many of them females, big with eggs, at which time, of course, in order to provide the necessary supply of food for the coming generation, they would eat more than before the period of gestation, ate such a small amount of the paper that I spoke about it to a gentleman who was present when I examined the parchment. A fly in one day will consume food equal to its own weight. This is also illustrated by birds, who, in proportion to man, eat a far greater quantity of food.

Researches.—During the past year, I have made a number of experiments, and much against my will have arrived at the conclusion that as far as our present knowledge of the effects of poisons on these small forms of life is concerned, we have not even laid the foundation upon which to build.

The potato bug is an example. The paris green is placed on the plant in the morning, but at night the bugs are still there and seem to be eating the plant with more voracity than when it was absent. The chemical elements in the air and plant cause a reaction to take place, by which the poisonous qualities are lost, and instead of poison to kill, a substance to the liking of the insect is produced, as I discovered during my experience in farming.

Another source of error is the lack of positive knowledge as to the resistance of these minute forms to poisons, heat, pressure, etc., in their early stages. I have been taken to task for the statement made by me in my first paper as to mosquitoes hatching from eggs that have lain exposed for a long period of time, but I think that the following example of life remaining dormant under adverse conditions is more wonderful.

When I started to collect insects, I used for a cabinet a case of drawers which had been kept in a dry room of my home and had been in daily use for about twelve years, and placed it in an outside shed, the atmosphere of which was warm and damp. Some time after, upon looking at the contents of one of the drawers, I discovered a specimen of a large species of *Cerambycidæ* lying on the bottom and wondered where it came from. After searching on the outside and finding no opening, I pulled the drawer entirely out and discovered that the insect had emerged from the board used in making the side of the drawer, show-

ing that while the case remained in a dry location, the life remained dormant, going on with its life cycle when the proper conditions were given.

Seeds stored in a dry location for quite long periods have been known to produce plants when placed in the soil, and anyone familiar with bacteriology knows the great vitality of these forms, invisible to the naked eye. The smaller forms also have bodies more capable of withstanding supposed remedies than the larger insects. Take one hundred roaches and the same number of red ants, pour boiling water on them, count the number of survivors of each kind, and you will find that all or mostly all of the roaches will have been killed, while a large proportion of the ants are still alive; an interesting line of experimentation for economic entomologists.

Remedies.—I have received letters from almost every country of the world suggesting remedies, some claiming success, but the majority acknowledging defeat; in many cases what was proclaimed to be a specific remedy by one writer was declared to be a failure by others.

Even books, treated with the strongest poisons, failed to give the desired results, but on the contrary the remedies seemed to give the insects that they were supposed to kill a new lease of life. In the case of experiments conducted by the United States Bureau of Standards,* and also by myself, the roaches (the insects experimented with) produced their young as though nothing unusual was taking place. The roach, although said to have a wonderful instinct, really has less than the smaller forms of insect life. A famous remedy for destroying roaches is made of a combination of sulphur and sugar, the sulphur causing a luminosity when the bait is placed in the dark. The roach is attracted by the glow that deadens its instinct which would otherwise warn it against the poison, and it eats the bait; but the little ant's instinct, not being affected by the light given off by the sulphur, warns it of the danger, and as a consequence it seldom eats a poison that is placed near its haunts. This Bureau made a very large series of experiments in order to obtain, if possible, a binding material which would be exempt from the inroads of insects, and also to withstand the effects of light and gases without fading, and which Prof. S. W. Stratton, the Director of the Bureau, very kindly loaned me for study. The tests were made with cloths, ducks and buckrams of various colors. A portion of each piece was chemically analyzed in order to find what substances were used in their manufacture, and the rest of each sample was exposed to the roaches for various numbers of days. The results, when tabulated, proved that it did not seem to make any difference as to what materials were used in the coating, many of which were poisonous, as they had nibbled all but one of the bindings. They then tried impregnating some of the samples with a weak solution of quinine and others with strychnine, but these failed to give the desired immunity; and, upon increasing the quantity of the poison in the solution, the attractiveness of the substances was increased. Even corrosive sublimate was ineffective. It is true that the insects died within a few days, but not until they had ruined the bindings. One sample, seeming to be exempt from their ravages, was selected and adopted by the Bureau as a standard for binding the United States Congressional documents, and also accepted by the American Library Association Committee on Book-Binding as the best binding for library books.

*Memoranda relative to binding of publications for distribution to state and territorial libraries and designated depositories.—United States Congress, Washington, 1908.

During a conversation in the Government Printing Office last winter, while being shown the various materials used for binding Government documents, I expressed doubts as to the buckram approved, known as No. 666, being insect-proof; and this opinion has since been confirmed by experiments made by the Philippine Bureau of Science, Dr. Stratton and myself.

My own experiments with a poison of an entirely different character gave better results. One-half of each of the various kinds of binding materials tested was treated with my preparation and the other half left untouched. They were placed in boxes and exposed to the attacks of the roaches for various periods. Upon examination, I found that while the coloring matter in certain samples had been eaten on both the treated and untreated portions, the poisoned portions of quite a number of the others were left alone. In some cases pieces of the same color, although of different manufacture as regards to one sample, were eaten and the other piece was left undisturbed. The remedy used by me did not, to my knowledge, kill any of the insects. From a comparison of the results, I arrived at the conclusion that the material used for coating the buckrams, etc., in a number of cases, had neutralized the effective action of the preparation used by me, and that in order to really obtain a material that would be insect-proof, it would be necessary to use such coloring matters as would not overcome the beneficial action of the poisons.

The fact that insects seem to show preference for certain colors used in binding materials, has already been noticed by a few of my correspondents; and also by myself while making researches in Florida last summer.

The Philippine Bureau of Science, finding that the buckram used as a standard was not insect-proof in the Islands, made another series of experiments, and have produced material which they claim is absolutely safe, but as I have not received any samples to test, although I have made request for same, I am unable to pass judgement upon it.

Although scientists have been experimenting upon binding materials in order to obtain one that would be exempt from the ravages of these little insects, little has been done towards preserving the most important part, and which, according to my investigations, receives the greatest injury, namely, the printed portion of the book. Some experiments made by J. Rodway, Esq., Secretary of the Royal Agricultural and Commercial Society of British Guiana, with papers impregnated with sulphate of copper, turpentine, kerosene and corrosive sublimate, failed to stop the borings of the insects. I have sent boards and books made of different papers which I have treated with a substance to Mr. Rodway, and to other parts of the world, and the results as to the effectiveness of the remedy used should be received during the coming winter.

Arsenic in its various forms is used in large quantities in the materials used in book-making, though denied by the manufacturers; but chemical analysis will generally show the presence of this substance, which is of use to the insects. The elimination of arsenic in materials used in book-making would not only do away with a source of attraction to the insects, but save people from being poisoned, as anyone familiar with the literature of poisons knows.

Books as Disease Carriers.—Again, I speak upon the transmission of diseases by books, because the greatest disease carrier among insects that we know of to-day is the common house-fly, *Musca domestica*, which is also one of the book-destroying insects. There are a number of instances where the maggots of the fly have been found living upon paper, kept in damp places, but the

damage done directly to the book is as nothing when compared to the damage done by their transferring germs, and, unless means are taken for their extermination, they will rank first among book enemies, because those who know of the fly's ability to carry disease germs, will refuse to read any book which the fly has stained. The common house-fly is only found around the habitation of man, showing that it has evolved from some other form which formerly lived in the open until it has now become thoroughly domesticated, as other forms have done, are doing, and will do in the future.

According to Dr. Howard, a single female fly in the spring might, therefore, become the progenitor of 195,312,500,000,000,000 flies by the end of the summer or mid-autumn, and allowing one million flies to a bushel makes over 193 million bushels, each one of whom is capable of spreading contagion. An investigation made at the Agricultural Experiment Station at Storrs, Connecticut, in 1908, upon 414 flies, showed that the number of bacteria on a single fly may range all the way from 550 to 6,600,000, an average of one and one-fourth millions bacteria on each, an almost incredible number to be found on such a small object. The objectionable class, coli-aërogenes type, was two and one-half times as abundant as the favorable acid type. Now this only includes those on the outside, and every bacteriologist knows that large numbers are found in the intestines and expelled with the excreta. Mr. N. A. Cobb, in his article "The House-Fly,"* states that a well-fed fly defecates 104 times in less than two hours, and that spores were found in fifty-five of the specks. These specks, containing germs, are laid upon the covers or pages of the books, and as personal observation shows that a very large portion of readers moisten their fingers in turning over the leaves of a book, it is readily seen how the fly speck upon the the paper is moistened, adheres to the finger and the germs transplanted to the mouth, where they at once find the proper conditions and proceed to breed, resulting in the reader becoming afflicted with the disease, the source of which it is impossible to trace, on account of the slight consideration given by the medical world at the present time to books as a source of disease.

The danger of contracting disease by the fingers dampened with saliva in order to turn over the pages of a book is especially so in the case of persons suffering from tuberculosis, whose sputum contains millions of the bacilli. The saliva drying, the *Tubercle bacillus* clings to the fibre of the paper, and soon as another person, who also has the vulgar habit of wetting the fingers in turning the pages, uses the book, the germs are removed to fertile soil. Many other diseases, especially skin diseases, are without doubt frequently transmitted by this means.

In conclusion, I cannot speak strongly enough on the importance of cleanliness in preventing the destruction of books by insects, and the spreading of disease. The volumes in the library should be kept thoroughly cleaned, the attendants ought to clean their hands frequently, and the patrons compelled to wash their hands before using the publications and should not be allowed to wet the fingers in turning the pages. These precautions will help to decrease the spread of tuberculosis and other diseases, and do away with the grease stains on the paper, which are breeding grounds for germs and attractive feeding places for insects. Screens should be placed on all windows and doors to prevent the

*National Geographic Magazine, vol. xxi, 1910, pp. 371-380.

entrance of flies, and by these means only will the destruction of the stores of accumulated knowledge be decreased and a source of death be overcome.

Theory Confirmed.—As this article goes to press, I have just obtained results from an experiment which goes to prove that books may be damaged by the hatching of life from eggs which were originally in the flour, or most likely, the grain.

In June, 1910, I obtained from Mr. James Stone, of Philadelphia, three samples of flour which he claimed were absolutely pure and each of the three varieties were placed in a sealed Mason jar and the jars put upon a shelf in a closet. They were thus kept in a dark location and also a dry atmosphere. At various times these jars were examined, but no sign of life appeared until the examination made October 6, 1911, at which time I was very astonished to find that two of the samples, "spring wheat flour" and "rye flour," were literally covered with what appears by looking through the glass of the jars to be a species of *Psocidæ* or book-lice. The third sample, "winter wheat straight," does not show any signs of life at the present time.

The results are quite startling, as it shows that the stages of some of these small forms take a period of time to evolve beyond our present knowledge, also that they did not need any oxygen to sustain them as the jars have never been opened since the flour has been placed in them, showing that the assertion made above, that many small forms live to a more or less extent upon gases supposed to be poisonous, had a foundation of truth. Lastly, that instead of one of the species known as grain-eaters appearing, that a species of *Psocidæ*, the habits of which are very little known, but I do not recollect that they have ever been classed as flour-eaters before, should appear in such immense numbers.

NOTE.—This article concludes the general outline of the divisions used by me, and I shall later publish a detailed account of each, giving descriptions and illustrations of the insects and examples of their work.

THE ANNUAL MEETING.

The 15th Annual Meeting of the Medical Library Association will take place in the Director's Room of the hotel Marlborough-Blenheim, Atlantic City, on June 3, at 8 P. M. There will also be a morning session from 10 to 12 A. M. on June 4. All the members are earnestly requested to be present if possible and take part in the meeting. Titles of papers should be sent immediately to the office of the Bulletin, 1211 Cathedral Street, Baltimore, Md.