EXPERIMENTS IN SIMPLIFIED CONTROL OF MOUND-BUILDING ANTS IN THE FOREST

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The financial factor is of great importance to the private owner in the consideration of forest insect control. The authors demonstrate simple and inexpensive methods for controlling the mound-building ant. Mounds should be treated when they are small. Treatment, with commercial carbon disulphide or ethylene dichloride, should be carried out in the late fall when seasonal activity has ceased or in the summer during periods of high humidity and low atmospheric pressure when most of the ants will be in the mound.

THE death of young coniferous trees, in both natural stands and plantations, in areas surrounding nests of the mound-building ant of the Alleghenies (*Formica exsectoides* Forel) was the subject of considerable discussion among foresters 15 to 20 years ago. In the JOURNAL OF FORESTRY for April, 1922, (Volume 20, No. 4, pp. 325-336), H. B. Peirson discussed this problem in detail, gave an historical account of the research done by previous writers, and showed the manner in which the trees were killed. It was definitely shown at that time that where the ants had gnawed the bark at the base of the tree formic acid had been injected into the wounds. The principal cell contents became coagulated, the flow of sap was prevented, and death of the trees followed eventually.

During the course of his investigation Peirson also carried on control experiments. He found that fumigation with carbon disulphide, which produces a gas heavier than air, was the most satisfactory means of control. The procedure he advised as being most effective was to pour from 1 to 1½ pounds of the fumigant into a depression at the top of the nest, cover the depression with a large dishpan or washtub placed bottom up, and then cover the rest of the mound with sod or earth. This would prevent the escape of the gas and would aid in keeping the ants in the nest. The method has proved very satisfactory on small or medium-sized mounds, but on a large mound, which may actually be two mounds grown together and which may be 8 to 10 feet in diameter, it is obvious that a simpler method would be desirable. It is also apparent that where a large number of mounds are to be treated, the item of dishpans or washtubs would entail considerable expense.

C. A. Coover, in *Forest Leaves* for April, 1930 (Volume 22, No. 8, pp. 119-120), stated that piling brush on a mound, thereby causing a dense shade that kills the ants or causes their migration to another nest, had proved effective in Pennsylvania. It appeared to the authors that with this method there would be nothing to prevent migration and the construction of a new nest, perhaps within a few feet of the old one, as this actually happened in some of the mounds, treated in the course of this study, in which the ants were not killed outright. Coover also reported that satisfactory control was obtained by digging out the mounds late in the fall and scattering the contents, exposing all stages of the ants, at a time when they are inactive, to lethal low temperatures. In districts, such as that of central Massachusetts,

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where there are many boulders and rocks in the subsoil, digging to a depth of perhaps 4 or 5 feet, to insure destruction of the queen, would often be extremely difficult, time-consuming, and therefore expensive.

With the primary idea of developing a simpler method of applying a fumigant than that mentioned by Peirson, the writers began a series of experiments in the summer of 1930 at the Harvard Forest, Petersham, Mass. At the time it was considered inadvisable to use poisons, such as thallium sulphate, as a base for baits because of the rather stringent regulations in Massachusetts against their use and because of the expense that would be necessary in order to comply with the law, which specifies that poison must be covered in such a way as to keep out animals.[3] Important considerations were the elimination of carriage of extra supplies of heavy or cumbersome equipment and the necessity for keeping the cost of destroying a mound at the lowest possible figure. Although it was definitely known that carbon disulphide was very satisfactory, but expensive if purchased in small quantities, it was decided to carry on experiments with this material as well as with others.

In considering the problem of a simplified measure of control two factors presented themselves: (1) The queen ant remains at the bottom of the nest, and a fumigant, in order to kill her, must be heavier than air, must reach the lowest confines of the nest, and must be lasting; or, if lighter than air, the lethal effect must be immediate. (2) On warm days, particularly, many of the worker ants are absent foraging or are in the upper layers of the mound at the periphery, where most of the entrance tunnels are found. The experiments have indicated that if all of the workers are not killed and if some of the winged males and females survive, these may migrate with the workers that were absent at the time of fumigation and may form a new nest, perhaps only a few feet from the old one. In central New England the winged forms of both sexes are active in July and early August, and mounds should be treated at a time when these forms are most apt to be in the nest.

In August, 1930, 7 mounds were treated with carbon disulphide (chemically pure) and 2 were treated with a fine granular calcium cyanide. The latter 2 mounds, with dosages of 4 ounces placed in drilled holes and then tamped with earth, were but slightly affected, only a few ants being killed in each mound. All the colonies treated with carbon disulphide were killed or weakened to such an extent that they were "depauperized." In all of them there was a little activity several days after the treatment, but it is believed that this was due to returning workers that were absent at the time of fumigation. These ants were crawling around rather aimlessly, not with their usual busy activity. In 3 of the mounds a variation of the method advised by Peirson was followed, damp leaf mold and moss covered by burlap being used with dosages of 1¼, 1½, and 1¾ pounds of carbon disulphide. The other 4 mounds had holes punched in them from the margin obliquely toward the center so that they converged toward the bottom. One and one-half pounds of carbon disulphide was then poured down the holes and a lighted match dropped in one of them. A muffled explosion took place immediately and the burning carbon disulphide caused the liberation of sulphur dioxide. The fumes were so strong that it was necessary for the operator to withdraw some distance from the mound. There was every indication that the ants in the "fired"

[3]The ruffed grouse, for example, is said to feed on ant larvae and also uses the mounds for dusting. In some cases a reasonable number of mounds might be considered of value in the forest.

mounds were killed more quickly than in the mounds not so treated, and the odor of sulphur dioxide was perceptible several days afterward. It is doubtful, however, whether, in view of the fire hazard, this extra step is advisable, especially if the litter and ground cover are dry.

About the middle of October, 1931, 10 mounds were treated with paradichlorobenzene crystals, 2-ounce lots being placed in 6 of them and 1-ounce lots in the remaining 4. Holes were bored to the solid earth or rock at the bottom of the nests and the crystals poured in. The holes were then filled with earth and it was tamped. In April, 1932, the mounds were examined and, although even then there was a perceptible odor of the chemical, the ants in all of them were active.

In June, 1932, additional experiments were initiated with commercial carbon disulphide and a relatively new material, ethylene dichloride. The latter is nearly as volatile as carbon disulphide, produces a gas heavier than air, is noninflammable, and has no dangerous or harmful effects on the human system as accidentally breathed by the operator in handling; whereas the mixture of carbon disulphide vapor and air is highly poisonous, as well as inflammable, and its inhalation must be guarded against as much as possible because of its effect upon heart action. The commercial grade of the latter chemical was used because of its relative cheapness, as compared with the chemically pure product.

In outlining the procedure for these new experiments it was decided to punch the holes at the margins as well as at the center, and also, in some cases, to scrape away the top of the mound and to replace it and tamp down the earth after the fumigant was applied. This, it was believed, would obviate the necessity of using extra material, such as burlap or a dishpan and sod, for covering the mounds after treatment.

Eleven mounds were treated in the early part of June with different quantities of carbon disulphide in an attempt to determine the minimum lethal quantity necessary for a mound of given size. In all of the mounds holes were punched at the center or at the margin, or both. One very active medium-sized colony treated through both marginal and central holes on a rainy, foggy day was destroyed with 1 pound of carbon disulphide. Two other colonies in small mounds, less than 18 inches in diameter, treated in the late afternoon of a clear day, also succumbed to a dose of 1 pound each. Seven medium-sized mounds of the remaining 8 required a second application for their destruction. In 2 of these the top was removed, the liquid poured into the holes, and the material replaced and tamped. The eighth, a very large mound, really 2 that had grown together and about 10 feet in diameter at the widest part, resisted three doses of 2, 3 and 3 pounds to destroy it, but in the spring of 1933 it appeared to be weakened.

Later in the month 7 mounds were treated with ethylene dichloride, somewhat the same procedure being followed as with the carbon disulphide. Two small colonies were destroyed with one application of a half pound each; 3 medium-sized colonies succumbed to doses of 1 pound each; and 2 large mounds, one having an original application of 1 pound and the other of 2 pounds, required a second application of 2 pounds each. In one mound, which had the top raked off and the material replaced after the liquid had been poured into the holes, the ants apparently were killed more quickly than in the others.

In order to determine the effect of fall fumigation with these two chemicals, 15 mounds were treated in the early part of November, after heavy frosts had caused the cessation of seasonal activity and the workers were well down in the mounds. Four of the mounds were treated with carbon disulphide and 11 with ethylene

dichloride, in lots of 1 and 2 pounds of either. Three methods were used with each fumigant: (1) Simply removing the top material to a depth of about 6 or 8 inches, pouring the liquid in the depression, and then replacing and tamping the material; (2) removing the top material, punching one central hole and several marginal holes deep into the nest, pouring the fumigant into the holes, and then replacing and tamping the top material; (3) the same as method 2, but without removing the top material. The carbon disulphide killed the ants in all cases. In the 6 mounds treated with ethylene dichloride by the first method all the ants were active, at least at the margins. Of 3 mounds treated by the second method the ants in two were dead and those in the third were feebly active. The ants in both mounds treated by the third method were dead when the examination was made early in June, 1933.

Because of the extended period of time that elapses before most forest crops can be harvested and because of the small margin of profit that ensues, the cost of any materials used in insect control and the amount and cost of labor necessary in applying them must be given serious consideration. The applications of chemically pure carbon disulphide in 1930 were expensive, as the material cost nearly 50 cents a pound. The commercial product used in 1932 was purchased in a 25-pound drum for approximately 10 cents a pound, and the ethylene dichloride was purchased in a 50-pound can for slightly less than 10 cents a pound. These figures are not excessive and ensure relatively cheap control.

Conclusions

The results of the experiments conducted over a period of 3 years are as follows:

Carbon disulphide or ethylene dichloride, if properly used, will control the mound-building ant (*Formica exsectoides* Forel). Both of these chemicals volatilize quickly and produce gases heavier than air.

The quantity of carbon disulphide or ethylene dichloride to be used will be governed primarily by the size of the mound. A dosage of 1 pound (approximately 1 pint) will be sufficient for a small mound, less than 18 inches in diameter. For a medium-sized mound, less than 2½ feet in diameter, 2 pounds should be used. A large mound may need two or more applications of 2 pounds each.

Ignition of the mounds after carbon disulphide has been poured into the holes has a quick lethal effect due to the liberation of sulphur dioxide, but this additional measure is not generally advised because of the fire hazard and also because carbon disulphide itself volatilizes quickly and forms a poisonous gas.

Fumigation late in the fall, after seasonal activity has ceased, or early in the spring, before it has been resumed, will be most successful because all the ants are then present in the mound. The best time to treat a mound in the summer is during a period of high humidity and low atmospheric pressure when most of the ants will be in the mound and the gas will be kept in the tunnels for a long time. Obviously mounds should be treated when they are small.

The most satisfactory method of killing the ants in a mound is as follows: Remove several inches of the top material and punch one hole deep in the center and several holes on the periphery; after pouring the liquid in the holes, replace the top material and tamp it firmly. It is obvious that a sufficient quantity of liquid to evaporate and kill the ants at the top of the mound will be spilled around the orifice of each hole.

Paradichlorobenzene and granular calcium cyanide were not effective when placed in drilled holes and then tamped.

A lighter-than-air gas, in order to be effective, must kill the ants quickly.