CONTROL OF ANTS IN TURF AND SOIL

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A new insecticide, Chlordane[2], has shown considerable promise in experiments conducted for the control of ants in turf and soil. It is a chlorinated hydrocarbon, having the empirical formula $C_{10}H_6Cl_8$, that is highly toxic to a wide range of insects, including several common agricultural pests. It kills in three ways, by fumigation, by direct contact and by ingestion. Toxicity to man and other warm-blooded animals is similar to that of DDT[3,4], rather mild, when compared on an equal weight basis. The insecticide was sprayed on pasture forage[4] at the rate of four pounds actual Chlordane per acre and mature sheep were immediately allowed to graze until all available forage was eaten. No ill effect on the animals was noted.

In common with other chlorinated insecticides, Chlordane reacts in the presence of a number of alkaline reagents to form products which are of a low order of toxicity to insects.[3] For this reason it should not be formulated with insecticides or diluents having an alkaline reaction. When applied to turf land or open soil to control insects, agricultural lime should not be used at the same time.

It is not thoroughly understood just how Chlordane affects insects; however, the extremely toxic nature of its vapors, which are heavier than air and settle rapidly, is significant. The fumigating and contact action of this chemical has been demonstrated in experiments conducted in soil and turf for the control of Japanese beetle grubs, ants, chinch bugs and other soil-inhabiting insects.

Dustan et al.[5] discuss the influence of air currents on the insecticidal action of DDT, benzene hexachloride, Toxaphene and Chlordane and conclude that air currents have an important influence on the effectiveness of insecticides having fumigating action. When these insecticides were exposed to air currents, the effectiveness of benzene hexachloride and Chlordane, which have pronounced fumigant action, was greatly reduced. Toxaphene, which has some fumigant effect, showed some reduction in effectiveness, and DDT, which has no fumigant action, was not reduced in effectiveness.

In the following pages the use of Chlordane for the control of ants is discussed. As a direct acting and final toxicant which kills and does not repel, hence causing no scattering of infestations, it has an important place as a new material for coping with serious ant infestations in turf and open soil.

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[1] Charles Lathrop Pack Fellow, School of Forestry, Yale University.

[2] All of the Chlordane used in the experiments was provided by the Naugatuck Chemical Company Division of the United States Rubber Company under the trade names "Synklor—50W" and "Synklor—5—D" and "10—D".

[3] Velsicol Corporation, Technical Information Bul. No. 205, 1947.

[4] Bul. No. 1, Dec. 1946, Julius Hyman & Co.

[5] Dustan, G. G., T. Armstrong and W. L. Putman, Can. Ent., Vol. 79: 45-50, 1947.

NOTE: Photographs for bulletin by Benjamin W. McFarland.

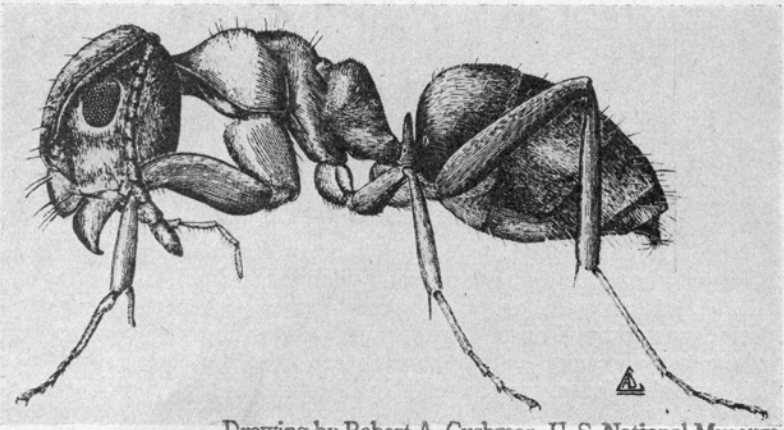

FIGURE 1. The cornfield ant, *Lasius niger* Linn. var. *americanus* Emery, which is frequently a pest in well kept turf, especially golf course greens.

ANT CONTROL IN TURF

For several decades there have been a number of ant poisons on the market, some of which are in general use today. The lethal principles of the most common ones are arsenate of soda, tartar emetic, calcium arsenate, sodium arsenite and thallium sulfate. None of these ant poisons however, has proved to be a panacea. With the advent of Chlordane, it seemed desirable to try this material in soil experiments to determine its lethal action. It has been reported to be specific for ant control.[1, 2] Experiments discussed in the following pages were conducted at the Wepawaug Country Club in the town of Orange. A complete summary of results is given in Table 1.

In our experiments, Chlordane was tried against the cornfield ant, *Lasius niger* Linn. var. *americanus* Emery, which is frequently a serious nuisance in well kept turf, especially golf course greens. In the northeastern part of the United States it is encountered more often than all other species of turf-infesting ants. It is a miniature brown ant that builds small mounds in open soil and turf, surmounted by small single clustered craters. Construction of the mounds may take place at any time of day, most commonly, however, during the night when the air and soil are coolest. Moreover, no matter how frequently a crater may be partially or completely destroyed, it will be rebuilt providing the colony has not suffered permanent injury.

To control ants in lawns, golf course greens or turf and unprotected soil in general, two methods of treatment were devised, each of which is applicable to a distinct set of conditions.

[1] Julius Hyman & Co. Technical Supplement No. 202, May, 1947.
[2] Brett, C. H. and W. C. Rhoades, Jour. Econ. Ent., Vol. 39: 663-664, 1946.

Spot Treatment of Individual Ant Nests

In one series of tests, individual ant nests were treated separately. One-eighth of a teaspoon of 50 per cent wettable powder was placed in the crater of each ant hill (Table 1: i). With the spreader removed from the nozzle of a portable pressure sprayer, a thin stream of water was directed onto the insecticide, causing the powder to go into suspension and be carried down into the galleries of the ant nest. When the spreader is left in the nozzle, the insecticide tends to cover too great an area in the vicinity of the nest. This results in loss of some of the insecticide and failure to achieve maximum control. Water slowly poured from a watering can, with the sprinkler head removed, was also an effective means of conveying Chlordane to the nests. This method is applicable to turf areas where nests occur infrequently or at least not in great abundance.

Alternately, the material can be applied in suspension form with a pressure sprayer, filling each ant nest and crater with the liquid. One ounce of 50 per cent wettable powder should be used to each gallon of water (Table 1: j). Sufficient time must be allowed for penetration and absorption

FIGURE 2. Crater-surmounted mounds of *Lasius niger* Linn. var. *americanus* Emery in turf.

of the spray mixture by the soil before charging the colony again with the insecticide. One gallon of suspension should be ample to treat 150 to 200 nests of average size craters (one to two inches in diameter).

Thorough watering of turf following either of these methods of treatment is desirable, since more complete penetration of the insecticide is thus obtained, vapor loss is reduced to a minimum, and the action of the toxicant is direct and final. Fifty to 60 gallons of water to every 1,000 square feet of turf area was shown to be advisable. Where smaller amounts were used, the lasting value of the toxicant was short-lived in contrast to comparatively long protection obtained where generous applications of water succeeded treatment.

Results obtained when the two methods of treatment discussed were employed, as well as an abridgement of details of procedure, are given in Table 1. Examination of ant-infested golf course greens 24 hours after treatment, showed no nests containing living ants. On greens where Chlordane was not used there were hundreds of active ant colonies and, in one instance, 260 per 1,000 square feet of turf was not uncommon.

For seven days following treatment no ant hills were seen on the treated greens. During the ensuing week, however, reinfestation developed. It is believed reinvasion of greens occurs from surrounding turf areas and is to be expected, as the small amounts of Chlordane dispersed over the turf by flushing lose their protective value.

In certain instances the toxicant was used at the rate of a level teaspoon to the crater of each ant nest, brushed into the opening of the nest and surrounding turf with the back of the spoon (Table 1 : m). Subsequently, no water was used to aid penetration nor to flush the turf generally. As a result, at each spot where the insecticide was applied the grass was killed by excessive concentrations. Immunity from reinfestation of turf areas treated in the above manner lasted only a few days.

Dusting a 50 per cent wettable powder directly into the craters of individual ant nests did not destroy all colonies treated and no protection of surrounding turf was observed (Table 1 : l). If areas supporting the treated ant nests had been flushed adequately with water following application, more lasting protection of the turf might have been obtained. By the 12th day there were 118 ant hills present in the 5,000 square feet of turf under treatment, many of which were counted among the original 350 present prior to treatment. Obviously, much loss of the toxicant resulted from exposure to air and sun. This method of treatment resulted in lasting injury to the turf in instances where excessive accumulations of Chlordane had been fogged into the crater of an ant nest. It is believed that if the turf had been flushed or had rain followed treatment, grass burning would have been reduced to a minimum or entirely absent.

Another unsatisfactory method of treatment was dusting and subsequent brushing of Chlordane into the opening of an ant nest and the surrounding turf (Table 1 : n). A small stiff floor brush was used. No water was applied to flush the turf and rain did not follow for some time. At each spot where the insecticide was applied, the turf was killed. Damage did not show for

several days following treatment but then became progressively worse until the grass was entirely dead. Seven weeks later portions of the injured spots were still evident. Furthermore, not enough toxicant reached the center of the colonies and reestablishment of the nests occurred. At the end of eight days 64 ant nests were present and in 12 days 105 were seen where originally there had been 1,050.

Complete Turf Treatment

A new technique for ant-proofing turf was devised to overcome some of the hazards of spot treatment, for example, toxicity to plants, and to expedite applications to large turf areas such as golf greens and lawn tennis plots.

Fifty per cent wettable powder in suspension was applied evenly over the affected turf, followed by thorough flushing of the ground surface with water to assure maximum penetration. Not only did Chlordane applied in this manner eliminate all ant colonies present at time of treatment, but protection from reinfestation continued for a number of weeks. Treatment may be necessary at the end of this time.

In one experiment, 16 ounces of Chlordane were added to 150 gallons of water and applied to an ant-infested golf green, 4,000 square feet in area, that is, four ounces of Chlordane to each 1,000 square feet (Table 1 : g). A 16-nozzle spray boom with the nozzles arranged in pairs at right angles to the boom and at 16-inch intervals was used. Two men carried the boom back and forth over the turf at nozzle height of 12 to 16 inches from the grass. A pressure of 400 pounds was maintained by the spray pump. The treatment was applied to golf greens before existing ant hills were disturbed by sweeping or flushing in early morning. It was believed that such operations would close the opening to the ant nest and result in failure to destroy the colony. Actually this was not the case. Later tests showed that interference with ant hills has no retarding effect on penetration of the insecticide to the heart of a colony. Following treatment, the turf area was sprayed with 150 gallons of water. In Table 1 it will be seen that one week subsequent to application, there were 75 ant hills where originally 350 were counted, and by the end of a month more than 125 were present.

With the exception of certain minor changes in procedure, much the same method of insecticide application was followed in treating an additional turf area of the same size. In this instance, however, two pounds of the powder were used on 4,000 square feet, that is, eight ounces 50 per cent wettable powder per 1,000 square feet (Table 1 : h). In this case the insecticide was not applied to the turf until after all ant hills had been thoroughly flushed from the green. Immediately following treatment, the turf was sprayed with clear water at 60 pounds pressure. Despite the fact that the actual amount of Chlordane was doubled, the results of this method of treatment were not significantly better than when four ounces per 1,000 square feet were used.

TABLE 1. GOLF GREENS TREATED WITH CHLORDANE (50% WETTABLE POWDER) TO DESTROY NESTS OF THE TURF-INFESTING ANT, *Lasius niger* LINN. VAR. *americanus* Emery.

	Date of treatment	Sq. ft. area of green	No. ant hills present when treated	Amount Chlordane used	Method of application	Water used after treatment	Number of ant hills present Number of weeks later									
							1	2	3	4	5	6	7	8	9	10
a.	7/18/47	4,000	100+	(2 ozs. to 1000 sq. ft.) 8 ozs. to green in 300 gals. water	Garden hose nozzle wide open, 100 lbs. pressure	Green not watered	0	15	23	13	12	14	14	13	10	..
b.	8/18/47	4,000	241.6	(4 ozs. to 1000 sq. ft.) 16 ozs. to green in 300 gals. water	"	Watered[1] green with 60 gals. per 1000 sq. ft.	0	0	0	0	0	0	3	3.3	2.6	0.3
c.	7/8/47	3,000	320	(4 ozs. to 1000 sq. ft.) 12 ozs. to green in 300 gals. water	"	"	13[2]	19	24	35	28	24	30	35	..	..
d.	7/8/47	3,000	823	(8 ozs. to 1000 sq. ft.) 24 ozs. to green in 300 gals. water	"	"	0	0	0	0	0	0	1	2	3	5
e.	7/18/47	4,000	79	(12 ozs. to 1000 sq. ft.) 3 lbs. to green in 300 gals. water	"	"	0	0	0	0	4	7	7	5	4	..
f.	7/18/47	5,000	90	(16 ozs. to 1000 sq. ft.) 5 lbs. to green in 300 gals. water	"	"	0	0	0	0	0	0	0	4	1	..
g.	7/8/47	4,000	350+	(4 ozs. to 1000 sq. ft.) 16 ozs. to green in 150 gals. water	16 nozzle spray boom. 400 lbs. pressure	Sprayed green with 150 gals. water	75	75+	100	125	142	..	..	..	..	..

[1] Average of three series of treatments carried through the season.
[2] Hose broke causing the loss of much spray material and consequently a light treatment on a portion of the turf.

TABLE 1 (Cont'd). GOLF GREENS TREATED WITH CHLORDANE (50% WETTABLE POWDER) TO DESTROY NESTS OF THE TURF-INFESTING ANT *Lasius niger* LINN. VAR. *americanus* Emery.

	Date of treatment	Sq. ft. area of green	No. ant hills present when treated	Amount Chlordane used	Method of application	Water used after treatment	Number of ant hills present Number of weeks later									
							1	2	3	4	5	6	7	8	9	10
h.	7/8/47	4,000	300+	(8 ozs. to 1000 sq. ft.) 32 ozs. to green in 300 gals. water	16 nozzle spray boom. 400 lbs. pressure	Watered green at 60 lbs. pressure	27	30	57	65	73	88	..	..	..	..
i.	6/12/47	5,000	750	⅛ teaspoon per ant hill (1 oz. to 150 ant hills)	Each ant hill treated individually	30 cc. or ⅛ cup of water per ant hill	0	28	98	..	..	..	..	..	..	..
j.	6/17/47	5,000	750	5 ozs. in 5 gals. of water (1 oz. to 150 ant hills)	Sprayed into ant hills with 5 gal. pressure sprayer	Flushed green with 300 gals. water	0	157	..	..	..	..	..	..	..	..
k.	6/17/47	4,000	850–900	5 ozs. in 20 gal. spray tank	Sprayed entire green at 60 lbs. pressure	No water used	0	100+	..	..	..	..	..	..	..	..
l.	6/19/47	5,000	350	10 ounces	Fogged onto ant hills with hand duster	No water used	24	118	..	..	..	..	..	..	..	..
m.	6/19/47	4,000	300	14 ounces	Applied to each ant hill with teaspoon	No water used—brushed into turf	21	36	..	..	..	..	..	..	..	..
n.	6/19/47	4,000	1050	26 ounces	Fogged onto ant hills with hand duster	No water used	64	105	..	..	..	..	..	..	..	..

The use of a boom of several nozzles to apply the insecticide in a mist-like spray to turf for ant control was not successful. It is believed the method resulted in great loss of Chlordane which, being quite volatile, was rapidly carried away by air drift. The fact that in one instance ant nests were mechanically removed from the turf before treatment and not in the second or that the turf was sprayed or flushed with clear water following treatments was not sufficiently important to overcome loss of Chlordane through volatilization. Furthermore, it was seen that material increase in quantity of insecticide under such conditions could not be justified by results obtained.

In another test 12 ounces of 50 per cent wettable powder were added to 300 gallons of water and applied to 3,000 square feet of ant-infested golf course green, providing four ounces of the toxicant to each 1,000 square feet (Table 1: c). A common one-inch garden hose and nozzle (the "Boston" type nozzle), the latter opened as wide as possible to provide a coarse rather than a fine or mist spray, were used to apply the finished spray mixture to the entire turf area under treatment. A pressure of 60 to 100 pounds gave best results with maximum penetration. There was no appreciable loss of the toxicant through drift and volatilization.

Following treatment, the turf was thoroughly watered for three minutes at 60 pounds pressure with 60 gallons of water to each 1,000 square feet. Results of the treatment show that, at the end of the first week, 13 ant nests had apparently recovered from the effects of the insecticide. The recoveries were confined to a section of the turf which, as a result of a break in the hose, received only a fraction of the treatment intended for it. It is believed that in this area an insufficient quantity of Chlordane reached the heart of the colonies. Ant mounds occurred in this part of the green during the first week following treatment and increased in numbers consistently from that time.

Additional treatments of heavily ant-infested turf areas were made throughout the season. A number of these treatments followed the basic principle of using four ounces of 50 per cent wettable powder to each 1,000 square feet of turf area (Table 1: b). However, variations both below and above the established standard were tried. Observations and experience have demonstrated that a four ounce level for use of the insecticide is the most practical and economical. Proportionately, it provided more lasting protection than all other dosage levels. Although 8, 12 and 16 ounce levels (Table 1: d, e, f) gave some additional protection beyond six weeks (a maximum period of immunity from reinfestation established for the four ounce level), the increased cost of ant-proofing is not at the present time justified.

A dosage level below four ounces is not desirable. Two ounces of the toxicant per 1,000 square feet of turf provided no more than one week of immunity from ant troubles (Table 1: a). If the turf had been thoroughly watered following the treatment, longer protection might have been obtained. This is, however, doubtful in view of results when increases in dosage levels above four ounces were used. At most dosage levels it was

seen that after the seventh to the ninth week the previously consistent rise in reinfestation was checked and a drop occurred. It is believed that although the turf was successfully reinvaded, Chlordane remained so that reestablished colonies were ultimately destroyed. With the advance of the autumn season, fewer colonies remain completely active. This may also be a factor in the noticeable decline of ant mounds during September.

If all sections of a golf green are treated, that is, the border, apron, sand traps, bunkers, fairways and rough for a radius of 50 feet or more around the green, reinvasion of the green proper could perhaps be prevented for a much longer time than four to six weeks. In the absence of such additional precaution, and subsequent to one or two complete turf treatments, reinvasion may be so slight as to obviate the necessity of complete turf treatment in favor of the individual ant nest or spot treatment method.

The number of treatments turf areas such as golf greens might require to destroy ant colonies and give maximum protection from reinvasion from spring through autumn is thought to be about three if properly spaced. An initial treatment made during early May should provide ample immunity from colonies until beyond the middle of June. A second treatment applied after the middle of June and not later than July first will give desired protection until about the middle of August when a third and final ant-proofing may be done. At the most, four treatments might seem necessary providing the first Chlordane application were made a month earlier than suggested. In any case, for an entire golf course with greens averaging 4000 square feet, expenses for material should not exceed $100 for the season.

Although we have not determined the minimum dose of Chlordane which causes injury to grass, four applications in one season have not caused any injuries in any of our experiments. In no instance when the complete turf treatment method was followed did turf injury result. In fact, the turf showed more vigorous growth and better color where the toxicant was used. This manifestation was not, however, permanent. As residual action of the insecticide lessened, the turf assumed a more normal appearance in comparison to adjacent untreated areas. On golf course greens where the insecticide had been applied, turf fungus troubles such as brown patch, dollar spot and copper spot common to bent grasses during hot, humid summer weather were almost totally lacking. Chlordane seems to possess certain fungicidal properties which give a measure of protection to bent turf from serious diseases.

MOUND-BUILDING ANTS

Since the damage to forest stands by the common mound-building ant (*Formica exsectoides* Forel.) was first described by Hawley and Record in 1916, numerous methods have been suggested for its control. Hawley and Record[1] suggested using carbon disulphide or naphthalene flakes. Peirson[2] experimented with various remedies and concluded that fumigation

[1] Hawley, R. C. and Record, S. J. 1916. Do Ants Kill Trees about their Colonies? American Forestry 22: 685-686.
[2] Peirson, H. B. 1922. Mound-Building Ants in Forest Plantations. Jour. For. 20: 325-336.

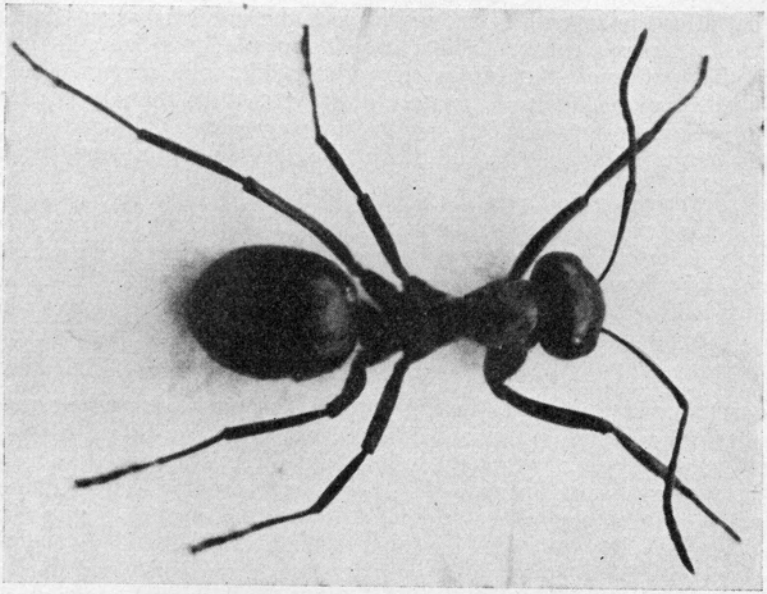

FIGURE 3. Common mound-building ant, *Formica exsectoides* Forel.

with carbon disulphide was the only effective method available at the time. MacAloney and Hosley[1] found that piling brush on the ants will not ordinarily destroy the colonies nor are paradichlorobenzene or granular calcium cyanide satisfactory. They concluded that carbon disulphide and ethylene dichloride are effective if used properly.

Johnson and Friend[2] concluded that methyl bromide is more efficient than carbon bisulfide and that ground derris root (containing at least 4 per cent rotenone) is probably an effective remedy. Price[3] states that a solution of 2 per cent pyrethrins stock diluted at the rate of 2 ounces to 10 gallons of water will kill all ants it touches and, when poured into an open mound, completely exterminate the entire nest within a few seconds after treatment.

Haviland[4], after testing a number of insecticides, concluded that the most satisfactory control consists of placing a complete barrier of sodium fluoride around the periphery of each mound. She experimented with DDT but found it a poor insecticide for use against ants.

Although several methods now commonly in use have proven effective, they have certain disadvantages. Liquids at best are difficult to handle,

[1] MacAloney, J. J. and Hosley, N. W. 1934. Experiments in Simplified Control of Mound-Building Ants in the Forest. Jour. For. 32: 1003-1006.

[2] Johnson, J. Peter and Friend, R. B. 1941. Notes on the Control of Mound-Building Ants. Connecticut State Entomologist Fortieth Report. Conn. Agr. Expt. Sta. Bul. 445: 370-372.

[3] Price, W. A. 1945. The Allegheny Mound Ant and Its Control. Jour. Econ. Ent. 38: 704.

[4] Haviland, Elizabeth E. 1947. Biology and Control of the Allegheny Mound Ant. Jour. Econ. Ent. 40: 413-419.

and liquids as inflammable as carbon bisulphide or as toxic to man as methyl bromide offer other difficulties. Furthermore, it is desirable that an insecticide be effective when scattered on the surface of the mound since opening it is both a time-consuming and disagreeable job. Sodium fluoride satisfies this requirement but can be a dangerous insecticide to use.

Chlordane seems fortunately to fulfill all of the requirements and has been reported by Schread[1] to be highly effective in killing ants. That it is quite toxic to mound-building ants was demonstrated in laboratory tests. Living worker ants were dusted with 50 per cent wettable powder and confined to a pint bottle. Another group of worker ants not dusted were confined to a pint bottle, the bottom of which had been very lightly dusted with the above insecticide. The individuals of both groups showed signs of paralysis in 10 to 15 minutes, were all down in 1½ hours, and were dead in 3½ to 4 hours. An untreated group confined to the same kind of bottle lived normally for several days.

It is possible, however, that other substances may exist that are as effective or even more effective than Chlordane in controlling the mound-building ant. Tests were therefore carried out during the past summer to determine the comparative efficiency of Chlordane and four other insecticides.

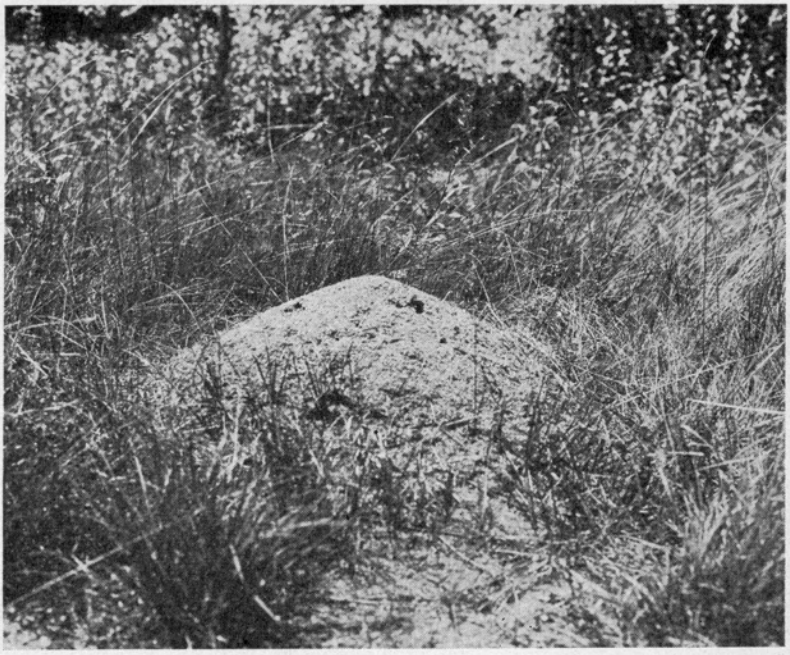

FIGURE 4. Mound of the common mound-building ant *Formica exsectoides* Forel.

[1] Schread. J. C. 1947. Ant Control in Turf. Conn. Agr. Expt. Sta. Special Bulletin. Entomology XXVIII.

TABLE 2. CONTROL OF *F. exsectoides* BY USE OF CHLORDANE (50% WETTABLE POWDER).

Ant mound no.	Date treated	Dimensions of mounds[1]	Dose	Results				
				20 hours later	2 days later	6 days later	7 days later	50 days later
1	July 15/47	14″ x 12″ x 6″	1.5 ozs.				colony completely killed	no activity
2	July 15/47	18″ x 14″ x 7″	1.5 ozs.				colony completely killed	"
3	July 23/47	20″ x 20″ x 4″	1.01 ozs.	colony completely killed				"
4	July 15/47	24″ x 24″ x 12″	3.0 ozs.		colony completely killed			"
5	July 23/47	30″ x 30″ x 8″	2.0 ozs.	colony completely killed				"
6	July 15/47	36″ x 36″ x 12″	5.0 ozs.		colony completely killed			"
7	July 23/47	36″ x 40″ x 9″	2.0 ozs.	colony apparently killed				"
8	July 7/47	48″ x 40″ x 12″	8.0 ozs.				colony completely killed	"
9	Aug. 27/47	96″ x 84″ x 10″	5.0 ozs.		several ants seen perimeter of mound	colony completely killed		"

[1] Length x width x height.

In the first tests nine mounds in a pasture were used. The surface of each mound was dusted with a 50 per cent wettable powder and then scratched to a depth of one or two inches. The amount of insecticides used in the individual mounds varied from 1½ to 8 ounces, depending upon the size of the mound. The results are given in Table 2. In all cases but one the colony was completely killed within a week. In the exceptional case (Table 2, No. 7) the mound was excavated two weeks after treatment, and several live workers were found below the 24-inch level. No live individuals were found above this and it appears quite certain that the living individuals had not yet come in contact with the insecticide.

In the second group of tests 25 active ant colonies located near New Haven were chosen for study. Five mounds distributed among the rest were reserved as controls. To the remaining 20 the following substances

TABLE 3. RESULTS OF TREATMENT OF TWENTY COLONIES OF THE MOUND-BUILDING ANT (*Formica exsectoides* FOREL.) WITH VARIOUS CONCENTRATIONS OF FIVE INSECTICIDAL DUSTS.

Treatment	Dimensions of mound L. W. H. (inches)	Ant activity[1] Aug. 11	Amount applied (pounds) Aug. 11	Aug. 25	Sept. 18	Ant activity Oct. 6
Sabadilla 5%	60x60x24	V. A.	1.1	0.9	0.7	A.
Sabadilla 5%	37x48x8	A.	0.5	0.5	0.5	A.
Sabadilla 10%	48x48x24	A.	0.6	1.0	0.8	A.
Sabadilla 10%	37x36x7	A.	0.9	0.7	0.5	V. A.
Cube 5%	72x72x24	A.	0.3	0.4	0.3	A.
Cube 5%	40x40x12	V. A.	0.3	0.3	0.2	S. A.
DDT 5%	60x60x21	V. A.	1.0	0.7	0.7	A.
DDT 5%	40x40x13	A.	0.6	0.5	0.4	A.
DDT 10%	60x60x22	A.	0.6	0.6	0.7	A.
DDT 10%	37x42x12	A.	1.0	0.0	0.5	A.
Benzene hexachloride 5%	48x48x18	A.	0.9	0.7	0.4	S. A.
Benzene hexachloride 5%	60x48x15	A.	0.9	0.0	0.7	A.
Benzene hexachloride 10%	40x40x7	A.	0.4	0	0.0	C. D.
Benzene hexachloride 10%	48x46x12	A.	1.0	0	0.4	S. A.
Chlordane 5% dust	36x36x13	A.	0.4	0	0	C. D.
Chlordane 5% dust	36x36x13	V. A.	0.6	0	0	C. D.
Chlordane 10% dust	60x48x26	V. A.	0.8	0	0	C. D.
Chlordane 10% dust	42x42x8	A.	0.5	0	0	C. D.
Chlordane 50% wettable powder	32x32x13	A.	0.4	0	0	C. D.
Chlordane 50% wettable powder	48x48x12	A.	0.4	0	0	C. D.
Check mounds (1)	40x40x10	A.	0	0	0	A.
(2)	48x48x18	V. A.	0	0	0	A.
(3)	60x40x10	A.	0	0	0	V. A.
(4)	32x32x11	V. A.	0	0	0	V. A.
(5)	30x30x12	A.	0	0	0	A.

[1] Symbols used to indicate degrees of activity are as follows: V. A., many living ants active on the surface of the mound; A., a moderate number of active ants; S. A., only a few ants observed on the surface; C.D., no living ants observed on the mound surface, within the mound, or to a depth of two to three feet beneath ground level.

were applied in the form of dusts: (1) sabadilla (5 per cent and 10 per cent concentrations); (2) cube (containing 5 per cent rotenone); (3) DDT (5 per cent and 10 per cent concentrations); (4) benzene hexachloride (5 per cent and 10 per cent concentrations); (5) three concentrations of Chlordane (5 per cent dust, 10 per cent dust and 50 per cent wettable powder).

The number of mounds available did not permit varying either the method of application or the amount of insecticide applied. The dusts were, therefore, applied by means of a sieve to a strip about eight inches wide around the perimeter of the mound. About half of the width of the strip fell on the mound and half on the grass around the base. Enough dust was applied to cover the surface with an even, thin layer. The amounts applied as well as the principal dimensions of each mound are included in Table 3.

The insecticides were first applied on August 11. A second dose was added on August 25 to those mounds that showed no signs of being affected by the first application, and a third was given on September 18 to all mounds still showing activity.

A thermograph was placed in the shade on the roof of the Yale Forestry School in New Haven, and average maximum, average minimum and mean temperature values were determined for periods of one week following each application of insecticide. These data are shown in Table 4.

TABLE 4. MEAN, AVERAGE MAXIMUM, AND AVERAGE MINIMUM TEMPERATURES DURING WEEKLY PERIODS FOLLOWING EACH APPLICATION OF INSECTICIDE.

	Mean temperature °F.	Average maximum temperature °F.	Average minimum temperature °F.
Week following first treatment	77	88	68
Week following second treatment	73	80	67
Week following third treatment	62	73	55

A record was also kept of the rainfall during periods of a week after each treatment. Following the first application on August 11, 24 hours of dry weather preceded a rainfall of one inch. A second rainfall of 0.51 inch occurred on August 19. Following the second application on August 25, 48 hours of dry weather ensued and then came a rainfall of 1.86 inches. The third application was made on September 18 and it was not until September 22 that precipitation occurred (0.68 inch) followed by 0.22 inch on September 25.

It is evident from the weather data that following each application of insecticide, the ant colonies passed through at least one and, following the second and third applications, more than one daily cycle of activity under such conditions of temperature and lack of rainfall that large numbers of ants must have come into contact with the dusts.

Observations were made of the ant mounds on August 12, 24 hours after the first treatment; on August 22; on August 25 at the time of the second treatment; on September 1; on September 18, at the time of the third treatment, and finally on October 6. Some indication of the activity of the colonies was obtained from the number of living ants on the surface of the mounds, and the presence or absence of dead ants was noted. If no living ants were seen during several observations, the mound was dug open and, if no living ants could be found within the mound or beneath it to a depth of two to three feet, the colony was considered dead. A summary of the observed ant activity on August 11 and again on October 6 at the close of the experiment is given in Table 3.

It is clearly indicated from the observations that Chlordane is an efficient insecticide for this purpose. Within 24 hours after application of the dust all but one of the six mounds treated had ceased activity. That at least one of these was not completely dead is indicated by the appearance of living ants on the surface a few weeks later, but all six colonies had been destroyed by the single application of dust at least by September 18. Only in one case were dead ants seen on the surface of the mounds treated with Chlordane, but when the colonies were excavated, dead ants and moulding pupae were found in large numbers in the galleries. No living ants were seen.

In general, the results obtained from sabadilla, cube, DDT and benzene hexachloride were not satisfactory. With the exception of benzene hexachloride, these insecticides apparently affected in no way the lives of the colonies treated. No dead ants were seen on the surface of the mounds and no consistent lessening in the activity of the colonies could be observed.

Benzene hexachloride, however, while not destroying the colonies with the speed of Chlordane, gave indication of some effectiveness. One of the four colonies treated was killed and the other three mounds were covered with dead ants. It is possible that even without further treatment these colonies may have been weakened beyond the point of recovery. This, however, remains to be seen since in all three cases live ants were present at the end of the experiment.

The results of the tests of the five insecticides show clearly that under the conditions set up in the experiment, Chlordane is superior to the others. It is possible that if applied differently, some of the other insecticides might prove useful but, with the exception of benzene hexachloride, this seems unlikely. Furthermore, the need for any extra treatment such as opening the surface of the mound, would reduce the value of the insecticide considerably. Benzene hexachloride, were it not for the excellent success of Chlordane, might be considered promising since repeated applications should eventually destroy any ant colony.

The data are not sufficient to draw conclusions concerning the relative values of the three concentrations of Chlordane used. Since all three were successful, however, and since the present cost of treating an average mound varies from 10 cents when the 5 per cent dust is used to 65 cents when the 50 per cent wettable dust is used, it is obvious that the weaker

concentration is preferable. These costs, however, mean very little, for the price of Chlordane will undoubtedly change and it is also quite likely that concentrations less than 5 per cent may be effective enough to destroy ant colonies.

It apparently is not necessary to cover the entire mound with insecticide, as the test with a band 8 inches wide around the mounds gave satisfactory results.

ADDITIONAL SPECIES OF SOIL-INFESTING ANTS

A number of colonies of a species of turf-infesting ant, *Formica pallide fulva* Latr. subspecies *nitidiventris* Emery, on a small lawn area were destroyed with a light dusting of Chlordane 50 per cent wettable powder. The subterranean nests of this species are surmounted by large craters or ant hills in a manner similar to *Lasius niger*. The ant hills of Formica are, however, much larger and coarser than those of Lasius.

Another soil-inhabiting ant, *Formica fusca* Linn. var. *subsericea* Say, which had excavated numerous galleries in open soil at the base of a shrub was completely eliminated by using ⅛ ounce of 50 per cent wettable powder. No signs of living ants were seen one month after the treatment was applied.

Chlordane was used to control a species of ant, *Lasius niger* var. *neoniger* Em., tending aphids on the roots of hardy chrysanthemums in beds totaling 3,000 square feet in area. The plantings were composed of a large number of varieties, some of which were apparently much more attractive to the aphids than others and, hence, suffered more injury.

Fifty per cent wettable powder was used at the rate of four ounces in 50 gallons of water to 75 linear feet or 750 square feet of chrysanthemum bed. On August 19 the suspension was applied by a hydraulic spray rig at 60 pounds pressure, using a single nozzle gun delivering a coarse rather than a fine cone spray. The spray nozzle was held close to the base of the plants in order to force the finished spray mixture into the soil around the roots.

The root systems of most of the plants were three to four inches below the surface. In a number of instances the roots were so completely covered with aphids that the vegetative parts of the plants above the surface of the ground became seriously affected and were stunted. In the most serious cases, not only did the tops of the plants wilt, but some of the foliage turned brown, shrivelled and died. Many plants died prior to treatment and required replacements.

Examination of the chrysanthemum beds 48 hours subsequent to treatment indicated that the insecticide had achieved 93 per cent control of the ant population (based on ants found around the roots of plants or in isolated pockets deep in the soil). Prior to application ants were found around virtually all plants examined. No live aphids were found on any of the plants examined after treatment. Three weeks following the use of the toxicant a great improvement was seen in the general condition of the

chrysanthemum plants, injury had been checked and most of the plants showed definite signs of recovery. For the most part no wilting could be seen and new shoots and foliage were developing. By the time the plants were in full bloom in the middle of October, little evidence of the injury that had developed before Chlordane was used could be seen. Slight burning of the foliage on the lower parts of a few plants occurred but was not serious.

CARPENTER ANTS

A large colony of carpenter ants, *Camponotus herculeanus* Linn. subsp. *pennsylvanicus* DeGeer, was established in what apparently was a dead

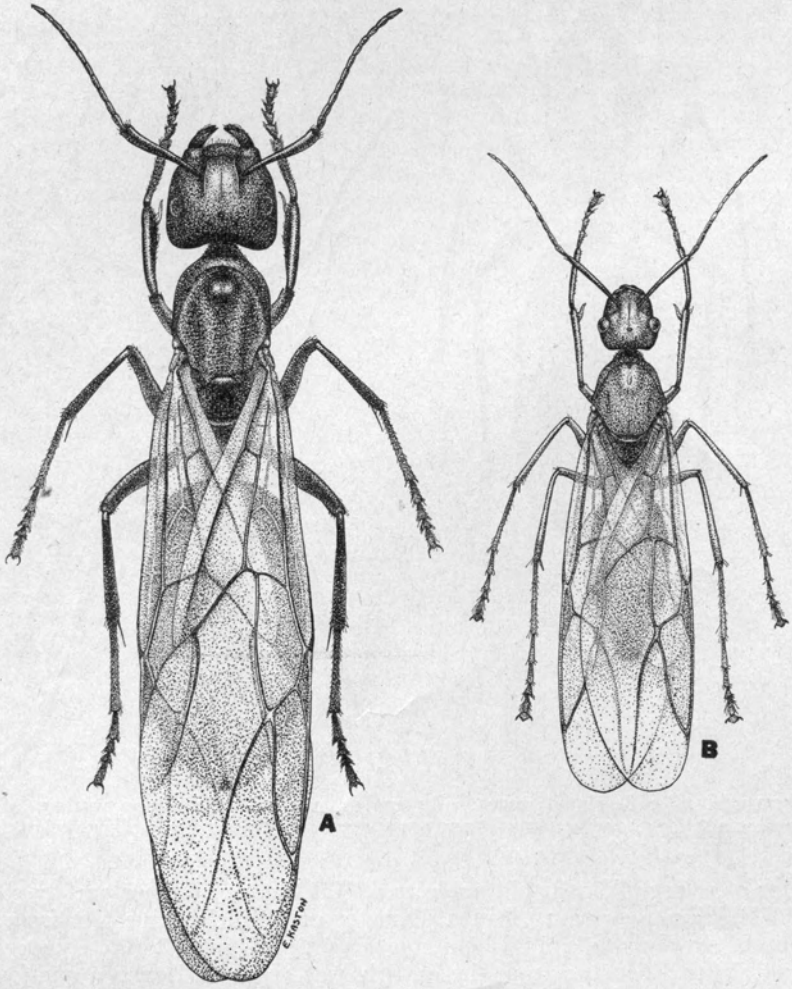

FIGURE 5. A: adult winged female. B: adult winged male of the carpenter ant, *Camponotus herculeanus pennsylvanicus* DeGeer. Both enlarged five times.

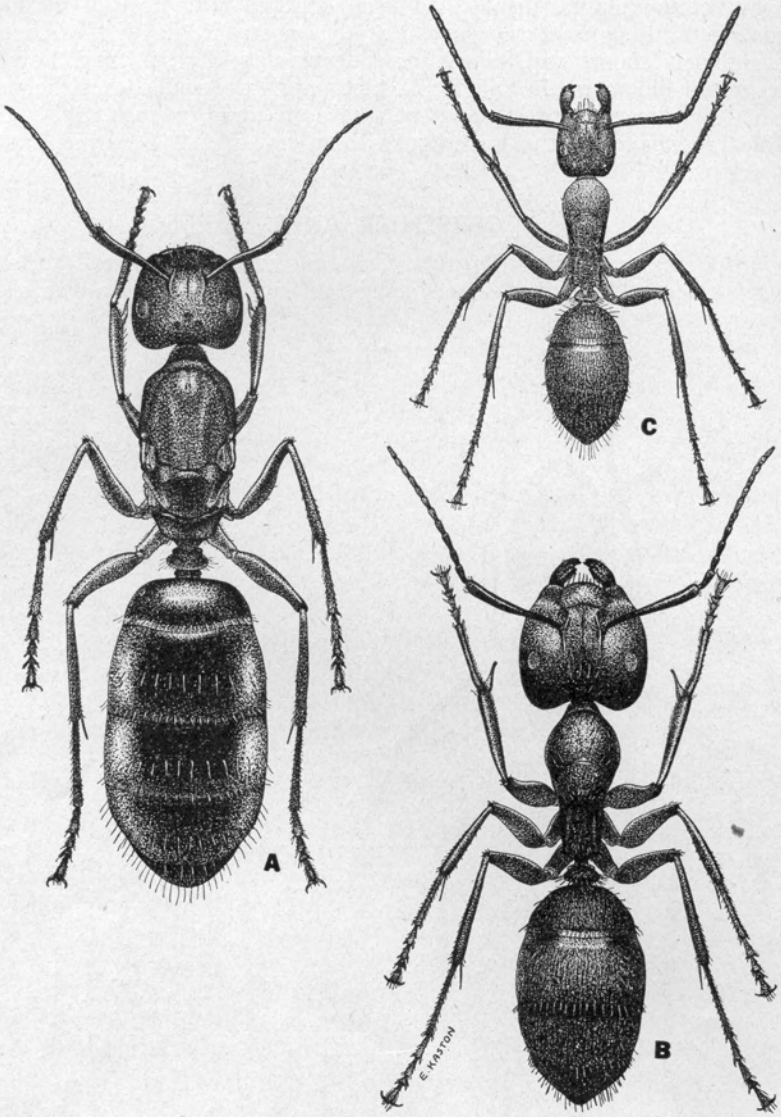

FIGURE 6. A: de-alated queen. B: major worker. C: minor worker of the carpenter ant, *Camponotus herculeanus pennsylvanicus* DeGeer. All enlarged five times.

center of a large 75-year-old apple tree. The tree, a summer variety called "Old Fashion Pearmain", had a diameter of 29 inches five feet from the ground. On July 5 a 1½-inch hole was bored into the tree until the cavity, 10 to 12 inches from the outside was reached. Between one-fourth and one-half ounce of 50 per cent wettable Chlordane was puffed into the cavity through the drilled hole. The hole was then plugged. A few puffs

were also fogged into the main crotch of the tree which showed evidence of decay.

Ten days following the treatment an examination of the tree disclosed a number of dead worker ants at the base as well as a large number in the bored hole which had been plugged after the treatment. No signs of living ants were seen after a lapse of six weeks. Two and one-half months from the time of treatment, examination showed the colony had not recovered.

A similar treatment for exterminating a colony of carpenter ants in an old sweet cherry tree was applied July 15. The results of this experiment were as successful as in the case of the apple tree. Three weeks after 50 per cent wettable powder was dusted into a decaying cavity in the tree, no ants were seen.

Chlordane 50 per cent wettable powder was fogged under the trim covering the sill of a house and into openings between the bricks of the foundation from which carpenter ants were issuing in large numbers. The ants had also found access to the inside of the house where they became quite a nuisance. Not only did the toxicant stop the activities of the species on the outside of the house, but no further trouble was seen from within. Apparently the insecticide destroyed the ant colony at its source, presumably in the sill of the house.

SUMMARY AND CONCLUSIONS

It appears from examination of results of the experiments that Chlordane is an efficient insecticide for the control of many species of ants. Not only will very small amounts of this insecticide destroy ant colonies present at the time of treatment, but the residual protection obtained in turf prevents reinfestation for a considerable period.

The spot treatment method is applicable to turf areas where Lasius nests occur infrequently or at least not in great abundance. It is not expected that this method will prevent reinfestation for any considerable time. The closer together treated nests occur, the more certainty there may be in obtaining reasonable residual protection from reinfestation over the entire turf area, especially when greens are watered following treatment. After two weeks, retreatment may be necessary. One ounce of 50 per cent powder is sufficient to treat 150 nests either by applying the treatment as a powder to the individual ant hill and then watering it into the nest, or by spraying a suspension directly into the nest.

The principle of the complete turf treatment method is to apply Chlordane in suspension to every square foot of golf course green, or other turf to be protected. Such procedure may be desirable when turf is heavily infested. Not only will this method result in complete extermination of the ant colonies in turf at the time of treatment, but reasonably long protection from reinfestation can be expected. Longest protection at the least cost was obtained when four ounces were used to each 1,000 square feet of turf. Using this concentration, ant colonies present at the time of treatment were completely destroyed, and four to six weeks freedom from reinfestation followed. The cost of material for a single treatment for an 18-hole

golf course with greens averaging 4,000 square feet in area would be about $26.00. Treatment of all greens on a course (average green size, 4,000 square feet) three times, from May 1 to late August, should give ample protection from ant (*Lasius niger*) troubles for the season. Although we have not determined the minimum dose of Chlordane which causes injury to grass, four applications in one season have not caused any injuries in any of our experiments.

It is believed that if all areas of a green are treated, including the apron, sand traps, bunkers, fairways and rough for a radius of 50 feet or so around the green, reinvasion of the green proper could perhaps be prevented for a much longer time than four to six weeks. Additional cost would necessarily be involved if a more extensive method were followed. Since the species of ant involved is capable of migrating long distances, additional expense incurred in treatment of areas around the greens may not be justified, especially if by so doing reinvasion is not materially checked.

It was observed throughout the season that bent greens treated with 50 per cent wettable Chlordane and also fairways receiving applications of 5 per cent dust were generally distinguishable from untreated areas by the vigor of turf growth and deeper color of foliage. This remained obvious for a considerable time. The insecticide seems to have fungicidal properties; to just what extent, however, is not generally known. Golf course greens having applications of one pound or more per 4,000 square feet were obviously resistant to severe outbreaks of brown patch and dollar spot.

Chlordane is a quick-acting and effective toxicant when used as a control of the mound-building ant, *Formica exsectoides*. Small amounts of this material destroyed colonies varying in size from one to eight feet in diameter. Under this condition of treatment it was found to be more efficient than several other materials used.

When sprayed into the soil around chrysanthemum plants at the rate of four ounces in 50 gallons of water, Chlordane controlled root aphids tended by ants as well as the ants.

Two additional species of ants, one constructing nests in lawns and the second working in grass free soil at the base of shrubs, were destroyed when 50 per cent powder was fogged into the openings to the nests.

Control of carpenter ants in the dead center of trees and in the foundation and timber of buildings was successful when less than one ounce of 50 per cent wettable Chlordane was applied as a dust.

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