Progress in Control of New Pest, the Stinkworm

By J. C. SCHREAD

Connecticut Agricultural Experiment Station

The discovery within recent years that the earthworm Pheretima hupeiensis, Michaelson (Oriental earthworm, "Stinkworm") is a nuisance because of the mounds it casts on golf course greens in the eastern and northeastern part of the United States stimulated interest in its habits, abundance and control. There is little published information on the subject.

Fleming and Hadley reported the use of DDT at the high degree level of 100 pounds of actual toxicant per acre with scant success as a control measure. Since then DDT has been used by them at 1000 pounds per acre with no control resulting. In addition they discussed unpublished reports to the effect that at a country club near Rye, N.Y., treatments for several years with excessive amounts of lead arsenate, calomel, mercuric chloride, mowrah meal and other materials commonly used to control earthworms gave negative results when applied to the Oriental species. Scott and Sons Co. published a brief statement about the use of Parathion, Chlordane and Toxaphene by Schread in 1948 in an effort to suppress the earthworm at Stamford, Connecticut.

Baker made a tudy of the effect DDT sprayed on foliage had on earthworms (not the Oriental species) when they dragged the fallen foliage into their burrows for food. Observations were made in a dense stand of elm trees at Columbus, Ohio, sprayed in September, 1944, with a 0.25 per cent DDT emulsion. Early in the following spring (1945) it was seen in the sprayed block that virtually no leaves had been dragged into earthworm burrows, whereas in the untreated blocks practically all the fallen leaves had disappeared. A count to a depth of 5 inches showed 27 worms to be present per 2 square feet in the sprayed plots and 95 in the unsprayed. By late May most of the leaves in the sprayed blocks had been removed by the worms.

Begin Stinkworm Control

The persistence of the pest in golf course turf in the New York metropolitan area and the futile efforts of greenkeepers to eradicate the pest led to the request, in July, 1948, by a committee representing the golf interests of New York, New Jersey and Connecticut that the Connecticut Agricultural Experiment Station undertake a program of research aimed at the development of efficient control measures. A fund to help support this was contributed by golf clubs and individuals in New York, New Jersey and Connecticut through this Committee. Thanks are due also to Arthur W. Twombly, greenkeeper at Pelham (N.Y.) and Mr. Lloyd Stott, greenkeeper at Woodway CC, Stamford, Conn. for their most valuable assistance since the initiation of the project.

Although we are here concerned with the suppression of this worm on golf courses, it may well be a valuable addition to the fauna of this part of the country, as, generally speaking, earthworms are beneficial and not by any means injurious. From the standpoint of crop production the earthworm is undoubtedly the most desirable and beneficial form of animal life in soils.

The effect on soil fertility involves the physical and chemical nature of earthworm casts and the pattern of burrows in the soil. In regard to the former, Lunt and Jacobson have discussed the chemical composition of earthworm casts and reviewed the literature on the subject. They include an analysis by Puh of soil and worm casts caused by Pheretima bucculenta. This indicates a significantly greater amount of nitrogen, phosphorus and potash as compared to the parent soil.

The effect of the application of certain insecticides on the population of this worm is interesting, not only from the viewpoint of suppressing its abundance, but also as a source of information as to what may happen to these worms in areas where the insecticides have been applied for the control of certain pests. It must be remembered, however, that the highest dosage level required to control all surface and subsurface insect pests is considerably less than that necessary to destroy Oriental earthworms.

Distribution and Method of Spread

Pheretima is the largest and most difficult, taxonomically, of all earthworm genera, being reported to contain 180 known species distributed in the Orient from China and Japan southerly through the Malay Peninsula and into India. P.

hupeiensis is believed to have gained entrance into the United States a number of years ago, perhaps via exotic plant material balled and bagged or in the roots of plants from which the soil was removed prior to shipment.

For 15 years there have been reports of the occurrence of the species in golf course greens in the eastern part of the country. During this time it has multiplied and spread until, at the close of the summer of 1949, it was known to occur from Stamford, Conn. (the only place it has been found in the State) south along the Atlantic coast to Miami, Fla. However, it is most abundant in Westchester County, N.Y., where about one-half of the 52 golf courses within a radius of 25 miles of New York City are infested.

The method of spread in this country is not definitely known. It is believed to be transported from place to place in the movement of soil, topdressing, plants and sod. To a limited extent mowing and other golf course equipment and the cleated shoes of golf players may distribute small worms which adhere to them, especially when picked up with wet freshly mowed grass or in mud.

Description of Stinkworm

Pheretima hupeiensis was described by Michaelson in 1895. Individuals vary in length from 150 to 222 mm. The diameter is usually 5 mm. "Color in life is light green on dorsal side, greenish buff on anterior dorsum, light green on posterior dorsum, purplish green along dorso-median line, lighter around setal zone; greyish pale ventrally. Clitellum milky or light chocolate."

An exhaustive study of the life history and habit of P. hupeiensis has not been completed. It appears, however, that there may be more than one generation a year. The rate of increase is high, probably 20 or more individuals per cocoon (egg capsule). The animal occurred in all soils examined and in all areas of golf courses where excavations were made to determine distribution and population. This includes greens, tees, fairways, roughs and grass nursery plots where diggings were made to depths of 41 inches.

The population of worms in a golf course varies from a scattered few or none in sandy and gravelly soils (mostly roughs) of relatively low fertility and water holding capacity to greater densities in fairways, tees and greens of higher organic matter and moisture content. It is present in greatest abundance in greens where the organic matter, fertility and moisture are highest.

Weather permitting, P. hupeiensis may surface, cast, or do both during all four seasons of the year in the New York metropolitan area. Records are available relative to tremendous casting, February 20, 1949, on an Aldrin treated green (December 3, 1949) at the Pelham CC.

Air temperature of 60° F. or better (preferably 70° F. or above) at the time of or subsequent to moderate or heavy rain and high humidity will bring the worm to the surface of the ground with virtually no casting. Usually, abundant castings are not seen until after rain has fallen during the daylight and night hours or night hours only of the previous day. Casting may then continue each day thereafter providing the temperature and humidity remain sufficiently high. Repeated performances are doubly assured during a rainy season when storms occur several times a week, particularly during the spring and autumn. When conditions are ideal, casting takes place repeatedly during the daylight hours, a habit peculiar to the species and not apparent among native earthworms. Continuous production of casts in great abundance (25,000 to 30,000 in 5,000 sq. ft.), requiring repeated attention to remove them from the golf greens, may occur during periods of favorable weather.

Based on the average weight of dry castings of 0.485 grams each (100 castings taken at random from a golf course green) an attempt was made to estimate the weight of soil per green of 5,000 sq. ft. and also per acre that may be cast once or several times in 24 hours by various worm pop. densities (Table 1).

Computing the weight of castings for an average of 15 worms per sq. ft., when three casting populations occur in 24 hours the weight of dry soil cast on 5,000 sq. ft. of green would be 240.30 lbs.; on an acre 2,065.5 lbs. When this occurs once a week during the spring and autumn (18 weeks) the minimum weight of castings per 5,000 sq. ft. green in one year would be 2.16 tons, per acre 18.58 tons. Under such conditions the turf cannot be

TABLE 1. WEIGHT OF WORM CASTINGS

No. Castings per 1 sq. ft.	Per Average Size Green 5,000 sq. ft.	Per Acre
1	5.34 lbs.	45.9 lbs.
5	26.70 lbs.	229.5 lbs.
15	80.10 lbs.	688.5 lbs.
25	133.50 lbs.	1147.5 lbs.

kept in the consistently good playing condition desired. The surface of the turf assumes a muddy discoloration, obstructions to accurate putting develop, and the game of golf is materially interfered with. This means costly maintenance.

An exception to the usual pattern of casting prevailed during latter part of the spring and first half of the fall of 1949. Despite unseasonable high temperatures and humidity plus periodical watering of greens, extended droughts during these two seasons prevented surfacing or casting by the stinkworm. Although infested greens are watered for a short time each day during periods of lessening precipitation, abundant casting on the surface of the green will not take place unless moderate to heavy rainfall occurs. Light rain of short duration or drizzle appear to have no greater influence on compelling the animal to surface than artificial watering. Excessive watering of an infested turf area during periods of high temperature and humidity will encourage more casting activity than may be expected when moderate watering is done.

Beginning with the sod of initial level diggings varying in depth from 22 to 41 inches examinations were made during the summer in fairways, roughs and greens to provide information relative to the abundance and location of the stinkworm. In soil "bone dry" to a depth of 20 inches, it could not be found. However, at subsequent moisture laden levels it was present. Native earthworms (Allolobophora caliginosa vars. pallid and dark, A. chlorotica, A. longa, Eisenia rosea, Lumbrious terrestris) were taken from the dry soil at virtually all depths from the sod to the 20 inch level inclusive.

Control

A number of chemicals were used experimentally to reduce the worm population in greens, mostly at Pelham CC. They were applied as dusts, wettable powders and emulsions. The latter group gave best results. When used as 2.5 and 5 per cent dusts, the materials were mixed with Milorganite as a diluent to facilitate distribution. The wettable powders were applied in 15 to 50 gallons of water per 5,000 sq. ft. of turf and the emulsions in 50 gallons of water per 5,000 sq. ft. A sprayer mounted with two 50 gallon tanks was used to make the treatment. Pressure at the pump was maintained at 400 pounds. Immediately following all treatments the turf was soaked with fresh water. This was also done on the two succeeding days.

PARATHION: On May 13, 1948, subsequent to heavy rain on the previous day, a 5,000 sq. ft. putting green infested with stinkworm estimated to be 20 per sq. ft.) at Woodway CC, was treated with 10 pounds of 25 per cent wettable Parathion at the rate of 21.50 pounds of tech-

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LIGHTNING ON OFFENSE AT NOTRE DAME

Chet Keeley, pro at University of Notre Dame's Burke course at South Bend, Ind., sent us this picture of his eighth green to prove that lightning strikes with the same force as the university's charging football linemen. There was no pole in the cup when lightning struck. The cup was 1¼ in. below the surface and sod was blown out at the same depth. Sod was replaced and no signs of the damage now are evident.

CONTROL OF STINKWORM

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nical toxicant per acre. The turf was then soaked with water. During the succeeding two weeks 50 to 60 per cent of the earthworm population was destroyed.

On May 25 a second treatment of 5 pounds of 25 per cent wettable powder was applied to the green in 16 gallons of water providing 10.75 pounds of technical Parathion per acre. Counts of castings on June 1 showed that 70 per cent of the original population had disappeared. During the second week of June, however, a slight increase in casting population developed, due perhaps to reproduction of the species in May.

The green was again treated on June 8 with 14 pounds of 25 per cent wettable powder in 16 gallons of water providing 30.1 pounds of technical chemical per acre. Two days later the grass was visibly scorched. The injury was superfiicial, however, and recovery was obtained in 10 days. Accrued reduction in stinkworm population appeared to be 75 to 80 per cent by June 20.

A fourth and final treatment was applied to the green on June 24 using 15 pounds of 25 per cent wettable powder in 40 gallons of water providing 32.25 pounds of technical Parathion per acre. Despite heavy watering, severe burning occurred from which most of the grass did not recover for a month. Sixty-one sq. ft. of turf required replacement. Casting counts prior to the last treatment appear in Table 2 on next page.

Compared with the initial population of May 13 counts made June 29 showed 97.1 per cent reduction to have been obtained.

Following the collection of 1000 worms from the surface of the green in early October nothing further was seen of the earthworm population until May 5, 1949, when 15 castings and 4 worms were counted. On May 23, 6 worms surfaced but no castings appeared. Notwithstanding the occurrence periodically of optimum weather conditions for maximum surfacing and casting during the remainder of 1949, no further stinkworm activity took place on the putting green at Woodway.

Turf samples were assayed for Parathion. The results are tabulated in Table 4 on page 84.

TABLE 2. COUNTS MADE JUNE 24

Heavily Infested Areas of Green No. Castings per 100 sq. ft.	Lightly Infested Areas of Green No. Castings per 100 sq. ft.
100	57
200	30
147	53
95	42
112	29
130.8 Av.	42.2 Av.

Combined average per 100 sq. ft. of green	86.5
Average per one square foot	0.86

On June 29 casting counts were again taken in the above areas (Table 3).

TABLE 3. COUNTS MADE JUNE 29

Heavily Infested Areas of Green No. Castings per 100 sq. ft.	Lightly Infested Areas of Green No. Castings per 100 sq. ft.
99	38
100	21
53	42
86	33
103	32
88.2 Av.	29.2 Av.

Combined average per 100 sq. ft. of green	58.7
Average per one square foot	0.58

TABLE 4. TURF SAMPLES ASSAYED FOR PARATHION

Composite Samples Taken	Ppm. Parathion in top inch of soil
July 14, 1948	30.0
Sept. 30, 1948	15.0
Dec. 8, 1948	4.9
Mar. 24, 1948	3.4
Sept. 12, 1949	3.1

ALDRIN (Compound 118): Twenty-five pounds of Aldrin, 2.5 per cent dust, was applied to a small area in August, 1948, at the rate of 5.0 pounds of technical toxicant per acre. A follow-up treatment of 11 pounds of actual toxicant per acre was made in early October. No injury to the grass resulted from the use of the compound; it did, however, stimulate the earthworms to abnormal casting activity at that time. In mid-April, 1949, subsequent to heavy rain, no castings or worms appeared on the green. At the same time untreated greens were covered with castings. Several weeks later (May 3) 5,000 worms were collected from the treated green. On May 9 a third Aldrin treatment was made, using 3 pounds of 25 per cent wettable powder per 1,000 sq. ft. so as to provide 32 pounds of technical toxicant per acre. From then on the population declined gradually. Occasionally during autumn when favorable weather conditions prevailed, a few castings and worms appeared on the green.

CHLORDANE: Chlordane 5 per cent dust at the rate of 20 pounds per 1,000 sq. ft. and 2 pounds of 50 per cent wettable powder per 1,000 sq. ft. were applied to infested greens in June and July, 1948. In both instances the rate was 44 pounds of technical chemical per acre. The dust treatments showed virtually no reduction in infestation during the remainder of the season.

Throughout the summer very little difference in casting populations could be seen where the wettable powder was used. However, by late autumn it appeared that the number of worms in the treated greens was comparatively low in contrast to check greens which were unplayable during periods of weather favorable for casting. On May 3, 1949, 1,500 worms were collected from 10,000 sq. ft.

of turf treated with 50 per cent wettable Chlordane in 1948. On this date the areas were retreated at the rate of 44 pounds of technical Chlordane per acre. It was observed that most of the worms that surfaced during the summer and fall did not return to the soil but died on the surface of the greens. Consequently there were only a few castings and worms on the greens in late autumn at times when untreated turf was literally covered.

EMULSIONS: During the spring, summer and autumn of 1949, Chlordane, Aldrin 118 and Dieldrin 497 emulsions were applied to Oriental earthworm infestations so as to provide 40 pounds of technical Chlordane and 30 pounds of technical Aldrin and Dieldrin per acre. The emulsions were diluted in 50 gallons of water applied per 5,000 sq. ft. The areas were soaked with fresh water immediately following treatment and in most instances once a day for two subsequent days. Despite strong sunlight, high temperature and humidity, especially when the summer treatments were made, injury to grass occurred on only one occasion in mid-July. Proper handling of the green, however, brought the turf back to normal in 10 days.

Destruction of stinkworm populations by emulsions was (in contrast to the use of dusts and wettable powders at much higher dosage levels) remarkably fast. Worms surfacing during rainy weather died on the turf by the thousands. It was estimated on July 10 that there were 20,000 to 35,000 dead and dying worms per green (av. 5,000 sq. ft.) where the emulsions had been used but none on the check greens.

On October 31, following heavy rain and high temperature on the previous day,

worms and castings appeared on all untreated greens. None, however, were seen on greens saturated with emulsions.

Many additional experiments were carried on at Pelham during 1949. One material showing promise was Lindane applied at the rate of 10 and 20 pounds of the pure gamma isomer per acre. The chemical was used separately and in conjunction with emulsions. Barely noticeable scorching of the grass occurred when the toxicant was used alone. In combination with other materials injury was much more severe. Stinkworm populations declined rather rapidly in the presence of Lindane. The chemical is being used in more extensive experiments, the results of which will be reported at a later date.

Gearphos has been applied to infested turf at the rate of 8.5 pounds of technical chemical per acre. Results of the use of this material will not be available until 1950.

Conclusions

It appears from the results of excavations made at Stamford, Conn. and Pelham, N.Y., that the Oriental earthworm may occur in several types of soils. Furthermore, moisture is a limiting factor in the distribution of this worm in soil horizons. The animal is nearer to the surface of the ground and more abundant where adequate moisture occurs at all levels. As moisture content drops, the worms recede deeper into the earth.

Organic matter may determine density of population. When this requirement is artificially accentuated as it is in heavily fertilized and frequently top-dressed greens, the worm population increases rapidly and may hold a high population level indefinitely.

Weather permitting, the earthworm appears to be active during all seasons of the year. By virtue of the frequent casting habit of the worm during daylight hours as well as at night it is admittedly difficult to maintain a playable green within the limits of economical operating costs unless it is treated.

Trials made with a number of chemicals in control experiments have demonstrated Parathion, Chlordane and Aldrin as worthy of use in general practice for suppression of the stinkworm. Initial tests with the first material were at excessively high dosage levels. Later experiments provided some evidence that much lower levels of this toxicant will achieve comparable control.

Chlordane used as blended dusts or wettable powders gave less satisfactory re-

sults than emulsifiable concentrates at comparable dosage levels. Where the toxicant was applied to an infestation in emulsion form control was accelerated. Moreover, less actual chemical per 1000 sq. ft. may be used when emulsions are employed. Wettable powders are superior to dust for the purpose.

Aldrin and Dieldrin emulsions show considerable promise. Both compositions may be used at lower dosage levels than either Parathion or Chlordane. As in the case of these latter items Aldrin and Dieldrin emulsions appear to be superior to dusts and suspensions in developing more rapid and complete stinkworm mortality.

Lindane in small plot experiments appeared to be excellent for control of worms. However, the tests must run longer to be certain of complete and lasting lethal effects on the populations. Additional large scale tests will be undertaken in support of the initial trials.

PLANNING CC POOL

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near normal circumstances, with utilities reasonably close by, a 30x75 spoon bottom pool, with high and low diving boards, lights above and underwater, a well appointed bath house for men and women with toilets and showers, snack bar, provision for attendant with baskets, and the water treatment, filtration, sterilization, coagulent, vacuum cleaning, etc., all designed in accordance with the State Board of Health of Illinois requirements, built in the vicinity of Chicago, the cost should not exceed $75,000.00, barring completely unexpected and unforeseen contingencies.

If the pool is located close to the club house so that the need for a separate bath house is eliminated and bathers can be served from the club kitchen a very substantial saving will be effected, and under normal conditions, the construction cost could be held down to between $50,000.00 and $60,000.00.

For clubs serving smaller cities or having a regular membership of around 200, a 20 or 25x60 foot pool with a low board only, seems to be entirely adequate and needless to say, the smaller pool results in a material saving both in construction and maintenance costs.

Separate paddling pools or spray pools for the very young are popular, and are recommended as a means of keeping the youngsters occupied and happy while the older boys and girls and the adults golf or bathe in the main pool.

A reasonable estimate for annual operating costs for a 30x75 pool, including a