# BIOLOGY AND CONTROL OF PHYLLOPHAGA LANCEOLATA

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*Introduction*

The recent outbreak of the wheat white grub, *Phyllophaga lanceolata* (Say), occurred chiefly in the north central and southwestern counties of Oklahoma. The major infested districts included parts of Harper, Woods, Alfalfa, Major, Blaine, Grant, Garfield, Kingfisher, Logan, Canadian, Oklahoma, Kay and Noble counties, and there were smaller areas in Jackson, Comanche, Tillman and Cotton counties. Other western counties reported localized damage. The first signs of coming trouble were the large numbers of beetles of this species seen during the summer of 1937 crawling in immense numbers across roads and along margins of wheat fields. A prediction of possible damage by this species was made by the author in a paper read in December 1937 (2). Widespread damage to wheat was reported in the fall of 1937. Many fields were replanted several times. The mild winter of 1937-38 was favorable for the grubs which continued to work on the roots of the young plants all winter, especially in the southern part of the State. Not until a severe late spring freeze and snow which occurred in April did the grubs disappear for a few weeks below the frost line. Conditions in the spring were very favorable for wheat over much of the State enabling the plants in many fields to outgrow grub worm attack. No recent survey has been made but there are indications that the outbreak has subsided due probably to the action of natural enemies.

The widespread and serious nature of the damage to wheat together with a lack of satisfactory information applicable to Oklahoma on reducing the infestation and on the susceptibility of other crops which might be planted in infested fields, prompted the investigation reported upon in this paper. Three general types of experiments were made. First, individual records were kept of grubs collected in the field and placed in one- or two-ounce tin salve boxes. Secondly, tests were made on the susceptibility of different crops to the grubs, the plants being grown in flower pots in an unheated green-house. Thirdly, six acres of land were rented in a heavily infested wheat field near Blackwell, Oklahoma, and several different crops were planted in the field to observe the effect of the grubs on the plants growing under natural field conditions. In addition, a field survey was made to determine if there was any correlation between crop rotations, dates of farming operations, types of farm implements used, etc., on the grub infestation. These experiments and observations were begun in February, 1937 and are being continued at present. This paper is a report of the greenhouse and field experiments.

*Review of Literature*

The wheat white grub has long been recorded as a pest of wheat in Oklahoma, Kansas and Texas. Howard (4) in reporting on some miscellaneous results of the then U. S. Division of Entomology stated that through correspondence with G. G. Hood of China Springs, Texas, the beetles attacked collards and has been noticed every year since 1890. The principal food was careless weed, *Amaranthus sp.* Sanderson (6) states that in

* The authkor gratefully acknowledges the advice and assistance given him in this work by Professor C. B. Cross of the Agronomy Department.

Texas it often occurs in large swarms and cuts off young cotton plants. Sanderson (7) again mentions the damage this species causes to young cotton and adds such other crops as "garden truck" and wild sunflower (*Helianthus*) as food plants. He observed that young grubs fed on cotton and grass roots during the first summer and fall. Davis (1) reared one specimen to the adult stage in two years. Hayes (3) gave the most complete account of studies on the life cycle in Kansas and a review of the synonymy and history as known up to that time. He also mentions grubs annually destroying thousands of acres of young wheat in southern Kansas and northern Oklahoma. Hayes found the species abundantly in native grasslands and reported that it was often a serious pest of pasture grasses and a long list of food plants was given. He recorded the geographic distribution to be practically confined to the region bordered on the west by the Rocky Mountains and on the east by the Mississippi River. McColloch and Hayes (5) studied the effect of soil temperature on the white grub. They recorded a complete overturn of the temperature of the soil twice during the year, the first in March and the second in October. Coincident with the first overturn white grubs come up above the plow line and with the second, return to the subsoil. Travis (8) reported on the relative toxicity of certain stomach poisons to the adults of *P. lanceolata*. Paris green was more toxic than cuprous cyanide, arsenious oxide or acid lead arsenate.

*History in Oklahoma*

The earliest record for the State as determined from our files is for 1914 when grubs were reported severe in wheat fields. This may have been this species. The records further indicate more or less continuous trouble from this pest from year to year but more than usual damage was reported during 1918, 1924, 1925, 1937 and 1938. The damage in the past, therefore, has been more or less sporadic, with some control factor coming in to reduce the grub populations soon after outbreaks.

*Distribution in Oklahoma*

Records for the occurrence of this species are such that it is practically certain to occur in every county in the State. It seems to be more abundant, however, in the more western part of the state.

*Greenhouse Experiments on Crop Susceptibility*

The general plan was to use five pots for each test, one of which was not infested with grubs. Four to five replications were made of each test except for the corn pots. Eight-inch pots were used, containing sifted loam. First the grubs were put in the pot, following which it was planted, the same number of seeds being used in each pot for each crop. At the start both first and second year grubs were used indiscriminately, but when it was found that the latter soon became prepupae, they were eliminated from the tests. When a surprising lack of injury to plants was observed, the number of grubs per pot was increased and the plants thinned. To provide best chances for damage some tests were run near the close of the experiment in which the plants were purposely kept dry to prevent or slow down root development. The crops tested were corn, darso, cotton, cowpeas, wheat, rye and oats. The first plantings of corn, darso, cotton and cowpeas were frosen after getting a good start. The small grains were not injured. Later plantings of corn, darso, and cowpeas did well. The cotton never seemed to thrive owing probably to the cool weather and to the fact that the greenhouse was not heated. In the case of the corn and darso there was no evident injury from the grubs. This was likewise true for the cowpeas and cotton. The oats were not injured and since oats were reported to be seriously damaged when planted on grub infested land, the

lack of any observable injury in pots heavily infested with grubs is difficult to explain. However, an extraordinary mass of roots developed in all oats pots, extending in a mass down the sides of each pot and across the bottom. Wheat was injured in some experiments but the stand was never entirely lost in any pot. Second-year grubs caused very little injury even in pots kept dry purposely. Rye was injured the most. Young plants were cut off under the soil. In one test there was an average of 10.5 plants in the grub infested pots to 52 in the check. In another where the rye was thinned there was an average of 7.5 plants in the grub infested pots to 16 in check. In one test no serious injury was caused by two-year old grubs.

*Field Experiments on Crop Susceptibility*

As previously stated, the department rented six acres in the heaviest infested part of a wheat field near Blackwell where the soil was uniform and suitable for experiments. Ten plots were staked out in this field extending in a north-south direction, each plot being 25 feet wide and 1,000 feet long. An examination of the soil in 306 samples taken uniformly in this field, each sample being the equivalent of 1/10 square yard, revealed an average infestation of 18.36 grubs per square yard or 88,862 per acre. A total of 562 grubs was recovered of which 316 or 56.2 per cent were from eggs laid the preceding summer. The distribution of the grubs was not uniform in the field, the north and east edges having the heaviest infestation which was particularly true for the second-year grubs.

Corn, darso and soybeans were planted in April and early May. One plot was plowed up and one was left in wheat. There were two replicates for each plot. Records of dates of planting, yield, etc. were taken by the Agronomy Department under Mr. C. B. Cross. A good stand was secured of all three crops despite a heavy grub infestation. When the soybeans were about six inches high, they were destroyed in a few days by the beetles which had transformed from the second-year grubs. The corn and darso were untouched by either beetles or grubs. No corn crop was made, however, because it was planted too late and was injured by a hot, dry period which came early in July just at the critical period in the growth of the plants. The darso made a good crop.

*Field Notes on Life Cycle*

The seasonal cycle of the grub was determined by periodic field trips taken at approximately 10-day intervals. An analysis of the grub distribution records in the field revealed that the most feasible unit of soil sampling which would show the least experimental error was three sets of five 0.1 square yard samples taken from the north, middle and south portions of an undisturbed plot. The one selected was the east wheat plot. These samples were regularly taken from March to September except during mid-summer when grub activity was at a low ebb. When the beetles were active they were likewise observed. The samplings showed a steady decline in the grub population in this plot, which was otherwise undisturbed, from the date of the first sampling taken in March until a low point was reached April 29 which continued until June 13. Part of this was due to pupation of the second-year grubs, which, as previously stated comprised 56.2 per cent of the total grub population. From this date until the last examination, September 29, the grub population remained practically constant. The first pupae were found April 29, the previous date of examination having been April 14. Most pupae were found May 12 and none were found after May 28. The first beetles were observed May 20 and by May 28 were observed very actively feeding on soybeans, pigweed (blood root), yellow evening primrose (*Oenothera laciniata*),

and pepper grass (*Lepidium virginicum*). They were quite specific in their feeding habits being found almost exclusively on these plants at that time. Pairing of the beetles was first observed June 4. At several different times beetles were collected and placed in cages for oviposition records but only a few eggs were obtained. Most of the beetles were dead June 30. June 7, the beetles were still very numerous, but quite a number were dying, especially the males. June 12, thirteen beetles were examined in the field for eggs. All contained immature eggs, mature eggs or both. The number of eggs counted per beetle ranged from 67 to 136, and mature eggs from 4 to 32. The females were thus ovipositing at this time but could not be induced to lay eggs under caged conditions. Also it was impossible to discover where the eggs were being laid in the field. It was noticed in the field that as one favored host plant was destroyed by the beetles they went to others and this was particularly true of the migration from the above mentioned weeds and evening primrose to such other weeds as sunflower (*Helianthus annuus*), whorled tickweed (*Coreopsis verticillata*), two species of knotweed (*Polygonum*), (*Psoralea tenuiflora*), sensitive briar (*Morongia ancinata*) and black-eyed susan (*Redbeckia hirta*). June 22, only two live beetles were seen and it appears that by the end of this month in this region the adults have laid their eggs and largely disappeared.

The grubs are very sensitive to changes in soil temperature. During most of the winter, even on cold raw days, they could be dug up from near the surface of the soil. Grubs in the greenhouse migrated to the bottom of the flower pots when the soil froze during a severe early spring freeze. This cold spell likewise forced the grubs in the field to move downward in the soil well below the plant roots where they remained until the soil warmed up in the spring. Again in the early summer they moved deeper into the soil where they remained until fall. Live grubs could sometimes be discovered on the inside of a lump of dry soil so hard that it had to be broken by a spade. This movement was noted as early as May 12. July 11, it was discovered that they were from 3½ to 10 inches deep in the soil. September 10, some appeared to be nearer to the surface than before but on the examination of September 26-October 1, many were still dormant, particularly in the extremely dry soil of the darso plot. There is some evidence that the grubs come to the surface and cut off blades of the wheat, carry them to a retreat in the soil at the base of the plant and there feed on them. Mr. Dahms of our staff has witnessed a migration of these grubs from a denuded area in a wheat field near Lawton to where plants could be obtained. In our field sampling we also have evidence of a migration of grubs. It appears that the first-year grub is the one capable of causing the greater injury in the spring. When two-year grubs were dug in the winter, brought into a warm greenhouse they soon pupated. This indicates an early cessation of activity. The fact that the pupal period is preceded by an inactive prepupal period and that pupae were found as early as April 29, indicates that this age grub feeds very little much after mid-April in this section.

The two most important natural enemies are skunks and a species of robber fly (*Promachus bastardii* Macquart)*. The activities of the skunks were evidenced everywhere in this field by little holes which they had dug. Moles were also present and doubtless accounted for some of the grubs. The robber fly not only fed on the beetles but its larva fed upon the grub. These and other factors caused a very marked reduction in the grub population of the field as previously indicated. The last examination taken late in September showed a reduction of 75 per cent

* Identified by A. E. Pritchard.

in the wheat plots, 82.6 per cent in the soybean plots, 83.6 per cent in corn, and 89.6 per cent in fallow.

*Summary*

Greenhouse tests show that when oats are growing under favorable soil fertility and moisture conditions they are not noticeably injured by the wheat white grub. Wheat was injured somewhat and rye was very seriously damaged. Corn, darso, cotton and cowpeas were not injured. Second-year grubs caused very little damage to the above crops, soon entering the prepupal stage after being brought into the greenhouse.

Corn, darso and soybeans were not injured by the grubs under field conditions. However, the beetles soon destroyed the soybeans and so this crop is not recommended to be planted in heavily infested wheat fields.

The grubs will, on occasion, come to the surface of the soil and crawl toward more favorable feeding grounds.

In the vicinity of Blackwell, the pupal stage is found from late April to late May. The beetles were present in the fields beginning with the third week in May but had largely disappeared 30 days later. They are quite specific in their feeding habits, preferring some weeds to others and never being found feeding on many of the common types of weeds.

The grubs are quite sensitive to changes in soil temperature, migrating downward when freezes occur or when the surface soil becomes hot during midsummer.

In the field studied, a robber fly, *Promachus bastardii*, destroyed large numbers of the grubs and beetles. Skunks and moles also destroyed many. As a result, there was a reduction in the grub population ranging from 75 per cent in the wheat plots to over 80 per cent in the other plots.

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