

ENTOMOLOGY

AT THE UNIVERSITY OF DELAWARE *

L. A. STEARNS **

INTRODUCTION

IN THE FIRST Annual Report of the Agricultural Experiment Station of the University of Delaware, for the fiscal year ending June 30, 1888 (which covered a period of only three months, the Station having been organized on May 8th of that year under the Hatch Act), the following statement occurs:¹ "The damage caused by the ravages of insects to various crops throughout the State is so great that the necessity for work in the line of economic entomology is fully recognized as being of the utmost importance."

Sixty-nine years have now elapsed since the establishment of the Delaware Station. Despite the original acknowledgment of the considerable losses sustained by Agriculture from pests and the fact that insect problems have increased notably in both their number and complexity, the entomological program from 1888 through 1929 suffered deplorably from frequent changes in administration and, even more, from a lack of continuity. Only since 1930, has there been an almost uninterrupted, gradually-expanding effort in this field.

From 1888 to 1899, the work in entomology and horticulture was combined under one head, M. H. Beckwith (1888-96) and G. Harold Powell (1897-99). In 1900, these responsibilities became separated, for the time being, with the appointment of E. Dwight Sanderson as Entomologist (1900-02) and C. O. Houghton (1903-08).

With the transfer of Houghton from station to college staff in 1908, limitation of funds reportedly prevented research and service

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¹ First Annual Report, Del. Agri. Exp. Sta., 1888, p. 14.

activities in entomology, all obligations relating to insect control again being handled by the horticulturist (and, subsequently, dean and director) C. A. McCue. Houghton, however, continued to teach one (or two) courses in entomology as offerings by the Department of Biology, until his retirement in 1942.

The present Department of Entomology was established in 1925, with H. L. Dozier as head (1925-29) and L. A. Stearns (1929-57). At that time, the provisions of the Purnell Bill permitted, once more, the initiation of research, while the Capper-Ketchum Act (1928) supplied the necessary funds for commencing extension work in 1929. The idea of a joint entomology-plant pathology major, including parallel courses of equal credit value in these two subject-matter areas, was conceived by Stearns and the late T. F. Manns (former head of the Department of Plant Pathology), and this curriculum was added to those of the School of Agriculture in 1946.

This brief historical summary, covering administrative personnel and the respective periods of their employment, is essential background, especially for a partial understanding of entomology's disrupted course from 1888 until late in the year, 1929. However, publications and other source material attest to the capabilities of the original group (Beckwith, Powell, Sanderson and Houghton) as investigators, to their efforts to "extend" information on insect control well in advance of the Smith-Lever Act of 1914, and to their performance as teachers. The purpose of this paper is three-fold: first, to review and evaluate their endeavors and thus provide a convenient reference on their noteworthy contributions; second, to consider developments during the period from 1908 to 1925, when entomological work in Delaware was at a standstill; and, third, to give a factual account only of happenings from 1930 through 1957.

PERIOD 1888-1929

Research

That fruit-insect-control problems were of first concern in the early days of the Delaware Station is emphasized by the facts that the duties of horticulturist and entomologist were delegated to one individual (M. H. Beckwith) and that one-half of the second floor (a single large room) of the original station building was assigned for the use of this division.² The office and laboratory were fur-

² *Ibid.*, p. 10.

nished with tables and other necessary furniture adapted to such work, including a cabinet case for the preservation of insect specimens. A glass structure (greenhouse) was soon constructed for experimental purposes; and it was proposed to devote a portion of this building to the cultivation of various plants for the purpose of rearing insects, in order to study their transformations and habits and to determine accurately the life histories of such as had not been described satisfactorily in all their stages.³

According to the Second Annual Report,⁴ a large number of circular letters were mailed to farmers in February, 1889, asking for information relating to crop pests. In the 130 replies, a total of 40 were mentioned (see Table I). These were recorded and directions then given concerning methods for combating the most troublesome ones. This became, also, the subject matter of Station Bulletin No. 4, the first entomological report (Sta. Bul. No. 2) having been but a short explanation covering the dual functions of this division. The majority of these species are of no less economic importance today. With respect to the codling moth, the conclusion was drawn (following experimental spraying with London purple as a possible remedy against this insect) "that worm eaten apples should henceforth be regarded a sign of slack and careless management."⁵ This statement is still true; also, the recommendation that, "in order to secure the best results, it is desirable to spray the trees at intervals of from 10 to 14 days from the time the blossoms fall until August 1, as the codling moths continue to deposit eggs of the first brood for three to four weeks, the moths from which begin to appear and deposit eggs about the middle of July."⁶ So, as long ago as 1889, effective timing of sprays for codling moth control on apples in Delaware had been rather definitely established through research.

Work with other, currently-injurious insects and the question of insecticides and spraying machinery were considered further in the Third Annual Report and in Station Bulletin No. 12. In both publications, the black peach aphid and its control were discussed at some length.

³ *Ibid.*, pp. 13-14.

⁴ Second Annual Report, Del. Agri. Exp. Sta., 1889, pp. 25, 109-136.

⁵ *Ibid.*, p. 25.

⁶ Del. Agri. Exp. Sta. Bul. No. 8, p. 16.

TABLE I

First List of Insects Injurious to Crops in Delaware

1. Apple Maggot. *Trypeta pomonella*.*
2. Apple Tree Borer. *Saperda bivittata*.
3. Apple Twig Borer. *Amphicerus bicaudatus*.
4. Army Worm. *Leucania unipuncta*.*
5. Asparagus Beetle. *Crioceris asparagi*.*
6. Black Blister Beetle. *Lytta atrata*.*
7. Cabbage Aphis. *Aphis brassicae*.*
8. Cabbage Worm. *Pieris rapae*.*
9. Canker Worm. *Anisopteryx pometaria*.*
10. Chinch Bug. *Blissus leucopterus*.
11. Codling Moth. *Carpocapsa pomonella*.*
12. Colorado Beetle. *Doryphora 10-lineata*.*
13. Corn Aphis. *Aphis maidis*.*
14. Corn Bud Worm. *Heliothis armiger*.*
15. Currant Roller. *Aegeria tulipiforme*.
16. Currant Worm. *Nematus ventricosus*.
17. Cut Worms. *Agrostis*.*
18. Fall Web Worm. *Hyphantria cunea*.*
19. Golden Tortoise Beetle. *Cassida aurichalcea*.*
20. Grape Vine Leaf Borer. *Desmia maculalis*.
21. Harlequin Cabbage Bug. *Murgantia histrionica*.*
22. Hessian Fly. *Cecidomyia destructor*.*
23. Imperial Moth. *Dryocampa imperialis*.
24. Peach Tree Aphis. *Myzus cerasi*.*
25. Peach Tree Borer. *Aegeria exitiosa*.*
26. Pear Blight Beetle. *Xyleborus pyri*.
27. Pear Slug. *Selandria cerasi*.
28. Plum Curculio. *Conotrachelus nenuphar*.*
29. Rose Beetle. *Macrodactylus subspinosus*.*
30. Rose Slug. *Selandria rosae*.
31. Spotted Pelidnota. *Pelidnota punctata*.*
32. Strawberry Grub. *Lachnosterna fusca*.*
33. Striped Cucumber Beetle. *Diabrotica vittata*.*
34. Tent Caterpillar. *Clisiocampa americana*.*
35. Horn Fly. *Haematobia serrata*.*
36. Tomato Worm. *Sphinx quinque-maculata*.*
37. Watermelon Insect. Undetermined.
38. Wheat Head Army Worm. *Leucania albilinea*.
39. Wheat Saw Fly. Species undetermined.
40. Wire Worms. Elateridae larvae.*

Source: Second Annual Report, Del. Agri. Exp. Sta., 1889, p. 110-111.

* 27 species still of economic importance in Delaware.

Special mention was made in the Fourth Annual Report ⁷ of the fact that crops of all kinds were unusually exempt from the attacks of insects during the 1891 season. Arsenites were used again for control of plum curculio and codling moth; in addition, opportunity was given to test an arsenical substitute (pyrethro-kerosene emulsion). This seemed advisable since "many persons hesitate to use some of the most efficient insecticides on account of their poisonous qualities"—a natural reaction, frequently encountered and necessitating similar work in later years.

First references to the strawberry weevil, a species actively investigated in the 1930's, occur in the Fifth Annual Report ⁸ and in Station Bulletin No. 18.⁹ A report was included, also, of an unsuccessful experiment to destroy white grubs by means of a fungous disease. Such work is now classified under the heading of "biological control," and an effective program of this kind to destroy the local population of Japanese beetle was completed between 1942 and 1944.

In 1893, Station Bulletin No. 21 dealing with "Insects Injurious to Stored Grain" was published; jarring as an effective measure supplementing spraying to reduce plum curculio injury was first reported; additional data were obtained on the strawberry weevil; and attention was directed to the activities of the strawberry root aphid (for strawberry weevil, refer to Sixth Annual Report ¹⁰ and Sta. Bul. No. 28 ¹¹).

Next, came the period when the San Jose scale appeared in orchard districts throughout this Country, and wide-spread and well-justified apprehension was felt as to the future of the horticultural industry. Although a considerable number of insect pests, including strawberry root aphid, were reported upon, the Seventh,¹² Eighth,¹³ Ninth,¹⁴ and Tenth¹⁵ Annual Reports were devoted largely to the San Jose scale; and three Station Bulletins (Nos. 25, 30 and 31) were issued on the same subject.

The first change in the Station's staff, since its organization in

⁷ Fourth Annual Report, Del. Agri. Exp., Sta., 1891, p. 89.

⁸ Fifth Annual Report, Del. Agri. Exp. Sta., 1892, pp. 103-107.

⁹ Del. Agri. Exp. Sta. Bul. No. 18, pp. 11-16.

¹⁰ Sixth Annual Report, Del. Agri. Exp. Sta., 1893, pp. 154-171.

¹¹ Del. Agri. Exp. Sta. Bul. No. 28, p. 16.

¹² Seventh Annual Report, Del. Agri. Exp. Sta., 1895, pp. 160-175.

¹³ Eighth Annual Report, Del. Agri. Exp. Sta., 1896, pp. 112-132.

¹⁴ Ninth Annual Report, Del. Agri. Exp. Sta., 1897, pp. 198-210.

¹⁵ Tenth Annual Report, Del. Agri. Exp. Sta., 1898, pp. 233-246.

1888, was the resignation of Beckwith. This vacancy was filled in July, 1896, by the election of G. Harold Powell.¹⁶ Thus ended several years of fundamental work in economic entomology, characterized by high quality, comprehensiveness and a full realization of outstanding local needs. The foundations of a Department of Entomology had been well-laid.

With the advent of Powell, however, the successive changes in leadership commenced which ended finally in the abandonment of all activities in 1908. An immediate forecast of what was to take place appears in Powell's statement as to future policy:¹⁷ "As the horticultural and entomological departments of the Station are combined in one office, and as either subject is sufficiently broad for the individual attention of one investigator, it is felt that the main effort of the horticulturist and entomologist should be expended in one department. The fruit and trucking industries of the state are of preeminent commercial importance, and the major work of the officer in charge should rightly be devoted to the investigation of horticultural problems. In the future, therefore, the entomological department will concern itself mainly with a study of new insect pests of economic importance as they arise, and with the existing species as they become unusually destructive. No work requiring original research will be undertaken." It is apparent that the load, borne so well by Beckwith, could (or would) not be shouldered by Powell. Two years later, he states¹⁸ that "the work of the Entomological Department during the fiscal year has been largely of a consulting nature. The experimental work has been confined to the strawberry root aphid, the results of which follow:" . . .

In 1900, the connection with horticulture was severed by the appointment of E. Dwight Sanderson as Entomologist.¹⁹ The work for that year extends over pages 142 to 238 of the Twelfth Annual Report. Much of it was concerned with the strawberry root-louse and the destructive pea louse, both of which also were discussed in Station Bulletin 49. A study of apple insects was undertaken, with special reference to those affecting young trees, buds and cions; and some consideration was given to insecticides. The station insect collection was divided, "forming two separate collections; one arranged systematically, according to the scientific classification of

¹⁶ Ninth Annual Report, Del. Agri. Exp. Sta., 1897, p. 7.

¹⁷ *Ibid.*, p. 198.

¹⁸ Eleventh Annual Report, Del. Agri. Exp. Sta., 1899, pp. 157-163.

¹⁹ Twelfth Annual Report, Del. Agri. Exp. Sta., 1900, p. 7.

insects; and the other embracing only insects peculiarly injurious or beneficial, arranged according to their food. In this biologic or economic collection, all stages of the insect and specimens of injury done by it [were] shown for the illustration of talks to farmers." "Considerable time was given, also, to making the records of the department comprehensive, easy of consultation and of permanent value." A beginning was made at describing and classifying the immature stages of certain insects, in particular the Chrysomelidae. This was a need, even at this late date, but partially fulfilled.

Space does not permit the full account which should be given of Sanderson's work and, especially, that of C. O. Houghton, who succeeded him on October 15, 1902. Their efforts and accomplishments are set forth in the Twelfth (1900) to the Twentieth (1908) Annual Reports, in bulletins of the Station and in technical reports. Both men were competent investigators (as their publications clearly show); entomology was their first (almost their sole) interest; their research programs were broad (possibly too diversified); and they were prolific writers (even more so than Beckwith). Yet the department, the groundwork for which had been well-laid by him, ceased operations in 1908 (with the transfer of Houghton to the faculty of Delaware College) and did not function again until 1925.

Records for the years thus far considered show a total of 57 publications on various aspects of economic entomology. In the case of 25 Station Bulletins, Nos. 2, 4, 8, 12, 18, 21, 25, 28 and 30 were prepared by M. H. Beckwith; No. 33, by G. Harold Powell; Nos. 49, 50, 56, 58 and 59 by E. Dwight Sanderson; No. 64 by C. O. Houghton; Nos. 68, 69, 72 and 73, by C. P. Close (horticulture); No. 74; by C. O. Houghton; No. 75, by Charles L. Penny (chemistry); No. 76, by C. P. Close; No. 79, by Charles L. Penny and C. O. Houghton; and No. 87, by C. O. Houghton. These bulletins constitute 29 per cent of the entire output of the Station, and represent a vigorous unassisted effort on the part of those early workers which can only be viewed with admiration.

Coming now to the interim from 1908 to 1925; and, considering the nation-wide growth of entomology as a profession and the large number of valuable studies completed in this field throughout the Middle Atlantic States, it is no less than amazing to find publications of this Station practically devoid of any reference to insect attack on the important crops grown in Delaware. Most of such problems were the concern of the horticulturist (C. A. McCue),

although mention of the prevalence of pests and the damage caused by them appears occasionally in reports of the associate plant pathologist (J. F. Adams).

This interval includes almost the entire period (1907-19) during which Harry Haywood was director and, in addition, the first six years of the administration of C. A. McCue. Had this been a period of retrenchment, what happened might naturally have taken place; but exactly the reverse was true. Notwithstanding World War I, this was a time when the Station was undergoing expansion. Although it was entirely dependent at first upon Federal appropriations for its support,²⁰ the original income of \$15,000 annually from the Hatch Act was supplemented by Adams Act (1906) funds, so that the total annual appropriation from Federal sources by 1911 amounted to \$30,000. This increase was augmented considerably by a state "appropriation of \$20,000 for the farm in 1907, and by a further appropriation of \$20,000 for buildings in 1909."²¹ The research staff, which included only five workers in 1888, had increased to eight by 1908 and subsequently was enlarged still further (16 by 1919 and 22 by 1925) in areas other than entomology.

The new agricultural building (Wolf Hall) was constructed and occupied (1917); better laboratory and other facilities became available; and the Station now had the backing of several strong agricultural groups. And yet, this interval was characterized by the complete absence of any constructive program in the field of insect control, a fact unquestionably responsible for the heavy infestations of many pests which developed during the 1920's and persisted well into the 1930's.

A fair appraisal of this unfortunate situation indicates that certain of the studies of both Sanderson and Houghton were much too extensive for a single investigator and had been undertaken by inclination rather than necessity; that their efforts were, therefore, lacking in organization and in essential local support; that Houghton, at least, was not sufficiently aggressive to protect the interests of the department under his direction; and, consequently, that there was a gradual encroachment of the horticultural division upon the field of entomology. But the fact that such an important unit of the Station was actually discontinued can only be attributed to a short-sighted administrative policy.

²⁰ Nineteenth Annual Report, Del. Agri. Exp. Sta., 1907, p. 6.

²¹ Twenty-first Annual Report, Del. Agri. Exp. Sta., 1909, p. 5.

The need for such work was never mentioned by Haywood in any of his reports. However, McCue (who had served as horticulturist since 1907 and who was well-informed therefore as to crop losses from insects) called attention to this deficiency in his second report as director, stating that "for over a decade the growing fruit interests of the state have been in need of investigation relative to insect depredations, and the Station has been besieged with calls for aid to which it has been unable to respond. A department for experimentation and research along the lines of Economic Entomology is a crying need."²² This responsibility on the part of the Station was emphasized by him again and again.^{23, 24, 25, 26} Finally, he reports²⁷ that, under the provisions of the Act of Congress known as the Purnell Bill, it will be possible to engage in these activities once more—after a lapse of about 18 years.

During this gap, notable changes had taken place in the development of Delaware's agricultural resources. In particular, there had been a large increase in the acreage devoted to the growing of various fruits and vegetables. Intensive planting of those areas of the state best adapted for the production of these crops, immediately aggravated insect infestations and complicated control problems. At the same time, both insecticides and application equipment had been undergoing equally important changes.

With the renewal of investigational work in 1925, the influence of the horticultural group was sufficiently great, therefore, to force the initiation of five projects, all financed on Purnell funds and all relating to the bionomics and control of the following fruit insects: codling moth, plum curculio, oriental fruit moth, grape-berry moth and grape leaf-hopper. It is obvious that this program lacked balance. Still further weight can be given to this conclusion by mention of the fact that, in total acreage, apples, peaches and grapes ranked fifth, eleventh and twentieth, respectively, among all crops in the state and sixth, ninth and fourteenth, respectively, in total value. At that time, however, these five insects unquestionably were outstanding pests, and it is extremely doubtful that any other program could have been instituted because of the organized demand for these studies.

²² Del. Agri. Exp. Sta. Bul. 129, p. 4.

²³ Del. Agri. Exp. Sta. Bul. 133, p. 4.

²⁴ Del. Agri. Exp. Sta. Bul. 135, p. 4.

²⁵ Del. Agri. Exp. Sta. Bul. 139, p. 4.

²⁶ Del. Agri. Exp. Sta. Bul. 141, p. 3.

²⁷ Del. Agri. Exp. Sta. Bul. 147, pp. 3-4.

H. L. Dozier was appointed entomologist on August 25, 1925. He served, under what may be described best as frustrating conditions, until October 27, 1929. L. A. Stearns replaced Dozier on November 1st of that year. A small room (324) on the third floor of Wolf Hall was made available to Dozier as an office, but no provision was ever made for laboratory space and much-needed equipment. Soon a small outdoor insectary was constructed in Newark (at the rear of South Hall); an entomological substation, operating on a year-round basis, was established at Camden; and additional accommodations, for summer work only, were supplied at Bridgeville. In retrospect and with the future development of the department in mind, this immediate decentralization of activities was definitely a mistake. However, it could hardly have been avoided without antagonizing certain interests whose support was indispensable to the Station.

The projects, previously mentioned, were undertaken by Dozier at the three points indicated, with the assistance, first, of H. G. Butler and, later, of L. L. Williams. None of these investigations had been completed by the time of his resignation. One bulletin and several technical reports, mostly of personal interest, and two Extension Circulars were published during his four years in Delaware; and two Station Bulletins (Nos. 175 and 176) dealing, respectively, with the plum curculio and grape-berry moth were issued, finally, under the joint authorship of Dozier, Williams and Butler in 1932.

Extension

Although extension work in entomology did not commence officially in Delaware until 1929, it is evident throughout the writings of Beckwith, Powell, Sanderson and Houghton (1888-1908) that all of them were fully aware of their responsibility in this direction, and that they made every endeavor (subject to the limitations of those early days) to "extend" the results of their investigations, so that they could be readily utilized by the agricultural industry of the state.

Frequently it is impossible to distinguish (as is still the case) between research and extension activities; in fact, such an admixture has certain inherent advantages over divided efforts along these lines. Especially is this true when a single individual is burdened with these dual responsibilities in any field. Without knowledge from research, service is impossible. Beckwith's ques-

tionnaire to farmers, from which a "list of the most troublesome insects was made out and directions were printed giving the methods for combating them" (previously referred to under RESEARCH), was basic to an understanding of local insect problems, indicated the direction of research and made possible advice on remedial measures. In the same Report,²⁸ he states that "throughout the season, a considerable portion of the Entomologist's time [was] devoted to identifying insects and reporting their life history to individual citizens of Delaware, who [had] been thoughtful enough to send specimens;" in other words, survey and service work, essentially the same as today.

This was carried a step further in 1890, when it appears that "a great deal of time [had] been devoted to the preparation and delivery of addresses and lectures before Farmer's Institutes, Granges and Horticultural Societies. Many of the lectures [were] illustrated by means of the stereopticon . . . and "correspondence in regard to entomological work [was] solicited, and all inquiries [were] promptly answered."²⁹

The Fourth (1891), Fifth (1892) and Sixth (1893) Annual Reports contain frequent references to farm visitations and to the success of recommended control procedures. In the last of these,³⁰ under the heading of "Insects Injurious to Stored Grain" (on which subject Sta. Bul. No. 21 had been prepared and distributed), it is stated that "many complaints of their depredations have been sent to the Station during the past year and, in every instance, we have been able to render assistance with satisfactory results." That such difficulties were no less acute the following season is evident from Beckwith's remark³¹ that "during the past year, we have personally superintended the treatment of nearly 5,000 bushels of wheat in six different localities in the State, with perfectly satisfactory results in destroying the wheat weevil and other insects working in the grain."

Comes next (as dealt with under RESEARCH) the period when the San Jose scale was rampant. Beckwith and his successor, Powell, adopted strenuous measures to suppress this pest, and supervised the control campaign which continued for several years. Such work

²⁸ Second Annual Report, Del. Agri. Exp. Sta., 1889, p. 25.

²⁹ Third Annual Report, Del. Agri. Exp. Sta., 1890, p. 110.

³⁰ Sixth Annual Report, Del. Agri. Exp. Sta., 1893, p. 154.

³¹ Seventh Annual Report, Del. Agri. Exp. Sta., 1895, p. 172.

"entailed a great deal of travel and a very great amount of labor in examining large numbers of trees." ³² Effort was directed then "to the application of remedies for its destruction and the prevention of its further spread;" ³³ and, later, "to a series of (demonstration) experiments in controlling scale" ³⁴—operations not unlike those carried on by extension entomologists in various parts of this Country during recent years, which likewise have been designed to reduce substantial crop losses occasioned by major insect pests.

With this situation finally in hand, Sanderson, who followed Powell, was able to turn his attention to other extension needs. The station insect collection was rearranged and, in the biologic or economic portion thereof (as stated under RESEARCH), "all stages of the insect and specimens of injury done by it [were] shown for the illustration of talks to farmers." ³⁵

Subsequently, ³⁶ mention was made of the "Encouragement of Nature Study Work in the Public Schools," and of the fact that "considerable attention has been given this movement, as one of vital importance to the agricultural interests of the State. Several Teachers Institutes were addressed; numerous articles were published in the State papers in School Columns established for this purpose; and the general subject of Agricultural Extension Work for Delaware [the *first* reference to such in Station Reports] was laid before the Annual Meeting of the Delaware State Grange in December, 1901, and published in the minutes of that meeting." It is apparent that Sanderson was thinking well ahead of the administration in this matter, since no reference to extension was made by the director (A. T. Neale) either in this or any of his later reports. Furthermore, although the beginnings of extension work in agriculture can be traced back to as early as 1785, this expression of such needs by Sanderson ante-dates the approval of the Smith-Lever Act by somewhat more than a decade.

At that time (1902), Sanderson resigned and transferred to the Texas Station. It is unfortunate that this possibility was not explored further by his successor. Houghton's contribution in this field seems to have been limited to work on the collection of eco-

³² *Ibid.*, 1895, p. 160.

³³ Eighth Annual Report, Del. Agri. Exp. Sta., 1896, p. 112.

³⁴ Ninth Annual Report, Del. Agri. Exp. Sta., 1897, p. 199.

³⁵ Twelfth Annual Report, Del. Agri. Exp. Sta., 1900, p. 142.

³⁶ Fourteenth Annual Report, Del. Agri. Exp. Sta., 1902, p. 109.

nomic insects, previously planned by Sanderson, and to the preparation of several semi-popular papers on certain troublesome pests of that particular period. As already indicated under RESEARCH, all entomological activities came to an end in 1908.

The first statement with respect to agricultural extension, insofar as entomology is concerned, made by a director of the Delaware Station, appears in the Twentieth Annual Report (Bul. No. 84; Harry Haywood's second report).³⁷ In discussing the purpose of experiment stations, as defined in the Act of Congress establishing them, he concludes that a station is given a "wide scope in its activities. However, [he notes that] there is a marked tendency on the part of the Office of Experiment Stations, which administers all Station funds to hold members of the Staff in Experiment Stations to research work, and to depend upon the State governments to provide for agricultural extension in its various phases. In this State, however, [he thinks that] conditions differ from those in most commonwealths. Delaware is so small that part of the duties of the Experiment Station can be performed in the most satisfactory way by personal contact with the farmer, either at Farmer's Institutes, Grange Meetings, or Farm Meetings. As yet, the demand for this intimate relationship between the farmer and the Station is limited, but it is hoped that it will rapidly increase, as it would be a most positive indication of the mutual interdependence that should exist between the Station and its constituents. Specifically, then, [he states that] the Station offers its services to Delaware farmers along the following lines: . . . 6. The identification of and remedies for noxious insects." Provision for "Agricultural Extension" was made ("as an experiment") by the Legislature of 1911 in an appropriation of \$9,000 for two years for the establishment and maintenance of such a division.³⁸ The activities, as later reported upon,³⁹ included three definite lines of endeavor: first, cooperative experiments; second, meeting the demand for speakers at various agricultural organizations and farmers' meetings; and, third, rendering assistance in the solution of specific problems.

No mention is made of any insect-control operations either at this point or in following reports until the Twenty-eighth (Bul. No.

³⁷ Twentieth Annual Report, Del. Agri. Exp. Sta., 1908, pp. 5-6.

³⁸ Twenty-third Annual Report, Del. Agri. Exp. Sta., 1911, p. 10.

³⁹ Twenty-fourth Annual Report, Del. Agri. Exp. Sta., 1912, pp. 12-13.

116),⁴⁰ wherein, under the discussion of county agent work in Sussex County, appears this statement: "Inasmuch as the strawberry weevil has in late years been doing serious damage to the berry crop of Sussex County, a demonstration was arranged by which to restrict its spread. The difficulty with the pursuit of the work was that many of the farmers wait until the weevil appears before they think of doing anything about. Because of the high cost of the dust mixture which is used to control its spread, it is likely that very little will be done in the future. Many difficulties have been met in this work and the results are in the preliminary stage. There is much to be learned regarding the habits of the weevil before recommendations can be made regarding its control. Several minor demonstrations have been conducted on the control of melon lice, etc." This, of course, was subsequent to the passage of the Smith-Lever Act (1914), which provided a separate staff of workers for agricultural extension. There was no indication, however, as to who carried on the demonstrations in question.

The bulletin (No. 116) just referred to is the last annual report of the director of the station which covers the results of investigational work and extension accomplishments as well. The first printed annual report of the Delaware Extension Service (issued separately from research) appeared as Extension Bulletin No. 8, May, 1922; and the second, as Extension Bulletin No. 17, January, 1933.

The record, therefore, from 1916 until 1929 (when the entomologist was first designated as part-time extension specialist) with respect to activities directed toward more satisfactory control of insects is very obscure. On pages 38 and 39 of Extension Bulletin No. 8 is an account of "fungus and insect control on cucurbits" attributed to J. F. Adams (part-time extension specialist in plant pathology). Inasmuch as Extension Circulars 12, 13, 16, 18, 21 and 23 (all of these, except 16, served the same purpose as the spray schedules published annually at the present time) were prepared wholly or in part by Adams, it seems probable that most of the entomological field service during that period was carried on (and very effectively) by him.

In view of the situation which existed at the time the research program on fruit insects was adopted in 1925 (see discussion under RESEARCH), spray service for fruit-crop protection logically became

⁴⁰ Twenty-eighth Annual Report, Del. Agri. Exp. Sta., 1916, p. 29.

the extension activity of first importance, when (as stated in the INTRODUCTION) the passage of the Capper-Ketchum Act in 1928 provided the necessary funds to commence such work the following year. Under the arrangement made then and still in effect, it was thought advisable to utilize a portion of the time of both the entomologist and an assistant (or associate) on the station staff in this connection. That decision resulted naturally in a close co-ordination between the programs for research and extension. It was the only course that could have been followed because of limited personnel; and, administratively and otherwise, it has benefited greatly both lines of endeavor.

In 1929, the extension effort in entomology was concerned entirely with activities—the distribution of “Orchard Spray Notes” during the growing season, spraying demonstrations, farm visitations, etc.—directed toward more efficient production of apples, grapes, peaches and strawberries.

Teaching

In marked contrast to the checkered record of research and extension entomology, already examined herein, the teaching of this subject has been featured by continuity; furthermore, by the fact that, for years, there were no significant changes in instruction in line with important developments in this field. This statement is especially true of the latter portion of the period from 1903 to 1942. The varying emphasis placed on entomology as a part of the agricultural curriculum also is worthy of mention. In the early days of Delaware College, it was considered an essential course; finally, it was not required of agricultural or any other students. It must be noted, finally, that the teaching of entomology antedates research and was always allied with either agriculture or biology until the time of Houghton's retirement. Therefore this section of the present review covers the period 1886 to 1942, rather than 1888 to 1929 as indicated in the subtitle.

According to the Catalogue for 1887,⁴¹ “This Institution, by the law of its existence, is the State Agricultural College and, by the act of Congress approved July 2, 1862, and the act of the General Assembly of the State of Delaware passed March 14, 1867, is required, as the leading object, to teach such branches as are related to agriculture and to mechanic arts, without excluding scientific

⁴¹ Delaware College Catalogue, 1887, pp. 1-2.

and classical studies, and including military tactics . . . The Agricultural Course is a three years' special course including instruction on . . . insects injurious to vegetation." Then and in the previous year (1886), such work was under Frederick D. Chester, professor of geology and agriculture. Insects injurious to vegetation, with practical study (three hours a week for the spring term of the "Middle Year" and two hours a week for the fall term of the "Third Year")—Harris—was a requirement.⁴² Apparently, "A Treatise On Some Of The Insects Injurious To Vegetation" by Thaddeus William Harris, M. D. (1st edition, 1841; 2nd edition, 1862) was used as the text.

During the years 1888 to 1894, inclusive, Beckwith served as professor of horticulture and entomology. From 1888 until 1891, the only change from the listing just given was a reduction in the total hours from five to four. In the Catalogue for 1891,⁴³ however, there appears a very full statement covering zoology and entomology, as follows: "In this study, the primary object sought is to give students command of the methods of zoological research. This is accomplished by means of lectures illustrated by Auzoux' models and specimens of typical animals. In pursuing this subject an elementary knowledge of entomology is also taught as a foundation for future study in that branch. Students in the Agricultural Course receive further instruction in entomology during two terms. This subject is necessarily made largely practical. The relation of insects to organic life and the interests of man is made specially prominent. A knowledge of structural entomology is gained by discussion and detailed study of typical insects. Special stress is laid upon the economic relation of insects to plant life. Opportunity is given for practice in field observation, and the ordinary methods of collection and care of specimens is taught, special attention being devoted to the means of controlling the ravages of noxious species and protecting those that are beneficial."

In 1895, entomology was transferred to William H. Bishop, professor of agriculture and biology. Instruction was given in the Senior year only. The description of the course was not revised, however, until 1897. At that time, it read:⁴⁴ "Entomology, Economic—The course in entomology consists of one lecture per week

⁴² Delaware College Catalogue, 1886, p. 21.

⁴³ Delaware College Catalogue, 1891, p. 24.

⁴⁴ Delaware College Catalogue, 1897, p. 43.

during the winter term. The aim of the lecture is to consider insect life in its relation to horticulture and agriculture. The following features are prominently emphasized in the course: the increase of insect pests; our insect friends; their relationships; their external and internal anatomy; their life history; the application of the preceding features to the prevention and destruction of insects; insecticides. A detailed account is given of the principal insects that attack fruit and farm crops, and specimens from the collection are placed before the students."

By this time (1898) there were three courses in agriculture—a four-year course, a two-year course and a winter course—in all of which entomology was taught.

The phraseology was changed again in 1899, as follows: "Entomology—1 Lecture Per Week—The course in entomology will consist of lectures on the injurious insects of orchard and garden crops. The student will be given an account of the external and internal anatomy of insects; of their life histories; of their injury to various horticultural crops; and of the means of holding them in control. Specimens of the insects under consideration will be placed before the class for examination." Such work was listed with horticulture for the winter term of the Junior year.⁴⁵

Sanderson was added to the staff in 1900, as lecturer in entomology. He was designated associate professor of zoology and lecturer in entomology in 1901 and 1902, the title also borne by his successor, Houghton, from 1903 to 1906, inclusive. Houghton received the rank of professor of zoology in 1907; professor of zoology and botany, in 1909; and professor of biology, in 1915.

The character of the general course in entomology, as set forth in 1899, remained practically unchanged until 1904. However, in 1900 the lectures and recitations were increased to three hours per week given, as formerly, in the winter term of the Junior year. In addition, in 1900 and 1901 a series of lectures was listed for the "Winter Course in Agriculture" under the following description: "Entomology—24 lectures; this course will consist of lectures in Economic Entomology, the character of the work given having special reference to the needs of agriculture and horticulture. The student will be given an account of the life history of insects; their relationships; their external and internal structure; mode of living;

⁴⁵ Delaware College Catalogue, 1899, pp. 45, 48-49.

and the application of these points to the destruction of insect pests. Specimens of insects under consideration will be studied." Entomology also continued to be a requirement in either the first or second year of the two-year agricultural course.

From 1904 to 1908, inclusive, the general course in entomology was scheduled for the winter term of the Sophomore year. However, in 1905 it was listed under the department of biology rather than agriculture. Several minor changes in the description of the course were made, but it remained essentially the same until 1906, when this addition was made: "Students, whose time will permit, may take special laboratory work in structure and classification of insects."⁴⁶ Commencing in 1909, entomology was moved to the Junior year of the agricultural curriculum. In the 1910 Catalogue, Houghton was no longer shown on the staff of the experiment station, but only as professor of zoology and botany.

The following new description of the course in economic entomology appeared in the Catalogue for 1915-16:⁴⁷ "A course treating of the more important injurious insects of orchard, garden and field crops, also the insect pests of domestic animals and the household. The work deals with their structure, life histories and descriptions, and the most approved methods for their control. The most important forms are placed before the class for their careful examination and comparison. Special emphasis is laid upon the necessity for the ready determination of species. Two recitations or one recitation and two hours of laboratory work a week. Elective for students in Arts and Science and in Agriculture." This course carried two credit hours for each of the two terms.

A second course in the field of insect study, called "Systematic and Economic Entomology," was added in 1922. This was described as follows:⁴⁸ "An advanced course in Entomology dealing with the structure, habits and economic importance of insects not studied in B5 and 6 (Economic Entomology). Considerable time will be devoted to disease-transmitting forms, and to a study of laboratory methods in economic entomology. Field work in studying and collecting insects will be required and the student will be expected to prepare a representative collection of insects, which will become his property when the course is completed. Four hours

⁴⁶ Delaware College Catalogue, 1906, p. 36.

⁴⁷ Delaware College Catalogue, 1915-16, p. 62.

⁴⁸ Delaware College Catalogue, 1921-22, p. 50.

of laboratory work a week." This course carried a total of four credit hours for the year.

Houghton, therefore, taught entomology continuously from 1903 to 1942. Only one course was offered until 1922; subsequently, two courses; both, with four hours credit for the year. Although there were changes in descriptions and numbering between 1922 and 1942, the content of "Economic Entomology" and "Systematic and Economic Entomology" was essentially the same.

It is evident from the foregoing discussion that, after ranking as a required course in agriculture, entomology was made elective in 1914. Subsequently, it was not required in the general agricultural curriculum, although listed temporarily as a requirement for students in horticulture from 1921 to 1937 and, for those in agronomy, from 1925 to 1937. From 1937 to 1942, it was not a requirement in any of the agricultural curricula. During most of this period (1914-42), it was scheduled for the senior year.

Statistics presented in Table II show that 36 (57.1%) of the 63 graduates of the School of Agriculture from 1930-31 through 1939-40 had enrolled in entomology. In agronomy and horticulture, where this subject was required for the first seven years of this decade, enrollment was relatively high (77.7 and 78.6%, respectively); in agricultural education and animal industry, where elective, it was moderate to nil (47.8 and 0.0%, respectively).

By reference to Table III, an enrollment summary covering all courses in the department of biology (Delaware College) for the same 10-year period, it will be noted that there was substantial agricultural participation, averaging 49.1 per cent, in five of eight courses constituting 74.5 per cent of that department's teaching load. Enrollment in economic entomology was very small, averaging 8.1 per year; but, in a total of 81 enrollments, 67 (82.75%) were agricultural students. The course in systematic and economic entomology was offered only twice (in 1934-35 and in 1935-36), with a single student in each case (neither of them agricultural). These two courses accounted for no more than 6.3 per cent of the department's average enrollment from 1930-31 through 1939-40. It is obvious that the emphasis which this subject merits was not being supplied during the decade in question.

The apparent discrepancy between the totals (33 and 34) for economic entomology in Table III and the total (36) shown in

TABLE II

Graduates of the School of Agriculture, University of Delaware, Classified by Curricula and Enrollment in Entomology, 10-Year Period, 1930-31 to 1939-40, Inclusive

Year	Number of Graduates				Number Enrolled in	
	Agricultural Education	Agronomy	Animal Industry	Horticulture	Total	Entomology
1930-31	2		1	1	4	2
1931-32	3	2	1	1	7	3
1932-33	1		1	2	4	3
1933-34	4				4	2
1934-35	2	1			3	2
1935-36	3			1	4	1
1936-37	2	2	1	4	9	6
1937-38	1	4		2	7	4
1938-39	3	2	1	1	7	6
1939-40	2	7	3	2	14	7
Total	23	18	8	14	63	36
Number	11	14	0	11		36
Per cent	47.8	77.7	0	78.6		57.1

Source: Data from records of office of the Dean of the School of Agriculture; supplied by George L. Schuster.

Geographical distribution of graduates: New Castle County, 31 or 49.2% (Wilmington, 8; rural, 23); Kent County, 6 or 9.5%; Sussex County, 16 or 25.4%; Out-of-State, 10 or 15.9% (Pennsylvania, 5; New Jersey, 4; Florida, 1).

TABLE III

Enrollment Summary, All Courses, Department of Biology (Delaware College), University of Delaware, with Data on Agricultural Participation, 10-Year Period, 1930-31 to 1939-40, Inclusive

Course and Catalogue Designation		Total for 10 Years			Average		Agricultural Participation
		First Term	Second Term	Both Terms	Term	Year	
General Biology*	B115-16	182	155	337	16.85	33.7	1 only***
General Botany*	B207-08	305	282	587	29.35	58.7	36.0%
General Zoology**	B301-02	124	114	238	11.90	23.8	27.3%
Economic Botany**	B309-10	20	27	47	2.35	4.7	37.3%
Systematic and Economic Botany**	B403-04	3	2	5	0.25	0.5	None
Economic Entomology**	B405-06	41(33)	40(34)	81(67)	4.05	8.1	82.75%
Systematic and Economic Entomology**	B411-12	2	2	4****	0.20	0.4	None
Systematic Botany**	B413-14	28	30	58	2.90	5.8	62.15%
Total, or Average Per cent		705	652	1357	67.85	135.7	49.1%

Source: Data from records of office of the Dean of the School of Agriculture; supplied by George L. Schuster.

* Instructor—F. C. Houghton.

** Instructor—C. O. Houghton.

*** One only in 1936-37.

**** Two only; one in 1934-35 and one in 1935-36; neither of them agricultural.

Table II is due to the fact that one of the students listed therein was enrolled in B5 (B405) in 1929-30; one, in B405 only; one, in B406 only; and one, in B11 (B411) and in B12 (B412) in 1929-30.

At the time (1940-41) that the data set forth in Tables II and III were being extracted from records of the dean's office, School of Agriculture, a survey was made of the departmental affinities of entomology in the land-grant colleges. A separate department of entomology was listed at 24 of these institutions, while in 17 additional ones the department name indicated a combination of entomology with some allied field. In five states, entomology was being handled by other departments; two colleges scheduled no work of this kind. Therefore, entomology was being taught in 46 of the 48 land-grant colleges and was granted full departmental rank in 41 (91%) instances. This subject was included under the School of Agriculture 32 (67%) times.

As would be expected, the status of entomology varied considerably in these many institutions. When enrollments in entomology (years 1939-40 or 1940-41) were expressed as percentages of total enrollments in Agriculture, the range was from 0.0 to 87.8, with an average of 26.4 per cent. Excluding the two colleges which did not schedule entomology, Delaware with 6.9 per cent was second from the bottom. Entomology was found to be a required course in certain curricula of 38 (79%) of the land-grant colleges; Delaware was one of the few (10) which did not require such study. Obviously and in every respect, the local situation was far from satisfactory.

Summarizing, briefly, the first section of this paper: the total of 89 publications—31 bulletins, 35 technical reports and 23 semi-popular articles—covering insect biology, depredations and control is tangible evidence of research accomplishments and of the effort to impart the results of such work to others; * 57 of these occurred during the first 23 and 25 during the last four of the 42 years under consideration. Although they represent contributions by 15 individuals, 72 are attributable to the five department heads. Nine

* In the file of departmental publications, this group includes numbers 1 to 86, 88, 101 and 102.

were authored by Beckwith; one only, by Powell; nine, by Sander-son; 30, by Houghton; and 23, by Dozier (nine of his, however, were concerned with studies conducted elsewhere).

It is obvious that the unfortunate 18-year hiatus (1908-25) in entomological activities was due to administrative policy with respect to the direction of the station's program; also, that the decisions of Directors Haywood and McCue (primarily the former) to concentrate available resources in other areas greatly retarded essential research and service in this field and, consequently, were responsible for future crop losses (apples, grapes and peaches) from uncontrolled insect populations amounting to several hundred thousands of dollars.

Although meeting satisfactorily needs during the early years of Delaware College, when compared with other land-grant institutions, the teaching of entomology had become inadequate by the 1930's. Since this subject is of general value in agriculture and of considerable importance in certain of its specialized branches, it should have been required in several curricula and elective in all others. However, it was elective only; enrollments were few; instruction was out-dated and financial support lacking. The predominance of agricultural students in the courses then offered made advisable the transfer of this work from the School of Arts and Science to the School of Agriculture (effected in 1946).

PERIOD 1930-1957

Whereas the period 1888-1929 has been reviewed at some length, with the intention of recording and analyzing entomological work in its various aspects, events during the period 1930-1957 will now be chronicled in much less detail in order that a complete account covering these 69 years will be available in a single paper.

Entomology, as of 1929, was a department in name only—insufficient staff (the entomologist and a recently-acquired assistant), negligible budget, small office, without laboratory space, library or reference collection of insects, limited equipment for insectary studies at three points (Newark, Camden and Bridgeville) and a completely unbalanced group of research projects.

Shortly after Stearns replaced Dozier on November 1st of that year, a long-range program for development of the department was prepared (and approved by Director McCue), under which research was to be broadened immediately, extension expanded

gradually and teaching absorbed eventually. Despite the advent of World War II and changes in the station's leadership (G. L. Schuster succeeded McCue, in 1939; and G. M. Worrilow succeeded Schuster, in 1948), advances during this 28-year period were almost fully in line with McCue's original directives and a tentative time-schedule suggested by him.

Funds for investigational work from 1925-26 through 1928-29 had averaged less than \$2000.00 annually. Obviously the necessary financial support for rapid growth of the department could not be expected from the University; and, with McCue's endorsement, it was decided to plan for its future with funds from outside sources. This basic decision has influenced, in varying degrees, all phases of entomology's activities since that time. In research, it was possible to capitalize at once on the awakening interest of the chemical industry in the development of new insecticides. Next, the contacts with such concerns disclosed a lack of research, service and sales personnel in the field of pesticides, which resulted in the establishment of Delaware's entomology-plant pathology major and has shaped the character of instruction to date. Lastly, the availability of public funds, appropriated for the relief of unemployment both during and after the "depression," afforded opportunity to engage in several extension-directed insect-control campaigns.

Supplemental funds (\$310,064.01) solicited and obtained by the department head amount to 67 per cent and University funds (\$155,487.52) to only 33 per cent of the total money (\$465,551.53) which has been available for departmental operations from 1925-26 through 1956-57. A breakdown of all grants indicates that \$141,215.50 were contributed by industry; \$89,705.51, by various local sources (state, county, municipal and private); and \$79,143.00, by several Federal agencies (C. W. A., W. P. A., etc.).

Certain of the benefits derived from these supplemental operating funds may be enumerated, as follows: (1) they permitted the employment of additional staff; (2) covered the purchase of much-needed equipment; (3) strengthened investigations under station projects; (4) made possible attack on problems for which money was lacking; (5) gave access to new chemicals for biological testing; (6) afforded stimulating contacts with industry; (7) financed the publication of valuable data; and, thus, (8) reflected credit on the department, Station and University.

With respect to the first of the above items, the number of full-

time research fellows receiving appointments since 1930 actually exceeds the total regular staff members since 1925. Records of entomological workers (in all job categories and with one or more months of employment) show a total of 105 for the period 1930-57 (to July 1, 1957) compared with only 10 for the period 1888-1929.

In 1942, with but one exception (an individual who resigned on February 28, 1943), all personnel left for active military duty. P. L. Rice (head of the department of biology, Alma College, Michigan, who had been employed as a seasonal assistant entomologist from April 1 to September 30, 1935, and as assistant research and extension entomologist from April 1, 1936, to August 31, 1937) served as acting department head from June 1, 1942, to September 30, 1944. Replacements during the war-time years were temporary appointees.

Since 1929, the department has enlarged gradually to its present six-man staff, all involved in research; four, in part-time teaching; and two, in part-time extension (graduate research assistants not included).

Between May and October, 1930, to allow for expansion, a move was made from Wolf Hall to South Hall; finally, one-half of that small building was occupied. With increased facilities at Newark, summer activity at the Bridgeville insectary ended in November, 1934, and the entomological substation at Camden was closed in November, 1935. The Newark insectary (at rear of South Hall) was shifted to the University farm in April, 1938. Following completion of the new chemistry building (Brown Laboratory), the department returned to Wolf Hall in January, 1938, having been assigned that section of the third floor over the auditorium. Finally, in August, 1952, the move was made to entomology's present and even-more spacious quarters in Agricultural Hall.

Research

For detailed statements on investigational work, those interested can refer to the Annual Reports of Directors McCue, Schuster and Worrilow for the fiscal years ending June 30, 1926, through June 30, 1949 (the latter being the last such printed report).⁴⁹

⁴⁹ Delaware Agri. Exp. Sta. Buls. 147 (1926), pp. 17-20; 152 (1927), pp. 19-25; 158 (1928), pp. 19-24; 162 (1929), pp. 29-43; 167 (1930), pp. 24-30; 172 (1931), 30-36; 179 (1932), pp. 29-37; 188 (1933), pp. 24-33; 192 (1934), pp. 28-37; 203

Station Projects. Since the re-establishment of the department in 1925, a total of 30 projects (financed, for the most part, on Federal funds) have been authorized. Of these, three were discontinued; 19 have been completed; and eight are still active. Included in the completed group are studies of the codling moth, Comstock mealy bug, grape-berry moth, grape leaf-hopper, plum curculio (two), oriental fruit moth, peach tree borer, strawberry weevil, bean, cucurbit and pepper insects, European corn borer, Japanese beetle, poultry ectoparasites, tabanid flies, ticks and mosquitoes (biology and effect of control procedures on agricultural activities). Included in the active group are studies of new insecticides for fruits, measures against vegetable insects, the status of farm-woodland species, controls for clover mite, mosquitoes (appraisal of control efforts, flight-range potentials and relation of wildlife practices to prevalence), and surveys of economic crop pests.

For the past 17 years, the department has served in a technical advisory capacity to Delaware's Highway Department, the agency responsible for mosquito-control operations in this state. Mosquito investigations have received, therefore, annual and increasingly-large contributions from that department (total of \$67,667.51 to June 30, 1957); and, since 1954-55, from the Delaware Board of Game and Fish Commissioners as well.

Industrial Projects. In the early 1930's, none of the concerns engaged in the production of agricultural materials had the well-established laboratories for pesticide research so common today; for that reason they were glad to avail themselves of institutional facilities for such work. Fortunately, the department was then in a position to contract with several outstanding firms in this field and to pioneer in the exploration of organic chemicals as insecticides. The grant in each case was sufficient to employ competent assistants, to purchase both consumable supplies and specialized equipment and otherwise to finance the desired program to its completion.

The principal participants in these cooperative endeavors were:

(1935), pp. 22-35; 205 (1936), pp. 26-34; 207 (1937), pp. 27-33; 214 (1938), pp. 22-27; 220 (1939), pp. 21-28; 227 (1940), pp. 21-30; 235 (1941), pp. 19-29; 238 (1942), pp. 16-25; 244 (1943), pp. 20-23; 251 (1944), pp. 23-29; 259 (1945), pp. 18-23; 263 (1946), pp. 24-28; 271 (1947), pp. 18-23; 276 (1948), pp. 20-24; and 283 (1949), pp. 20-23 (years in each case are fiscal, not those of publication).

the California Spray-Chemical Company (1930-31 and 1931-32), the General Chemical Company (1932-33 and 1933-34), E. I. du Pont de Nemours and Company (1932-33 through 1935-36), the Hercules Powder Company (1934-35 through 1947-48), the National Sugar Refining Company (1949-50 through 1954-55) and the B. F. Goodrich Chemical Company (1954-55 and 1955-56). Through these investigations, several effective chemical groups (thiazines, thiuram sulfides, thiocarbamates and terpene ethers) were disclosed and three now-world-known, trade-marked pesticides (Phenothiazine, Thanite and Toxaphene) were developed, while the possible use of certain other products (Volck, Orthol-K, pine oil and Strobane) for insect control was broadened considerably.

Research results, since 1930, and their application to local and regional problems are considered in a total of 234 publications—24 bulletins, 181 technical reports and 29 semi-popular (extension) printed or mimeographed releases.* Industrial projects are covered by eight technical bulletins (Nos. 184, 196, 206, 217, 221, 253, 264 and 304), totaling 367 pages; also by many of the technical reports. Although a few publications include more than one area, the approximate subject matter distribution is as follows: fruits, 90; mosquitoes, 51; vegetables, 37; forest and shade trees and ornamentals, 16; field crops, 14; man and animals (excluding mosquitoes), 11; household, 10; and beekeeping, 5.

*Extension ***

It will be recalled that, when extension work in entomology was authorized first in 1929, it was limited to spray service for fruit-crop protection. Such was also the case in 1930 and 1931. At that time and for several years thereafter, the normal requirement of modifying the annually-published spray schedules during the growing season to compensate for the usual spring and summer variations in weather, in apple, grape and peach development and in insect prevalence was complicated by the depressed condition of the fruit industry (as a part of the nation-wide business situation) and by stringent regulations covering spray residues. It was then,

* In the file of department publications, this group includes numbers 87, 89 to 100, 103 to 289 and 30 unnumbered ones listed between P207B (1947) and P289 (1957).

** Discussion based on Annual Reports of Extension Work in Entomology, Delaware, years 1930 to 1956, inclusive.

for example, that the measures for codling moth control had to be acceptable, at the same time, from the standpoints of the existing infestation, insecticidal effectiveness, pesticide residues (arsenic, lead and fluorine) on harvested fruit and the financial capacity of the grower. This has proved, therefore, a responsibility which, in its details, has been subject to frequent and painstaking modification over the years.

Although anticipated changes already have taken place in Delaware's agricultural complex and wholly unexpected shifts may yet occur, as a result of increasing urbanization, it seems reasonably certain that there will always be sufficient acreage in orchards to justify continuing emphasis on the control of fruit pests.

The knowledge that service was being rendered in that area resulted gradually in demands for information and for field assistance on approved methods of control for important pests of other crops and for help in combating insects affecting man and animals as well.

Procedures involved in this portion of the extension program have included: (1) preparation of annual fruit spray schedules (printed card, circular, bulletin, or folder), 1930 to date; (2) distribution of "Orchard Spray Notes" (mimeo material), 1930 to 1950; (3) weekly release of "Late News About Insects And Diseases" (mimeo sheet), 1949 to date; (4) preparation of annual recommendations for insect and disease control on vegetables (printed folder), 1952 to date; (5) annual spraying demonstrations on fruits and/or vegetables; (6) weekly visits during the growing season to a select group of farmers, canners, processors and pesticide dealers (jointly with the part-time extension plant pathologist since 1951), 1930 to date; (7) state-wide rat control campaigns, 1944-45-46; (8) potato tuberworm survey, 1944; (9) state-wide European corn borer control campaigns, 1944 to 49 and 1957; (10) publicity on measures to prevent stored grain losses due to insects, 1948 to date; (11) recommendations (mimeo) on fly control in dairy barns, 1949 to date; and (12) folders (mimeo) and/or spraying demonstrations against alfalfa pests, 1951 to date.

The third item listed above deserves special comment. This informational sheet was initiated in 1949 as "Late News About Insects." In 1951, it was retitled "Late News About Insects And Diseases" (the part-time extension plant pathologist cooperating); and it then replaced the "Orchard Spray Notes," which had been

distributed by the two departments for many years. The objective of this one-page release, mailed weekly throughout the growing-season and during the remainder of the year whenever necessary, is to supply its readers with concise reports on insect and disease prevalence and with positive, workable control measures. "Late News," commonly referred to as "Delaware's Pink Sheet," has met with widespread approval on the part of home owners, farmers and chemical and other concerns supporting Agriculture. At the close of 1957, the nine-year distribution total was 93,138 copies of 220 issues.

Turning now to the more important of many miscellaneous extension activities, first should be mentioned the state-wide survey of Delaware's mosquito problem completed in 1932 on state, Rehoboth Beach and private funds.⁵⁰ The information thus obtained served as the basis for extensive control operations between October, 1933, and November, 1938, carried on by Civilian Conservation Corps labor under the direction of the Delaware Mosquito Control Commission (on which entomology was represented). Not only did this effort reduce immediately and substantially mosquito annoyance in the resort section of the state but, by the expenditure of almost two million dollars, it aided materially in alleviating the local unemployment situation during the "depression years." This initial survey also led to what is now a 25-year period of mosquito research and to technical assistance in the State Highway Department's control program from 1940 to date.

Second, in chronological order, was the beginning of Boy's and Girls' Club Work in entomology in 1933. It was conducted at first in conjunction with the existing Home Vegetable Garden Project; later, it involved beekeeping; and, finally, it included an instructional program in connection with the annual 4-H Club Short Course and the judging of insect collections exhibited each year by club members at the Kent-Sussex Fair.

Third, was the direction of a Civil Works Administration project in 1933-34 (a federal appropriation of \$16,450.00 for relief of unemployment in Delaware), which permitted clean-up operations about schools, lakes and rural recreational centers designed to reduce the Rocky Mountain spotted fever hazard.

Fourth, the introduction in 1935 of annual surveys of insect

⁵⁰ Del. Agri. Exp. Bul. 181, 106 pp.

abundance (summarized in Annual Reports of the Director under the heading "Important Insects of the Year").

Fifth (following a temporary increased allotment of funds from 1936 to 1943), work with the Home Demonstration Clubs for the purpose of reducing insect and rodent damage about farm homes.

Sixth, long-continued apicultural activities, as a result of which the Delaware State Beekeepers' Association was organized on December 10, 1936, and the present Delaware apiary law was enacted on July 1, 1947.

Seventh, the promotion and supervision, during the years 1941 to 1943, of an effective state-wide program for colonization of the milky disease of Japanese beetle larvae (\$11,616.00 from state, county and municipal sources) and of national defense, Works Progress Administration mosquito-control projects for army posts in the state totaling \$98,788.00 (\$62,693.00 for the Fort duPont area).

The authorization for extension work in entomology (figured as participation by a single individual) was 15 per cent for the seven-year period, 1929-35; 76 per cent, for the eight-year period, 1936-43; 70 per cent for 1944; 40 per cent, for 1945, and averaged 30 per cent (low 22 and high 38), for the 12-year period, 1946-57. Obviously, all of the obligations scheduled in the annual plans of work and other essential activities regularly superimposed on these programs could not be absorbed on so small a time allotment. The over-run has ranged from 51 to 56 per cent; and contributions of research, teaching and personal time by the part-time specialists and other members of the staff have been necessary to meet this deficiency.

Because of the situation outlined above, no attempt was (or could be) made between 1930 and 1957 to develop a coordinated effort in extension entomology. At first, the service "pressure" was entirely from the fruit-growing industry. The present "load" is due to a spontaneous demand for assistance on the part of all Delawareans, with the portion from agriculture more or less stabilized in both amount and kind and the inquiries from non-rural sources rapidly mounting. The volume of extension correspondence handled by the department head emphasizes this recent shift: for the 10-year period, 1926-35, only 366 letters; for the 10-year period, 1936-45, 1519 (a 4.2 increase); and, for the 10-year period, 1946-55, 6639 (a 4.4 increase). The total service requests (19,688 phone calls, office visits, letters and farm or home visits since 1946) also sup-

ports this conclusion; for the eight-year period, 1946-53, they averaged 1632 and, for the three-year period, 1954-56, 2212; a 26 per cent increase directly attributable to insect-control problems in suburban communities. Without question, the indicated trend will continue well into the foreseeable future.

Teaching

Early in 1945 and for the first time in more than seven years, the entire undergraduate program of the School of Agriculture was subjected to thorough examination and considerable revision. Previously, there had been opportunity for study in only four departments (agricultural education, agronomy, animal industry and horticulture; see Table II). Two additional majors were then added (entomology-plant pathology and poultry industry) and a third (agricultural economics) in 1950.

The general curriculum approved for 1945-46 was described in part as follows:⁵¹ "The first two years of the four-year [program] consist of required courses" (including three-hour introductory courses in entomology, field crops, livestock production, plant pathology, pomology, poultry production and vegetable gardening). These two years of study are "designed to provide the student with a working knowledge of agricultural production and the sciences relating thereto. Should the student not have the opportunity to pursue the four-year [program], he will thus have gained much in the two years that will aid him in his chosen field and enable him to attain a better standard of living." "Each student must, at the close of his Sophomore year, register with the Dean of Agriculture his choice of [a specific] curriculum." This particular revision of the over-all program was predicated on the principle that students are entitled to equal "exposure" to all subject matter fields before designating a major, and on the desirability of a broad agricultural training, with but a moderate degree of specialization in some selected area.

No really significant change, aside from the steady growth in graduate-school offerings (which had been limited to agricultural education, plant pathology and soil bacteriology in 1945-46),⁵² occurred until 1950-51. Since that year and purportedly in recogni-

⁵¹ Bul. Univ. Del., Catalog Number 1945-1946, p. 39.

⁵² *Ibid.*, pp. 149 and 159.

tion of today's more complex social and agricultural problems, educational needs have been continually under review and revisions frequent, possibly the most drastic one becoming effective in September, 1956.

The successive steps, as affecting entomology-plant pathology were about as follows: in 1947-48 and in all (six) cases, a decrease (of either one or two) in the number of laboratory hours required with no reduction, however, in course credit; in 1950-51, the deletion of three three-hour courses and substitution for the same of two four-hour courses on an alternating basis; in 1951-52 (and thereafter), only the first year contained the same courses for all students, a new course (Introduction to Agriculture, Ag 103-104, participated in by all departments) replaced the major introductory courses which had been required of all students since 1945-46, and the time for choice of a specific curriculum was advanced to spring preregistration for the Sophomore year; in 1953-54, the deletion of two three-hour courses, substitution for the same of one four-hour course and the addition of one three-hour course (in entomology), while four "area" courses (Plant Science, Ag 105; Insect & Disease Pests, Ag 107; Animal & Poultry Science, Ag 106; and Rural Social Science, Ag 108) replaced Introduction to Agriculture (Ag 103-104); and finally, in 1956-57, the adoption of a general curriculum composed of course groups, offering some latitude in meeting Freshman requirements, providing an even greater freedom of selection at the Sophomore level and permitting considerable specialization in the Junior and Senior years.

Despite the changeful situation outlined above, enrollments in entomology for the 12-year period, 1945-46 to 1956-57, totaled 844 (804 in undergraduate and 40 in graduate courses).^{*} Of the 279 graduates with a B. S. degree in agriculture from July 1, 1945, to June 2, 1957, inclusive,⁵³ 48 (17.2%) majored in entomology-plant pathology (2.9% over an equal distribution for the seven majors). Of 20 "degrees with distinction," exactly one-half were awarded to students in this major. Of the 63 graduates with an M. S. degree in agriculture, during the same period, 16 (25.4%) came from this major. Of the 48 students who had specialized in these fields be-

* Enrollment in courses Ent 201, 203, 301, 303, 401, 403, 405, 407, 409, 474, 501, 503, 505, 507, 569, U401, 402, Ag 104 and 107.

⁵³ Buls. Univ. Del., Catalog Numbers 1945-1946 to 1955-1956, inclusive, and Commencement Program, June 2, 1957.

tween 1945-46 and 1956-57, 17 (35.4%) continued with graduate study; six are working still toward an M. S. degree; eight have already received that degree and an additional three, the Ph. D. degree. While a few of the remainder (of the 48) are engaged in work with federal and state agencies, the majority are well-paid representatives of industrial concerns, servicing Agriculture both in the United States and abroad.

The stated objectives of the entomology-plant pathology curriculum (the only one of its kind in this Country) at the time of establishment were as follows to train students so that they can (1) meet better the requirements of the chemical industry for research, service and sales personnel in the field of pesticides; (2) serve as technical production men in the canning industry; (3) operate agricultural enterprises of their own; and (4) qualify for advanced study in graduate schools. The record to date indicates that this broad aim is being realized.

The 1953-54 report of the Evaluating Committee for Agriculture (Commission on Institutions of Higher Education, Middle States Association of Colleges and Secondary Schools) states that "A particularly strong and unusual program is offered in the curriculum in Entomology-Plant Pathology. The teachers are well trained and possess a well organized approach to classroom and laboratory procedures. There is a natural and substantial demand for graduates so trained. This curriculum carries the highest number of seniors, indicating its popularity and value."

Summarizing, briefly, the second section of this paper: in all phases of entomology's operations, the years 1930 to 1957 were a period of orderly progressive expansion attributable, largely, to a constant and sizeable income from extra-University sources. Generally speaking, research under station projects was "applied" in character, and was designed to supply Delaware farmers with effective controls for currently-troublesome pests; while that under industrial projects was "fundamental" in nature, and was undertaken to discover chemicals of high insecticidal value without regard for their local utilization. In both cases, the contributions of the investigators are well-documented by 234 publications.

Because of inadequate funds, extension work has had no basic plan. Aside from the several major control campaigns listed herein, it has simply been a "growth in service," with the requests for assistance always far exceeding the time allowance for such activities. However, Delaware's accomplishments in this field were recognized when the senior extension specialist was designated as representative of the Federal-State Extension Services on the Entomological Society of America's six-man Centennial Commemoration Committee, charged with responsibility of planning for the nation-wide celebration of "100 Years of Professional Entomology" in 1954.

The joint entomology-plant pathology curriculum has met with general approval. From the viewpoint of the chemical industry, this is an especially attractive combination; and the two departments cannot fulfill the heavy demand for graduates with such a background.

During these 28 years, a substantial departmental library has been developed (including subscription to all important entomological periodicals); also, an insect collection of 90,000 pinned specimens (72,000 identified), 40,000 liquid specimens (26,000 identified) and 5,000 slide specimens (all identified) for reference purposes. In this connection, certain gifts should receive here due acknowledgement.

On June 8, 1931, the honorary degree of Doctor of Science was conferred by the University on Frank Morton Jones of Wilmington, Delaware, internationally-known naturalist and (now) president emeritus of the Natural History Society of Delaware. In 1950, Dr. Jones donated from his private collection 2000 specimens comprising 850 species of Macro and Microlepidoptera. Although in some cases there is no record of occurrence in Delaware, the entire lot is representative of the northeastern states. In 1951, he also donated from his private library 196 bound volumes of journals which the department lacked and an additional 46 bound volumes, including almost 1000 miscellaneous papers on insects. Late in 1954, a bequest was received from the late Dr. Harry F. Dietz (Mgr., Agri. Chem. Sec., Res. Div., Grasselli Chem. Dept., E. I. duPont de Nemours and Co.) of his personal bulletin and reprint files for student use.

PERIOD AHEAD

This historical review of entomology's trials, short-comings and achievements would be incomplete if it failed to relate developments in the recent past to needs in the immediate future. In order to maintain its present status in research, either the University must triple the allotment for investigational work or a comparable amount of outside funds must be solicited regularly by the department. The anticipated yield from industry is no longer an encouraging figure. In fact, the era of intensive development of chemical controls, which commenced in the early 1930's, apparently has passed its peak; and increasing emphasis will certainly be given to the study of biological and other means of regulating insect populations. If advantage is to be taken of the indicated trend toward the greater utilization of natural controls, outside agencies of various kinds must be explored as a source of supplemental revenue.

In extension, the gradually worsening situation can only be corrected by a much more liberal and realistic attitude in the matter of both staff and operating funds. Continued active participation in such activities by the department head is essential from the standpoint of public relations, for an adequate understanding of local difficulties in this field and for the successful direction of the entire entomological program. Two full-time specialists are required, one to deal primarily with insects attacking crops and the other to handle urban and suburban pest-control problems.

The present classroom and laboratory facilities and the allotment for teaching are sufficient for ordinary needs. Actually, the number of undergraduates in entomology could be doubled, without any increase except in the operational allowance. At the graduate level, however, additional funds should be supplied to support at least one graduate assistant in each area of active research.