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THE PRESENT METHODS OF TEACHING ENTOMOLOGY

By J. H. COMSTOCK, *Ithaca, N. Y.*

The present methods of teaching entomology followed in the United States have been developed almost entirely by men now teaching this subject. A second generation of teachers has begun its work; but the first is still on the stage. We have progressed far enough, however, to make it worth while for the teachers to compare methods, in order that each may profit by the experience of the others.

In a conference of this kind the contribution of each to the discussion will be, naturally, at first, merely a statement of the methods evolved in our several widely separated institutions. Then can follow comparisons and discussions of the various methods, which may result in the modification of each. I regret exceedingly that I cannot be present to hear the papers of my colleagues, and to take part in the discussion. But unfortunately for me, I can only send my report of progress.

The first professor of entomology in an American university was Dr. H. A. Hagen, who held this position in the Museum of Comparative Zoölogy of Harvard University. But, although the influence of Doctor Hagen upon the few pupils who had the good fortune to study with him was very great, his teaching of entomology was subordinate to his researches in systematic entomology and his work as curator of the great collections of insects of that museum.

Although Doctor Hagen came to the Museum of Comparative Zoölogy in 1870, his first course of lectures was given in the summer of 1873, and his class consisted of a single student, the writer of this paper. That was a course of lectures never to be forgotten by the one who heard it. It was a very hot summer, and Doctor Hagen suffered with the heat. About nine o'clock each morning he would come into the laboratory, say a cheery good morning, take off his coat and hang it back of the door, take off his vest and put it with his coat, take a seat by a small table, light a German pipe with a very long flexible stem, place the bowl of the pipe on the floor behind him, take a few puffs, and then say, "Come and I will you tell some dings what I know." The student would then take a seat on the opposite side of the table, and the professor, with sheets of paper before him, which served the purpose of a blackboard, would take up the subject where it had been dropped the previous morning.

I take the space to narrate this personal experience because this course of lectures had a profound influence in shaping the development of my teaching of entomology. It was just at the beginning of my experience as a teacher of this subject. Although still an undergraduate, I had given one course of lectures in the institution with which I am connected, and the broadening influence of this master came at a very opportune time. Thus early I gained a hint of the scope of entomology, and was led to realize that the practical applications of this science should be based upon a broad and accurate foundation of scientific knowledge.

One, however, must not forget that nearly all of the chairs of Entomology in this country owe their existence to the economic bearing of this subject; it is almost only in agricultural colleges that we find professorships of entomology; and they have been established in these colleges because of the great importance to agriculture of insect pests.

While, therefore, the teacher of entomology should teach the science of entomology, he should not fail to make practical applications of this science so far as possible.

Let us turn now to the more specific problems that the teacher of entomology must meet. In discussing these I will state the conditions that exist in the institution with which I am connected, and will

briefly outline the methods with which the entomological staff of this institution is trying to meet these conditions. In other institutions other conditions doubtless exist, which can be better met by other methods.

The students of entomology in Cornell University can be grouped into four classes; and the special needs of each of these classes must be considered separately in order to reach the best results in our teaching. We have what are termed "Special Students," students who take a short course of study in general agriculture extending over only one or two years; regular students in a four-year course who take entomology only as part of a course in arts and sciences or in general agriculture; regular students in a four-year course who are fitting themselves for entomological work; and graduate students.

First, special students. The special or short-course students can devote so little time to any of the several subjects that they study during the one or two years of their stay in college, that we are able to give them only two periods of entomology per week for a half year. In this brief course given to a class consisting largely of students who have no background of biological knowledge, we can only hope to give some information that will be of immediate practical use to them in their growing of crops or their care of stock, when they return to their farms a few months later.

The course consists of very elementary discussions of the structure and metamorphoses of insects, of accounts of the more important insect pests, with suggestions as to the best methods of combating them, of accounts of beneficial insects, and of field excursions to observe, so far as practicable, the insects discussed. The course is illustrated by many sets of specimens, put up in the Riker mounts, by diagrams, and by a liberal use of the stereopticon and the projection microscope.

Owing to the fact that this course is given during the months of October, November, December, and January, the field-work part of it is of necessity limited. We expect that in the near future there will be a summer session of our College of Agriculture, when an elementary course can be given in which a more desirable balance between lectures and field-work can be obtained.

This course for the special students differs so fundamentally from what we consider desirable as constituting the entomological part of a course leading to an academic degree, that regular four-year students are not permitted to elect it. We look upon it as merely extension work given at the college.

Second, regular students not specializing in entomology. The class of students whose needs are to be considered next are those regular

students in the four-year course of the College of Agriculture who elect entomology as a part of a course in general agriculture and those students in the College of Arts and Sciences who wish to take some entomology but do not care to specialize in this subject.

For these students we give a course consisting of two lectures per week throughout the year and one laboratory period of two and one-half hours each week during the first half-year.

In this course the object is to give information by lectures and training in observation by laboratory work. The students in this class have some foundation of biological knowledge, as a year's work in general biology or a year's work in zoölogy is a prerequisite for admission to the course.

During the first half-year the lectures are on the characteristics of the orders, suborders, and the more important families of insects, and on the habits of representative species; the laboratory work includes a study of the structure of insects and practice in their classification. During the second half-year the subject is treated from the economic standpoint. In the lectures the more important insect pests and methods of controlling them are discussed; and at opportune times the class is taken into the field to observe insect pests at work. It is planned to expand this course by the addition of one period of two and one-half hours per week of laboratory work in economic entomology, which shall be taken in connection with the lectures of the second half-year.

It is obvious that in a course consisting so largely of lectures, the imparting of information plays a more prominent part than does the giving of scientific training. But the latter element is not lacking. The lectures are so planned that the student in preparing for the required examinations, which come at frequent intervals, must obtain some conception of the foundation principles of the science. And in the laboratory work, where the more general features of the structure of insects, both external and internal, are studied, and where a large number of specimens are classified, the student is given some training in accurate observation.

Third, regular students specializing in entomology. It is for this class of students that the greater part of the work offered by the department of entomology has been planned. All of our courses, with the single exception of the course designed for the special students, is open to them; the only restrictions being that certain elementary courses must be taken before advanced courses in the same field can be elected, and a year's work either in general biology or in zoölogy is a prerequisite for regular work in entomology.

In all of the courses taken by this class of students, the imparting of

information is subordinated to the giving of a training that shall enable the student to ascertain facts for himself. Much more attention is given to laboratory and field work than to lectures. Thus at the outset, these students when taking the introductory course on general entomology, described above, take only the lectures, and instead of the "one-hour" ($2\frac{1}{2}$ hours actual time) laboratory work, take first a "three-hour" laboratory course ($7\frac{1}{2}$ hours per week) in elementary morphology of insects and then a "three-hour" laboratory course in elementary systematic entomology; the two constituting a "three-hour" laboratory course throughout a year.

In this elementary laboratory course the student is held to the performance of his work in the most accurate manner possible for him, and we usually convince him that he can do it more accurately than he thinks he can at first. We care comparatively little for the facts that he learns. It is not much to have learned the more general features of the external anatomy of a grasshopper; but it is a great deal to have worked out these features in a painstaking way. It is here in the performance of this elementary work that is largely determined the kind of a worker that a student is to be. It rarely happens that a man who persists in doing slovenly work here becomes a careful worker later. It sometimes takes considerable time for a student to learn to work in a careful manner, but if he has the right kind of stuff in him he will learn before the end of this year's work. If he does not do so, he is advised to devote himself to some other field of activity. Here, as elsewhere in nature, a thinning-out process is necessary to produce the best results.

I have given considerable space to the discussion of this course, for we regard it the most important course in our curriculum; it is the foundation on which all the other courses rest. Later the student who has been started in the right way needs only to be given the facilities of the laboratory and library and occasional suggestions as to methods of work and interpretation of results.

I will not take the space to describe in detail the more advanced courses. Those who are interested will find them listed in our Announcement of Courses, a copy of which I will append to this paper. A few words, however, regarding the organization of our department of entomology may be of interest.

The work in systematic entomology is under the direction of Dr. A. D. MacGillivray. It includes the elementary work in this field, already referred to, and several special advanced courses. One of these, a three-hour course (*i. e.*, $7\frac{1}{2}$ hours per week for a half-year) is devoted to the classification of the Carabidæ. This family was selected because it contains many genera, and these are separated.

by minute but definite characters, the determination of which gives an excellent training in accurate work. It was also selected because it is easy to purchase of dealers sufficient material so that each student can have for his own collection a set of the genera studied. Then there is a five-hour course (*i. e.*, 12½ hours per week for a half-year) on the classification of the Coccidæ; this is a combined lecture and laboratory course, which enables the student to obtain a knowledge of the classification of this important family, and to acquire the ability to accurately determine species belonging to it. There is also a laboratory course on the classification of immature insects, and a lecture course on the literature of systematic entomology.

An advanced lecture course on the morphology and development of insects is given by the writer assisted by Dr. W. A. Riley. This course is supplemented by a course on the histology of insects. This is under the direction of Doctor Riley, and is largely a laboratory course. The students in this course work individually, some devoting much more than the minimum time required, which is three laboratory periods per week throughout the year. It is here that the students get their training in histological methods, and thus lay a foundation for research work in either the morphology or the development of insects.

Courses on the embryology of insects, on the relation of insects to the diseases of higher animals, and on parasites and parasitism, are also given by Doctor Riley. The last two courses are taken by many students in the Veterinary College and by premedical students in the College of Arts and Sciences.

The work in economic entomology is under the direction of Professor Glenn W. Herrick, and consists of both elementary and advanced work in this field. The work in the morphology of insects and in systematic entomology, taken in other divisions of the department of entomology, is here supplemented by a course in advanced economic entomology and insectary methods, in which the student is trained in the technic of breeding insects, mounting of specimens, insect photography, the preparation and application of insecticides, and other details of insectary work.

In the courses on limnology, which are given by Dr. J. G. Needham, and which treat of the life of inland waters, much attention is given to the study of aquatic insects, and especially to their ecological relations to each other and to other aquatic organisms. A considerable part of this work is carried on at a biological field station, located in the midst of the marshes at the head of Cayuga Lake, and easy of access from the University; so that the work can be continued during the college year as well as in the summer.

Fourth, graduate students. The work of each graduate student is

planned for him individually; and the nature of it is determined by his needs and attainments. Usually this work is largely research; and it is expected to be independent and original. All of the facilities of the department and of the university library are placed at his disposal. He is given advice as it is needed; and is required to make frequent reports on the progress of his investigation. When these reports are made, the results obtained are carefully scrutinized, and frequently suggestions are made as to methods of attacking the problem other than those already employed. But the constant effort of the instructor is to teach the student self-reliance. The completed thesis must be satisfactory in style and composition; and if illustrated, as is usually the case, the illustrations must be suitable for publication.

At the final examination the student is examined not merely on the subject of his thesis, but also on the fields in which his major and minor subjects have been taken. A major and one minor are required for the Master's degree, and a major and two minors for the Doctor's degree. These subjects must be in different fields, under the direction of different teachers. The obvious object of this requirement is to prevent too narrow specialization.

There is space merely to refer to a course in German entomological reading, a course on the morphology and classification of the Arachnida, and to the entomological seminar which meets weekly for the discussion of current entomological literature, and at which advanced students present the results of their investigations. Much is made of this feature of the seminar, as, by means of it, the entire department can keep in touch with the more important work done by the different members of it; and the students presenting papers get experience in public speaking. At this seminar the members of the staff of the department also present the results of their investigations.

In conclusion, I wish to say a word about undue specialization in entomology. Frequently young men come to us who wish to study only entomology, and sometimes those even who wish to devote themselves to the study of a single order of insects; such specialization is never permitted. Usually such students need one or two years' study of languages and of other sciences than entomology to fit them to take up special entomological work profitably. And even when they are fitted to take up this work, it is not best for them to devote themselves exclusively to a single division of the subject. For example, the man who is fitting himself to be an experiment station entomologist should study insect morphology and systematic entomology as well as economic entomology. As "the worst weed in corn may be corn" so a too exclusive study of entomology is the poorest kind of preparation for an entomologist.

APPENDIX

The course for special or short-course students is No. 16 in the following list of courses.

The courses for regular students not specializing in entomology are Nos. 3 and 8.

The *introductory* courses for regular students specializing in entomology are the lectures of Course 3, and Courses 4, 5 and 8. Any or all other of the courses (except Course 16) may be elected by these students.

Biology

1. **General Biology.** Throughout the year. Three hours. Lectures (2) T Th, 10. *Auditorium.* Practice (1) M T W Th or F, 2-4:30 or S, 8-10:30. *Main 302.* Assistant Professor Needham, Professor Comstock, and Messrs. Matheson and Lloyd.

Prerequisites. None.

This is an elementary course designed to acquaint the general student with the main ideas of biology through selected practical studies of the phenomena on which biological principles are based. Both lectures and laboratory work will deal with such topics as: the interdependence of organisms, the simpler organisms, organization and phylogeny, oögenesis and ontogeny, heredity and variation, natural selection and adaptation, segregation and mutation, the life cycle, metamorphosis and regeneration, and the responsive life of organisms. The object of so general a course is to give a bird's eye view of the biological field and an elementary acquaintance with the principles of development.

This course and Entomology 22 and 23 may be taken to meet the requirement of biology for entrance to the Medical College.

Entomology and General Invertebrate Zoology

(1. **Invertebrate Zoology.** Not given by this department in 1910-11. See Course 1 in Department of Vertebrate Zoology in the College of Arts and Sciences.)

2. **Morphology of Invertebrates.** Either term. Two or more hours. Lectures, none. Practice by appointment. *Main 301.* Assistant Professor MacGillivray.

Prerequisites. None.

The comparative study of the anatomy of representatives of the principal groups of invertebrates.

3. **General Entomology.** First term. Two or three hours. Lectures (2) M W, 9. *Main 392.* Professor Comstock. Practice (1) for those who have not had Courses 4 and 5, Th or F, 2-4:30. *Main 301.* Assistant Professor MacGillivray.

Prerequisites. Biology 1 or Zoology 1.

Lectures on the characteristics of the orders, suborders, and the more important families, and on the habits of representative species. The practical exercises include a study of the structure of insects and practice in their classification.

4. **Elementary Morphology of Insects.** Either term. Two or three hours. Lectures, none. Laboratory open daily ex. S, 8-5. *Main 391.* Assistant Professor W. A. Riley and Mr. ———.

Prerequisites. None.

An introductory laboratory course, required of all students planning to do advanced work in the Department of Entomology.

5. **Elementary Systematic Entomology.** Either term. Three hours. Lectures, none. Laboratory open daily ex. S, 8-5. *Main 301.* Assistant Professor MacGillivray and Mr. ———.

Prerequisite. Entomology 4.

A study of the wing venation of insects and the identification of specimens belonging to the more important orders and families. An introductory laboratory course required of all students planning to do advanced work in the Department of Entomology.

6. **Advanced Systematic Entomology.** Either term. Three hours. Lectures, none. Practice by appointment. *Main 301.* Assistant Professor MacGillivray.

Prerequisite. Entomology 5.

A training course in the identification and interpretation of obscure characteristics used in the classification of insects.

7. **Histology of Insects.** Throughout the year. Three or more hours. Lectures (1) first term, Th, 11. *Main 392.* Practice, either term, by appointment. Assistant Professor W. A. Riley.

Prerequisites. Entomology 4 and 5.

Designed for students of general zoölogy, as well as for those preparing for research in insect morphology.

8. **Economic Entomology.** Second term. Two hours. Lectures (2) M W, 9. *Main 392.* Assistant Professor Herrick.

Prerequisite. Entomology 3.

Discussion of the more important insect pests and of methods of controlling them. At opportune times the class will be taken into the field to observe insect pests at work.

9. **Advanced Economic Entomology and Insectary Methods.** Second term. Two hours. Lectures, none. Seminar, field and laboratory work by appointment. *Insectary.* Assistant Professor Herrick.

Prerequisites. Open only to graduates and to undergraduates who have had Entomology 3, 4, 5, and 8.

Economic problems connected with applied entomology, discussed, reported upon, and field observations made. Experimental methods in breeding, photographing, investigating, and controlling insects discussed and studied. Designed for advanced students in entomology who desire to fit themselves for Experiment Station work.

10. **Classification of the Coccidae.** Second term. Five hours. Lectures (1) by appointment. Practice by appointment. *Main 301.* Assistant Professor MacGillivray.

Prerequisite. Entomology 6.

A course designed to familiarize the student with the more injurious species of scale insects, the methods of preparing specimens for study, and the systematic arrangement of the species.

11. **Morphology and Classification of the Arachnida.** Either term. Three or more hours. Lectures, none. Practice by appointment. Professor Comstock and Miss Stryke.

Prerequisites. Open only to graduates.

12. **Morphology and Development of Insects.** Second term. Two hours. Lectures (2) T, Th, 9. *Main 392.* Professor Comstock and Assistant Professor W. A. Riley.

Prerequisites. Entomology 1, 3, 4, and 5. Students are advised to take Entomology 7, also, before taking this course.

14. **German Entomological Reading.** Either term. One hour. W, 7-9 p. m. *Main 391.* Assistant Professor W. A. Riley.

Prerequisites. Open only to advanced students in entomology or zoölogy.

16. **Elementary Economic Entomology.** First term. Two hours. Lectures (2) T, Th, 9. *Main 392.* Assistant Professor Herrick.

Prerequisites. None. A course designed for special students. Not open to students who are prepared to take Entomology 8.

Discussion of insect pests in general, with remedial suggestions. Occasionally, the class will be taken to the field to observe insect pests at work.

[17. **Literature of Systematic Entomology.** First term. Two hours. Lectures (2) W, F, 8. *Main 392.* Not given in 1910-11. Assistant Professor MacGillivray.]

Prerequisite. Entomology 5.

A systematic study of bibliographies, indexes, and general entomological literature; the preparation of catalogues of insects; the evolution of the rules of zoological nomenclature; and the methods of determining the priority of generic and specific names.

[18. **Embryology of Insects.** Second term. One hour. Lectures (1) Th, 9. *Main 392.* Not given in 1910-11. Assistant Professor W. A. Riley.]

Prerequisites. Entomology 3, 4, and 5. Alternates with Course 12.

19. **General Limnology.** Second term. Three hours. Lectures (1) at an hour to be arranged. Practice (2), laboratory or field work T, 2-4:30, and a second period by appointment. *Main 302 and Biological Field Station.* Assistant Professor Needham and Mr. Lloyd.

Prerequisites. Open only to students who have taken or are taking General Biology 1 and Entomology 3.

An introduction to the study of the life of inland waters. Aquatic organisms in their qualitative, quantitative, seasonal, and ecological relations.

20. **Research in Limnology.** Throughout the year. Three or more hours. Practice by appointment. *Main 302 and Biological Field Station.* Assistant Professor Needham.

Prerequisite. Entomology 19 or its equivalent.

A course consisting of laboratory and field work.

22. **Animal Parasites and Parasitism.** First term. Two hours. Lectures (1) T, 8. Practice (1) M or T, 2-4:30. *Main 392.* Assistant Professor W. A. Riley.

Prerequisite. Must be preceded or accompanied by Biology 1 or Zoology 1. Entomology 3 is also advised.

A consideration of the origin and biological significance of parasitism, and of the structure, life-history, and economic relations of representative animal parasites.

23. **The Relations of Insects to Disease.** Second term. Two hours. Lectures (1) T, 8. Practice (1) T, 2-4:30. *Main 392.* Assistant Professor W. A. Riley.

Prerequisites. Must be preceded or accompanied by Biology 1 or Zoology 1. Entomology 3 is also advised.

Considers primarily the agency of insects and other arthropods in the causation or the transmission of diseases of man and animals.

24. **The Classification of Immature Insects.** Second term. Two hours. Lectures none. Practice (2) by appointment. *Main 301.* Assistant Professor MacGillivray.

Prerequisite. Entomology 5.

A course in the taxonomy of nymphs, larvæ, and pupæ.

27. **Research in Morphology of Insects.** Throughout the year. Three or more hours. Lectures, none. Laboratory open daily ex. S, 8-5, S, 8-1. *Main 391.* Professor Comstock and Assistant Professor W. A. Riley.

Prerequisites. Entomology 3, 4, and 5.

Special work arranged with reference to the needs and attainments of each student.

28. **Research in Systematic Entomology.** Throughout the year. Three or more

hours. Lectures, none. Laboratory open daily ex. S, 8-5, S, 8-1. *Main 301*. Professor Comstock and Assistant Professor MacGillivray.

Prerequisites. Entomology 3, 4, 5, and 6.

Special work arranged with reference to the needs and attainments of each student.

29. Research in Economic Entomology. Throughout the year. Three or more hours. Lectures, none. Laboratory and field work by appointment. *Insectary*. Professor Comstock and Assistant Professor Herrick.

Prerequisites. Entomology 3, 4, 5, and 8.

In most cases it is impracticable to complete an investigation in this subject during the college year. Students must arrange to conduct their observations during the growing season.

Seminar. Throughout the year. Monday, 4:30 to 5:30. *Main 392*.

The work of an entomological seminar is conducted by the Jugatae, an entomological club which meets for the discussion of current literature and of the results of investigations. Attendance at the meetings may be counted as laboratory work.
