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PRESIDENT SANDERSON: The next paper which was prepared by Dr. H. T. Fernald will be read by Dr. Back.

PRESENT METHODS OF TEACHING ENTOMOLOGY

By H. T. FERNALD, *Amherst, Mass.*

In teaching entomology, much depends upon the ultimate aim of the student. A course in introductory entomology, whether as a required or an elective subject is sure to include many students who will not continue the subject farther. It is at least probable, that these students will form over half of the class, and accordingly, the introductory treatment should be arranged on the basis of the greatest good to the greatest number. This will usually mean some slight knowledge of insect anatomy, particularly external anatomy, and a general survey of insects as a group, with special attention to the pests of greatest economic importance in the region where the majority of the students taking the course are likely to settle, together with a rather careful consideration of methods for the control of these pests, and with field work, so far as possible, which shall enable the students to recognize them and their work.

The advanced work, following the introductory course, would naturally be for those students who wish to make entomology their profession, or who wish to use it as collateral knowledge in other lines of work, such as fruit growing, forestry, market gardening, etc. Under such conditions, a course best adapted for one, might be far from the best for the others, and it would seem that an important point to keep in mind is that the course should have elasticity. Certain portions of

the work should be common to all, while other parts should be radically different, in order to best meet the needs of the different students. This means individual training, and I cannot too strongly urge that the best results come from a careful study of the plans of each student, and the shaping of quite a part of his work with direct reference to those plans.

For those not intending to make entomology a profession, but who wish to be able to recognize, or if this is impossible, to determine insects which they may find attacking the crops they raise, the course should aim to teach the student how to obtain the answers to the questions which will so often arise in his work—"What is this pest, and how can I control it?" External anatomy, therefore, so far as this is necessary for the identification of insects is essential, and the writer has found that the most satisfactory way of teaching this is by the careful study of the external structure of a rather typical insect of each of the more important economic groups, followed by the identification, at least as far as families, of quite a large number of insects. The course in external anatomy should assure the familiarity of the student with those parts used in analytical keys, while the determinative work to follow, will call his attention to variations in these parts, besides giving him practice in the use of the keys themselves.

It seems to the writer that too little attention has been paid to the question of insecticides, in connection with this work. He gives, and is heartily in favor of quite an extensive course of lectures, together with as much laboratory work as is possible, on the different insecticides, their chemical composition, preparation, methods of detecting adulterations, etc., and this course could be extended with profit.

Beyond this point, however, he believes that the work of the students should be, to a large extent, individual, and that the man going into fruit raising for example, should make a careful study of the insects most seriously injuring the fruits he expects to raise, both in the field, in the laboratory, in the collections available, and in the books. Of course, within the ordinary time limits of such a course, it is impossible to cover all the insects of any crop in this way, but the more important ones can be considered, and the man will thus be enabled to recognize the most important pests or their work, when he may find them, and take active measures at once for their suppression.

In this way, the student who receives the training outlined above, will recognize many of his insect enemies without study, but if this is not the case, he knows what steps to take, in order to ascertain the foe which is attacking his crops, and having determined this, is in a position, as the result of his studies on insecticides and other measures of control, to utilize the best methods for its destruction.

For the student who expects to make entomology his life work, the problem is somewhat different. Such a man must know all the important insect pests, and be able to identify those which he may not recognize. He must thoroughly understand the various methods of controlling these insects, and must be able to successfully raise insects through their early stages to the adult condition, in case a pest can not be recognized until it is adult. In other words, he should understand how to do systematic work, life history work, and how to conduct methods of treatment, and this should not be knowledge gained from books or in the lecture room alone, but by practical experience. And it is here that the difficulty of adapting collegiate sessions to entomological work appears. Structural and systematic work can easily be conducted during the winter, and methods of treatment, to a slight extent, can also be undertaken at this time, but the larger part of all field work, which is so important, must either be begun so near the end of the spring term that the student leaves before it has been completed, or must be undertaken entirely during the summer vacation, when he is not ordinarily available. Under such conditions, the only substitute is to give as thorough a training as possible along the lines of external anatomy already indicated, and in the systematic determination of insects, and then as much as possible in the other lines, and it is an interesting comment that correspondence with a large number of men trained in this way, who have been out of college for some time, shows that they feel that they are weakest, not in methods of control, nor in life histories, but in their ability to identify the insects with which they have to deal, and they frequently state in the correspondence, that in their work, which is largely economic in its character, they feel the need of more extensive systematic training.

How much of this it is possible to give within the limits of an undergraduate course, will naturally, of course, depend upon the amount of time allotted to the subject, and this is something that is rarely in the hands of the teacher in charge. A college course, as laid out by a college faculty, is usually more or less of a compromise, and while the elective system in the last years, permits of some specializing, it is at best, specializing within a certain group of subjects, rather than in any one. Perhaps this is a good thing in some ways, for the broader the foundation in college, provided the man is able afterwards to specialize, the better will be the results, and Agassiz's remark to his students at Penikese, "Learn something of everything, and everything of something," is still in the opinion of the writer, a fundamental principle.

In too many cases, however, the college course, which, from this standpoint, should be the place to learn the "Something of everything," is the last opportunity for training, and if we attempt to crowd

into this four years the "everything of something," as well, the results are liable to be unsatisfactory in both directions. For the intending graduate student, therefore, I would urge a broad undergraduate course, with plenty of chemistry, physics and botany, but with sufficient attention paid to the cultural subjects, and those connected with our duties as citizens, to give breadth in every way. Languages as tools, aside from their cultural value should not be omitted, and if such a course as this for the future graduate student in entomology must mean a reduction in the amount of undergraduate entomology which he could take, I would still advise such a course, believing that the concentrated study of the one subject to follow after graduation would be much more valuable when placed upon such a foundation.

Starting with this, the graduate student is in a position to go ahead rapidly. I hardly think it comes within my province to discuss lines of work for graduate students, but if we remember that after completing his course, he will be expected to have personal experience in methods of control, methods of rearing insects and in identification, it would seem desirable that these three lines of work should be given great stress in his training, and at the Massachusetts Agricultural College, it is the present purpose to recognize this by requiring an original piece of research in each of these three lines, to constitute the thesis, rather than one piece of work, perhaps three times as large. The student may get out a splendid thesis, well worthy of an advanced degree, on the median segment for example, requiring nearly all his time for three years to prepare, but it is probable that one of the first questions he will meet on taking a position thereafter, will be as to the relative merits of two different brands of arsenate of lead for spraying. Under such conditions as these, the writer favors what he may term the tripartite thesis.

In conclusion, an opinion cannot be too strongly expressed as to the amount of supervision to be given graduate students. The idea of letting a graduate student "work out his own salvation," without any supervision is, in the opinion of the writer, a serious mistake. The average student on graduation has been so carefully led by the hand and guided for four years, that he really does not know how to take a step by himself. Of course, he will learn, but even the best man loses much time and often gets discouraged in this process. It would seem wiser to begin graduate work under much the same supervision as that given to undergraduates, but to gradually reduce this, so that after six months or so, a man is generally working for himself. Thus, the time and money of the student are saved, greater progress is made, and the great change from the nature of undergraduate work to that of graduate work is successfully bridged over. In this way, the stu-

dent loses no time, and can make his advanced work more satisfactory and more profitable than would otherwise be the case.
