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THE ROLE OF SYSTEMATICS IN BIOLOGICAL CONTROL: A BACKWARD LOOK

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In applied biological control traditional systematics provides a means of identification, names to designate the species, an organized system for re- cording information, and clues for searching. A perfected classification should do more than that. It should provide answers to many questions that perplex biologists now in connection with forms below the level of the old morphological concept called a species. However, there is a wide gap between perfected clas-sification and the greater number of those now in use.

In perfected classifications organisms are arranged in ascending order according to phylogenetic relationships. Classifications that express natural relationships are final works dependent on a knowledge of a species variations and affinities throughout its entire geographical range. Systematists may aspire to prepare classifications that conform to evolutionary history but the greater number of classifications are highly artificial and based on the gross morphological characters most easily seen in dead insects.

In fighting insects biologically, some entomologists work with living insects, and the purpose of their research is to learn what insects do. Living insects have both static and dynamic characters. The latter may be expressed in different host and habitat preferences, climatic adaptability, host reactions, ovi- positional instincts, etc. An understanding of the dynamic characters of a species is the principal purpose of biological studies.

The greater number of systematists work with dead insects as mu- seum specimens which have static characters only. As a matter of necessity the systematist's attention is focused on the structural characters of adult insects, and these features become the object of his study quite apart from the bionomics of the organism.

If all the modes of divergence which characterize living insects were reflected in the skeletal structures of the adults, a source of conflict between systematists and biologists might be reduced or perhaps eliminated. When insects exhibit morphological similarity and biological dissimilarity a source of possible conflict exists. The systematist classifies them as the same and the biologist as different.

Those working with living insects often proclaim that classifications based on structure alone are outmoded. They seem to overlook the need for a framework based on structural characters to provide fixed points of reference in classifying the morphologically indistinguishable forms - species, sibling species, subspecies, varieties, races, subpopulations or whatever they may be.

"The apparent anomalies which we encounter if host and biological differences be disregarded will usually disappear as our knowledge increases and at the worst are as nothing in comparison with the anomalies which appear if the morphological evidence be disregarded in the same manner." (Ferris 1918). The writer believed that dictum to be true until facts of nature - too apparent to disregard - contradicted it. Presumably, there is a middle ground and a need to compromise. On the one side, opportunities to do useful work in introducing valuable species have been lost by adhering to that dictum. On the other side, an enormous amount of unproductive work in introducing the same species over and over again has been done by disregarding that dictum.

If an attempt is made to control a destructive insect biologically two questions immediately arise, "What is it?" and "Where did it come from?" Unless these two questions are answered correctly the planning of a project may lead far astray - to a wild goose chase. The delay in controlling the coffee mealybug, Pseudococcus kenyae LePelley in Kenya, by parasites obtained in neighboring Uganda, is a case in which much unnecessary work in the Orient is attributable to the misidentification of the mealybug. On the other side the control of a mealybug in Israel presents a different picture.

The case of the control of Pseudococcus citriculus Green in Israel by Clausenia purpurea Ishii is, in all probability, an exception to the rule. P. citriculus was misidentified as P. comstocki Kuwana. Attention was directed to Japan as a promising place to obtain parasites of P. comstocki for trial in Israel. The most important enemy of that species of mealybug in Japan is C. purpurea. That species of parasite - C. purpurea - reared from P. comstocki imported into Israel from Japan controlled P. citriculus in Israel before the host species in the latter country was identified correctly. In the case cited, the pest was misidentified and the systematic information misleading, nevertheless, P. citriculus was controlled as expediently as if a correct identification had been made originally. C. purpurea obtained from Japan was most important in controlling P. comstocki in Eastern States in the U. S. A.

It is desirable to know the identity of all the parasites that attack an introduced species in the local fauna before importing more species from foreign countries. However, it may be more important to know what parasites exist in foreign countries, or in the country where the pest originated. In the old days, when the life blood of the greater number of biological control projects was the importation of new or untested species of beneficial insects, articles in which new species of beneficial insects are described were regarded highly and examined for clues. Today, in institutions of higher learning, the study of population dynamics seems to be regarded as more important.

An outstanding example of a successful biological project, initiated by a systematic paper, was the control of the citrus black fly, Aleurocanthus woglumi Ashby, in Cuba by the aphelinid Eretmocerus serius Silvestri. The existence of that parasite in Malaya was first made known in a systematic paper, by Silvestri, in which new species were described with host records. During the years 1924 and 1925, Dr. F. Silvestri was in Asia, employed by the University of California, primarily to search for parasites of the red scale, Aonidiella aurantii (Maskell), for use in California. Incidental to this project, Silvestri obtained parasites from other citrus-infesting insects. In 1926 and 1927, he published descriptions of the parasites collected in Asia. His description of Eretmocerus serius, as a parasite of Aleurocanthus woglumi, came to the attention of Professor J. T. Tristán, of San Jose, Costa Rica, who corresponded with Silvestri regarding the possibilities of obtaining that species for trial against A. woglumi in the West Indies and Central America. On the basis of information furnished by Silvestri, it was decided to attempt the introduction of Eretmocerus serius into tropical America. This project, initiated by the discovery and description of a new species, eventually led to the establishment of E. serius in Cuba.

The early history of red scale, A. aurantii (Mask.), in California provides an example of contradictions and confusion which arise when systematists deny the existence of distinct forms because they appear to be morphologically indistinguishable.

The history of red and yellow scales, A. aurantii and A. citrina (Coquillet), as recorded in the entomological literature, is confused to this day owing to a mistake on the part of systematists. Confusion dates back to Comstock's (1881) famous "Report on Scale Insects" for 1880. In that report Comstock stated two forms of red scale occurred in California but, since they appeared to be morphologically indistinguishable, they must be the same. At that early date citrus growers and horticultural officials without formal training insisted that two distinct forms of scale were involved which had different habits, looked different in life and required different treatment. One form was comparatively easy to kill, infested only leaves and fruit, and in life appeared pale yellow. The other form was more difficult to kill and in addition to infesting fruit and leaves, injuriously infested the wood, and in life the scales appeared reddish yellow.

The question of whether or not two forms of red scales were involved in California was debated between C. V. Riley and non-technically trained horticultural officials before a meeting of the California State Fruit Growers Convention. In substance Riley stated that the allegedly different forms of red scale had been the subject of prolonged study by the most expert systematic entomologists and that the two forms were not distinct but represented one species only.

Later when explorations were made for parasites to control red scale biologically the situation was further complicated by the existence in other countries of scales other than red and yellow but morphologically indistinguishable. Over a period of thirty years repeated attempts were made to establish in California on red scale the Asiatic parasite Comperiella bifasciata

Howard. In 1932 when it was discovered that the introduced form of Comperiella was a parasite of yellow scale and not of red scale, colonies of the parasites were released in the yellow-scale infested orchards of California. A satisfactory degree of control of the yellow scale was obtained over limited areas by that form of Comperiella. In the interval between 1900 and 1932, scales from Asia which produced Comperiella were repeatedly identified as A. aurantii. We now know that the Asiatic scales were misdetermined and more than one species and lesser forms of Comperiella were involved. The systematic paper by McKenzie (1937) on the species of Aonidiella provided an answer to some questions which were riddles previously.

The history of red scale is largely an account of a series of contradictions and blunders, all directly owing to the failure of systematists, biologists, and collectors to identify correctly the insects with which they were working.

The literature on Trichogramma provides an example of nomenclatorial confusion resulting from formally naming morphologically indistinguishable forms. The morphologically indistinguishable forms were discovered by experimental methods and in the absence of a pedigree the various forms cannot be identified except by the experimental methods that revealed them. The tenets of traditional insect systematics do not recognize such forms but the experimental entomologists have ignored the traditional conventions and have given them formal species names. The result has been the production of a mass of literature, under the name of one species or another, in such a way as to make it impossible in some cases to ever know what species the authors were writing about unless it can be grown again under prescribed cultural conditions.

By far the greater number of parasitic insects belong to the great superfamily Chalcidoidea. William H. Ashmead, who had a more comprehensive knowledge of the Hymenoptera than that ever attained by any other man, wrote:

"Among the ten great groups or superfamilies of the Hymenoptera... there is none so large numerically, more important economically, or so difficult to study and classify as the superfamily Chalcidoidea or the chalcid flies. The species exist everywhere, not by the hundreds but by the thousands and millions, and they are probably of far greater importance, from an economic standpoint, than are the Ichneumonoidea or ichneumon flies... If we look back for a century and a half we find comparatively few who have given much attention to those "atoms of creations" and of these a few names only stand out conspicuously as students of this great complex". (Ashmead, 1904:226-227).

What Ashmead wrote in 1904 regarding the Chalcidoidea applies equally well today except that his estimate of millions may be considered excessive and there is need for a modern figure of speech to replace Ashmead's metaphore, "atoms of creation".

Since Ashmead's time, an enormous number of new Cahlcidoids have been collected and many of them named. Of the named species relatively few have been adequately described; and of these fewer still classified with regard to natural relationships. The great majority of described chalcidoids cannot be identified with any degree of certainty on the basis of existing descriptions. In one family alone, the Encyrtidae, more than 600 genera have been established but not classified. Only a small number of genera have been classified phylogenetically.

In Ashmead's time chalcidoids were studied largely with the aid of a hand lens. Modern instruments and methods of preparing specimens for examination reveal a multitude of structural characters of fundamental importance that were unknown to the pioneer systematists. Some insects, such as the Coccoidea, are now classified to a large extent on morphological characters rendered visible by stains. In the scale insects the improved descriptions and classifications are due largely to the improved techniques employed by several men of outstanding ability who have devoted a lifetime to the study of these forms. When chalcidoids are classified by competent men on the basis of a study of specimens prepared so as to reveal all the structural characters of fundamental importance, it is probable that the classifications will be as much improved as are the classifications of the coccids of today as compared with those of fifty years ago.

A first step has not been taken in the preparation of a classification of the Chalcidoidea based on an accurate and comprehensive knowledge of the comparative morphology. In regard to the Encyrtidae, Ashmead (1900, p. 323) wrote: "Among the many thousands of minute hymenopterous insects existing in the world and to which have been given the popular name chalcid flies, there is probably, no single family of more interest or of greater economic importance than the family Encyrtidae." Since that was written the Encyrtidae has received probably more attention from entomologists than the species of any other family in the Chalcidoidea; but, even so, with few exceptions, there is not a key to any extensive group of genera based on natural relationships. Even the gross external anatomy of a single species is not known satisfactorily. For proof of the latter statement it is only necessary to examine a cleared or stained chalcidoid skillfully dissected and the parts arranged so as to reveal the important structural characters. Then, compare that with published figures and descriptions. Classifying the species of the family Encyrtidae may present a task as formidable as that of classifying all the species of Coccidae. Generally for every species of coccid it is possible to collect more than one species of coccid-inhabiting parasite. In the attempt to control black scale, Saissetia oleae (Bern.), biologically, approximately seventy species of Chalcidoidea were reared from this one scale. A total of twenty-two species of Coccophagus have been obtained from black scale alone.

The following is largely repetitive and slightly modified. In applied biological control old fashioned systematics is the basic discipline without which there could not be sound advance planning or an organized system for permanently recording biological information. Moreoever, the old systematics provides the framework for the more precise new systematics. Rothschild and Clay (1952, p. 106) wrote: "In fact sound systematics are the foundations upon which all biological theories, great or small, are built." To that I added, "... theories, plans and practices are no sounder than the systematics on which they are based" (Compere, 1961, p. 265).

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