

- XII. *On the economic importance of the parasites of Coccidæ.*  
 By ALICE L. EMBLETON, B.Sc., 1851 Exhibition  
 Science Research Scholar. Communicated by Dr.  
 DAVID SHARP, M.A., F.R.S., etc.

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OF the numerous families of insects which possess great economic importance, it is generally admitted that there are none more deserving of attention than the *Coccidæ*—insects popularly known as “mealy bugs,” “scales,” and “bark lice.” The enormous damage they do to plants of various kinds in all climates is effected by means of the long thread-like proboscis which is buried deeply in the host’s tissue, and through which the sap is sucked.\* They are excessively prolific, and their insignificant size, too, enables them only too easily to escape detection, the result being that many of them are becoming almost universally distributed. Add to this the fact that they are notoriously difficult to kill, and it is then easily comprehended that they are amongst the worst insect-pests the horticulturist has to reckon with. Not only are there immense numbers of individuals in a species, but also there are a great many species—the number already known has recently been computed at over a thousand.†

In spite of their undeniable importance as pests of a well-nigh ubiquitous character, they have received comparatively slight attention, with the result that the study of these creatures is but little advanced, being far in arrear of the state of knowledge in several other departments of Entomology. In this country in particular, the study of *Coccidæ* has been carried on by one or two naturalists; in America, especially during recent years, considerable interest has been taken in them and their economic aspects, for in that country it has been necessary to combat the

\* KOCHS [Jahrb. Hamb. Anst., xvii, 1900, Beiheft iii.] has recently studied the subject of the penetration of this proboscis into the plant tissues, and the effect its presence has on the host.

† “A check-list of the *Coccidæ*.” T. D. A. COCKERELL. Bull. Illinois Lab., iv, pp. 318–339.



very serious ravages of a variety of scales including the "pernicious," or San Jose scale (*Aspidiotus perniciosus*).

The history of the work done in this subject was summarized last year by Mr. R. Newstead,\* and, in speaking of the contributions which have come from this country, he says: "Up to the year 1887 the English works were fragmentary and most inaccurate, but at that time Mr. J. W. Douglas began a series of articles on British and Foreign *Coccidæ*, in the "Entomologist's Monthly Magazine," which he continued till the year 1894, when he then completed his twenty-seventh article. Needless to add, these were very thorough, and contain a vast amount of valuable information to the student of the British *Coccidæ*." In 1891 Mr. Newstead began to publish his own work on the subject, and he has continued to do so up to the present time, the first volume of his monograph on British *Coccidæ* having only just been issued.

Although many of the species of *Coccidæ* have now been described and figured, our knowledge at present of the life-histories, parasites and all their varied biological aspects and relations is very limited; unfortunately, too, the knowledge that does exist is scattered and disconnected, so that it is of little help to the horticulturist, to whom the chief consideration is how to control these pests. For success in this matter it is of the first importance that the life-histories of the creatures should be thoroughly well known, and that the modes by which they are kept in check in a state of nature should be ascertained.

The insect enemies of scales are usually called "parasites"; but the term is ambiguous, for there are two distinct kinds: (i.) The predaceous enemies which roam about freely and devour the scales, and which it would be well to speak of as "predators"; (ii.) the true parasites, the best known of which are small Hymenopterous flies, whose growth and development take place inside the *Coccidæ*. In this way the pests may be actually exterminated, while at the same time there is little or no external evidence of what is occurring. The term "parasite" should be restricted to these internal destroyers.

The predaceous enemies of *Coccidæ* have received more attention than their internal parasites, and they have been

\* "On the progress in the study of *Coccidæ*," Ent. Rec., xiii, 1901, pp. 57-59.



shown to be of enormous value, though their action is to some extent uncertain. But the internal parasites are less known, and, in fact, have been too much neglected, though a considerable amount of work has been done on them in recent years by Dr. L. O. Howard, Mr. Hubbard, and other able American Economic Entomologists. Mr. W. H. Ashmead has also published some valuable work on these parasites, including the "Classification of the old family *Chalcididæ*," \* and a paper "On the genera of the Chalcid flies belonging to the sub-family *Encyrtinæ*." † In the latter work he gives the host, or hosts, of each species, which much enhances the importance and value of the paper.

A very interesting characteristic of some of these parasites is that they will attack more than one species of scale, which makes them especially valuable from the economic point of view. Information as to this may be found in Mr. Ashmead's second paper referred to above, but experiments are urgently needed to ascertain what parasites are likely to be most valuable on this account. Among those that attack more than one host, Ashmead mentions *Encyrtus infidus* Rossi, *Aphycus lecanii* Howard, *Blastothrix sericea* Dalman, *Microterys chalcostomus* Dalman, *M. fuscipennis* Dalman, *M. flavus* Howard, *M. sylvius* Dalman, *Arrhenophagus chionaspidis*, and *Signiphora flavopalliata* Ashmead, giving the hosts of each.

A case of considerable interest has lately been recorded by the Economic Entomologists, Köningsberger and Zimmerman, in their work on the enemies of coffee-culture in Java; they found that *Lecanium viride*, a highly injurious scale, is kept in check by the Hymenopterous parasite, *Encyrtus bogoriensis*. It is worthy of remark that this important and interesting relation has only been discovered within the last few years, and we may confidently anticipate that other parallel cases will soon be added to those already brought to light.

The fact that comparatively little is known about these parasites is scarcely a matter for surprise, for it must be remembered that the existence of these enemies is only obvious to the trained observer. A colony of scales may be thoroughly parasitized so that every individual is doomed, and yet to the unskilled eye there exists no

\* P. Ent. Soc., Washington, iv, 3, pp. 242-249.

† P. U. S. Nat. Mus., xxii, pp. 323-412.



evidence that such is the case. This ignorance is often responsible for much harm that is done in the way of applying so-called remedies to exterminate the scale or mealy-bug; for, when the creature is already destroyed by the parasite, it is not only superfluous but highly injurious to apply insecticides or similar remedies, for these are then really destroying the beneficial insects which keep the scale in check.

Attention has lately been called to this important point\* in the report of a discussion on the subject in America. Mr. Johnson "said that he had bred *Aphelinus fuscipennis* in great abundance from the San José scale this autumn. He is inclined to think that this parasite has become so abundant that it will be necessary to alter remedial measures against the scale. Instead of cutting down and burning at once, he will recommend girdling the trees and killing them, and then leaving them until all parasites have had a chance to escape before they are burned. He stated that he even doubts the wisdom of winter spraying, although he is not certain as to the stage in which the parasite hibernates." This discussion finally took the form of considering in what state these parasites of scales hibernate.

My own observations induce me to emphasize the importance of the remarks quoted above. As regards hibernation I can say that the parasite of *Lecanium hemisphæricum* var. *filicum* passes the winter in quite a variety of stages. Specimens of the perfect insect were observed in the act of emerging early last autumn, and they have continued to do so during the winter, except that emergence was interrupted by the very cold weather. During the winter I have examined and mounted a large number of the *Lecanium* and its parasite, and I have found all stages of the latter from half-grown larvæ to pupæ as well as adults ready for emergence, and waiting apparently only for a favourable moment. All the specimens that emerged in the autumn and winter were females, but in the last few days (March) the other sex has begun to appear. This *Lecanium* I have studied chiefly on ferns, but it occurs on other plants. King† says of this species: "*Lecanium hemisphæricum* Targioni Tozzetti, 1869. This is one of the commonest of scale insects found in greenhouses and on potted plants in dwelling-

\* P. Ent. Soc., Washington, iv, part 4, July 1901, p. 413.

† "Greenhouse Coccidæ." Ent. News, Philad., xii, p. 311.



houses, especially on ferns; in the department greenhouses at Washington, D.C., it is found on the orange, *Drisipyrus*, *Chrysophyllus*, sago-palm, and *Croton variegatus*; on *Nephrolepis exultatus* and on *Cycas* in the College greenhouse at Colorado; on the house-fern and potted plants in New Mexico; on *Cycas revoluta* at Ames, Iowa; on two species of ferns at Warehouse Point, Conn.; on the sword-fern *Pteris*, sp., at Lawrence, Kansas; on ferns, palms, orange and oleander in Georgia; on *Arecha catecha* grown in pots in Jamaica; on *Cycas revoluta*, orange, oleander at Lawrence, Mass.; and on the fern *Nephrolepis tuberosa* at Cambridge, Mass. A common greenhouse pest in Europe, according to Signoret. It is found living out of doors in Europe and America." No mention, however, is made of any parasite.

This scale I find is parasitized to an enormous extent by a small Chalcid, viz. *Comys infelix*, n. sp.\* On many of the same plants I also found another scale, *Chionaspis aspidistræ*, in great profusion, and I ascertained that it was parasitized by a very much smaller Chalcid, which may be *Aspidiotiphagus citrinus*, Howard, or more probably a form allied thereto. This insect has not, so far, been recorded in Britain, though it is possible it is in Walker's list under some name that has been unknown to the American Entomologists, who have done almost all the recent work on this subject. This is one of the smallest of insects, being scarcely visible to the naked eye (.35 m.m.), but its power of destroying the scale is enormous. On examining some of the badly infested plants I have noticed that scarcely any of the *Coccidæ* have escaped destruction by the Chalcid. Though the scales look perfectly natural, a minute round hole in each individual may be detected on close inspection. And yet the work of this microscopic

\* This insect has been submitted to Dr. Howard, Mr. Cameron and Mr. Newstead, neither of whom is acquainted with it. It is closely allied to *Comys albitarsis* Zett., and *C. bicolor* Howard. The following diagnosis will be sufficient till I give a fuller description in the paper I am preparing on its life-history and structure.

*Comys infelix*, n. sp., Encyrtinarum. ♀ variegata, capite thoraceque fusco-aurantiacis, scutello nigro-hirto, abdomine nigro-subviolaceo; pedorum coxis omnibus femoribusque anterioribus et intermediis albidis, femoribus versus apicem tibiisque fusco-flavis, his apicem versus laete flavis; tibiis posterioribus nigris; tarsis posterioribus albidis, basi apiceque nigro-maculatis; antennis scapo flavo, flagello nigro, flavo-maculato; alis anterioribus late nigro-signatis. Long. corp. 2 m.m., expans. alarum  $3\frac{3}{4}$  m.m.



creature passes unobserved as the scales continue to adhere to the plant, and show to the unaided eye nothing to indicate that they are really exterminated. The question as to the distinguishing marks by which one may recognize scales that are parasitized is one of great interest, bearing as it does on the practical operations for controlling the diffusion of *Coccidæ*.

Returning to *Comys infelix*, the parasite of *Lecanium hemisphæricum*. During the latter stages of the development of the fly within the scale, it becomes evident from the outside which scales are parasitized and which have escaped attack. At first there is little or no difference in the scales; then it is noticed that those containing the larval fly look rather whitish and swollen. Later on as the pupa inside develops and becomes black, the scale can be seen to be swollen and black. In the fully-grown condition it is very evident when the fly is present, for the scale looks black instead of brown, due doubtless to the black pupa inside. The scale is more narrow and arched than in the normal condition. In the earlier stages it needs more experience before deciding which scales contain the parasites; those sheltering the large white larva look rather more pale and swollen than the others. In the very earliest stages it is almost impossible to detect the presence of the parasite by a superficial examination, but the larva, if present, is found on opening the scale. The mature forms of the scale usually exist on the same plant with the immature stages, and if these are seen to contain the parasite then it is fairly safe to deduce that the others are also attacked. Taking the average from a great many plants that I have examined, I find the proportion of scales destroyed by the parasite to be very high indeed, for usually almost every scale is killed. My experience is, of course, limited, and is relatively unimportant, for in order to make a reliable statement regarding the proportion of *Coccidæ* destroyed, many months would have to be devoted to collecting evidence and compiling statistics on this point, and my work has been mainly on other aspects of the subject. But as far as I can judge from the facts that have come under my immediate observation, I am led to rate very highly the value of these parasitic *Hymenoptera* as destroyers of Coccid pests. In the case of *Lecanium hemisphæricum*, King's statement that it is one of the commonest pests in greenhouses, applies to the neighbour-



hood of Cambridge as well as to the United States, and in the locality I refer to the pest is satisfactorily controlled by the parasite. If the parasite is not found in other localities where the scale is injurious it should be introduced there. Considerable difficulty has been experienced in the attempts to distribute the predaceous enemies, but in the case of the internal parasites, the task is much simpler, and success will be easier to attain, for it is only necessary to transmit a small plant bearing a few parasitized *Coccidæ*. From my work on this species of parasite I am led to believe that the *Encyrtinæ* are remarkably tenacious of life in their early stages.

Judging, therefore, from my own observations on the subject, supported as they are by Mr. Johnson's remarks quoted above, it is clear that, from the point of view of the cultivator, it is of the utmost importance that, previous to any attempt to destroy the *Coccidæ*, it should be ascertained whether internal parasites are present or not. If they are found in large porportion, then the application of a remedy should be abandoned. If they are present in a smaller proportion then time should be allowed before any insecticide be used, so that the parasites may emerge from all those individuals containing them, so as to allow the beneficial creature to be perpetuated and increased. After the emergence of the flies, then the *Coccidæ*, if any such there be, may be killed by using those insecticides which are especially adapted to the particular case.

An impression still seems to prevail in this country that the parasites of scales are of little importance from an economic point of view. Mr. F. V. Theobald,\* in a report just issued, recommends the importation of Coccinellid predators to destroy scale, and then remarks: "A few minute *Ichneumonidæ* also feed on certain species of scales, but unfortunately our worst pests seem immune against them." By the term "*Ichneumonidæ*," doubtless Mr. Theobald is here referring to the *Chalcididæ*. It would be interesting to learn what efforts have been made in this country to ascertain how far "our worst pests seem immune against" Hymenopterous parasites. If the natural parasites have been found and their presence established, then experiments and trials ought to be carried on and the results published, and then one can judge more accurately as to the general question of economic importance of the Coccid parasites.

\* Rep. South-Eastern Agric. Coll., Wye ; March 1902.



Abroad, however, and particularly in the United States, this problem of the natural enemies of insect-pests is receiving attention and careful study. In a paper\* just come to hand, Mr. H. Maxwell-Lefroy remarks that, beyond useful birds and other animals, "there are the hosts of predaceous and parasitic insects of whose work it is difficult to form any conception. Little can be done to encourage these beyond taking reasonable precautions that our preventive or remedial measures do not destroy them, and spreading such a knowledge of them as will prevent their destruction through ignorance as pests."

It is very satisfactory to find from such notes as this and that of Mr. Johnson, that Economic Entomologists are recognizing that their operations must not be confined to mere destruction; and that to be of permanent value they must be based on a reliable knowledge of the natural history of the pests.

In connection with this it may be remarked that a knowledge of the natural modes of dissemination of both the pests and their parasites is essential in the work which is carried on in various parts of the world to prevent the introduction of pests, and often spoken of as quarantine. These regulations exist in Austria-Hungary, Belgium, France, Germany, Canada, British Columbia, Cape of Good Hope and elsewhere, though not in Britain.

It is indeed difficult to understand how insects that are not only apterous but which have, in many cases, even lost their legs, become so widely distributed, or even how they succeed in spreading from tree to tree. All *Coccidæ*, however, have the power of walking when newly hatched. I have watched the active young of several species—*Lecanium*, various spp., and *Pulvinaria camellicola*—and I found that they wandered restlessly about on the plant, and in a very short time I noticed they were migrating from the plant, so that out of the myriads which appeared only a few remained on the host plant. These, however, are quite sufficient to carry on the destruction of that plant, though the majority wander off in search of new hosts. I carried on experiments in this matter on scales on camellia and rose-plants, grape vines, ferns, and other plants, and the result was always that the majority of the young wandered away in spite of all obstacles. It is known that considerable

\* "Suggestions for Insect Control in the West Indies." West Indian Bull., ii, No. 4, pp. 318-344.



variety of behaviour prevails among the young of different species; but as far as I can judge from the facts which came under my notice and from previous observations, it seems that all the forms are very tenacious of life when young; I found them wandering for days over the shelves of the hot-house in which I was rearing them.

*Lecanium hemisphæricum* is noted for its unusual powers of locomotion. Signoret\* speaking of this Coccid says: "Cette conformation des tarse indiquerait peut-être que les espèces de cette série sont moins fixes que leurs congénères." Comstock† confirms this by the statement that "actual observation shows the surmise of Signoret as to the locomotive powers of the insect to have been correct. We have seen the adult insects, when removed from their positions, crawl back with apparent ease." I have seen this happen repeatedly. Reh‡ made experiments and found that certain young Coccids could move a metre in about an hour. But he thinks, and I agree with him, that it is improbable that their own powers of locomotion are the most important means by which they become distributed. The most valuable information on this point is to be found in some briefly-described observations by Hubbard. I cannot do better than quote some passages from this talented and lamented American observer.§ "During the migratory age the restless habit of the young bark-lice impels them to crawl actively about, turning aside for no obstacles, but mounting every object met with in their path. The instinct of self-protection being entirely wanting in these degraded creatures, they make no distinction between dead and living objects, and crawl without hesitation upon the bodies of other and larger insects. The latter, impelled by the annoying presence of the intruders, fly away, bearing with them the scale larvæ, and thus assist in distributing them upon surrounding plants. . . . But spiders more than any other animals must be considered efficient instruments in this mischievous work. Not only do they transport the lice—and it is an observed fact that the movements of the latter upon their hairy backs do not incommode the spiders—but they also

\* "Essai sur les Cochenilles ou gallinsectes (Homoptères-Coccides)," Ann. Soc. Ent. France (5), iii, 1873, p. 437.

† "Report of the Commissioner of Agriculture for 1880," p. 334.

‡ Jahrb. Hamb. Wiss. Anhalten, xvii, 1899; 3 Beiheft, pp. 1-6.

§ Amer. Natural, xvi, 1882, p. 411.



harbour them under their webs in folded leaves, etc., where, safe from the attacks of parasites and enemies, they increase and multiply inordinately." He thinks the popular theory that wind carries scale insects from tree to tree is fallacious to a great extent, but that there is an indirect action of the wind, due to the influence it exerts upon the flight of insects and other winged animals which transport *Coccidæ*; this applies with particular force to spiders whose webs are carried in the direction of prevailing winds.

Hubbard's brief observation in his paper on "Insects affecting the Orange," suggested the experiments connected with insects and spiders conveying the pest, which I carried on last year with Mr. C. Warburton, as to the modes of dissemination of the black-currant gall-mite (*Eriophyes* [*Phytoptus*] *ribis*).<sup>\*</sup> Here it was found that spiders, Aphidæ, Coccinellid larvæ, and, indeed, any passing creature, carried the mites in considerable numbers from bush to bush.

Thus it appears probable that, in a state of nature, *Coccidæ* are largely disseminated by the agency of other insects. The males are active on the wing, and if a single female were transported by an insect to another tree, a new colony would in this way soon be established. This mode of dissemination, and the observations I have related as to the crawling of the young on inanimate objects, are clearly of considerable significance in connection with the quarantine operations that I have referred to as being carried out in different parts of the world. For the creatures may be imported on merchandise or by insects as well as on plants. Neither should it be forgotten, that if a pernicious scale be once introduced and then all other importations be prevented, then the parasites that may be contained in the scales are excluded. To avoid this, a knowledge of the marks by which parasitized scales can be distinguished from others, is really essential in the carrying out of the quarantine regulations.

Fortunately for the prospects of the cultivator, it sometimes happens that in places where noxious insects have been introduced, some native insect may be ready to take up the work of control that is performed by other destroyers in the original country. Marlatt † in his recent

<sup>\*</sup> Linn. Soc., London, xxviii, pp. 366-378, pls. 33, 34.

† Proceedings of the Thirteenth Annual Meeting of the Association of Economic Entomologists, 1902, p. 45.



report on the San José scale in Japan, after stating that this Coccid has been lately established in that country, says, "the scale is attacked also by one or two Chalcid parasites, presumably the ones we have in America, and brought to Japan with the scales or cosmopolites." It is very probable that the pernicious scale is really a native of Japan,\* and that this is the reason why it is not injurious there; scale insects are very rarely destructive in their natural homes because of the natural relations that exist between them and their destroyers. Sasaki † says the principal enemies of *Aspidiotus perniciosus* are a red mite, *Coccinella japonica*, and a Chalcid fly (? *Coccophagus*). He states that "in the specimens of the scale allied to the pernicious scales collected by myself, I have often found a roundish, or rather small irregular opening in most of the scales, which is evidently perforated by the parasitic Chalcid fly" (p. 172).

My object in writing this paper is not merely to add a few items to the facts of Economic Zoology, but rather to point out how very much remains to be discovered, even as to matters that have a very serious economic bearing. This is a somewhat invidious task, for it seems to involve a reflection on those who have worked at the subject. I should like to say that I hope no inference of that kind will be drawn from anything I have said. The work done by many Economic Entomologists is admirable, and the American school has accomplished wonders; and in nothing are they more worthy of admiration than in their readiness to modify their methods in accordance with the advance of knowledge.

It is encouraging to find how clearly it is being recognized that the chief consideration of the Economic Entomologist should not be the mere prescription of modes of destruction, but should be rather in the direction of learning the facts of the natural history of the pests. It may be predicted that the Economic Zoology of the future will be generally recognized as being "Applied Natural History." The prevention of the undue increase of enemies should therefore be the object of the economic investigator, so that wholesale destruction of life should be rarely, if ever, required.

\* See Marlatt and others in Bull. U.S. Dep. Agric. Ent., xxxi, 1902, pp. 41-48.

† Annot. Zool. Japan, iii, p. 171.









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