The Principles of Biological Control in Economic Entomology.¹

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II.

THE CONTROL OF INJURIOUS WEEDS.

WE turn now to the second problem, in which the introduced plant, not the insect, is the enemy of man. We have to decide the question whether it is advisable to undertake researches on the lines of introducing insects which will feed upon and tend to check the growth of those plants which, in new lands like Australia and New Zealand, have got beyond the control of man and threaten to swallow up large areas of valuable land.

I think the first point, undoubtedly, must be to insist that the method should only be used where a solution cannot be attained in any other direction. All are agreed that the unrestricted importation of plant-feeding insects into a new country is highly undesirable. The problem awaiting solution must be sufficiently grave in its nature to warrant the attempt being made with adequate safeguards, and under the guidance of the most competent experts obtainable.

We can turn again to the Hawaiian Islands for the pioneer experiments in this direction and learn very valuable lessons from them. The first attempt at biological control of a weed was that made in Hawaii on Lantana. This weed was attacked by the introduction of a considerable number of its natural insect enemies from Mexico. The result has been that it is prevented from seeding and has been successfully restrained from spreading all over the islands. Most fortunately for the experiment, none of the introduced insects has proved detrimental to crops or other cultivated plants, with the single exception of one species which occasionally does slight damage to the egg-plant or Aubergine. Considering the absence of the safeguards which I have elsewhere laid down as indispensable in these experiments, the result must be considered a lucky one rather than a strict precedent to follow.

Further experiments are now being carried out in Hawaii on the control of nut-grass by introduction of certain insect enemies from the Philippines, and also on the control of the Mexican weed 'Pamakani.' These are being carried out with good safeguards, and the results will be awaited with much interest.

I now come to the most remarkable attempt so far made in the direction of control of a noxious weed by insects, namely, the prickly pear campaign in Queensland and New South Wales. The prickly pear, *Opuntia inermis*, was introduced into eastern Australia long ago as a botanical curiosity, and was even propagated and distributed in pots to visiting squatter's wives. When these ladies tired of it as a pot plant it was thrown out. But instead of dying, as an ordinary plant would do, it proceeded to take root and multiply exceedingly. The luscious fruit were fed on by many species of birds, and the ripe seeds were carried far and wide

in their droppings. This went on until about thirty million acres of land had been put out of cultivation by the pest, and the rate of increase was about one million acres per annum.

Then at last the long-suffering Australian populace raised its voice and demanded that something should be done. A Prickly Pear Board was set up, and the first attempts to control the pest were carried out along chemical lines, resulting in the discovery of certain poisonous gases which could be liberated over the infected areas, destroying the weed. This method, however, failed, as the cost of manufacture and application of the remedy proved far too high. Failure also resulted from all attempts to utilise the pest commercially; the water content was found to be exceptionally high, the quality of the fibre very poor, and the fodder value very low. Thus the vision arose of eastern Australia becoming in about a hundred years time a vast desert of prickly pear, with a few walled cities alone holding out against it. Then the demand for a remedy became so insistent that the natural prejudice against the introduction of insect enemies was at last overcome, and an organised attempt was made to deal with the pest in this manner. Prof. T. Harvey Johnston took charge of the work, which was later on further advanced under the charge of his original assistant, Mr. W. B. Alexander. These men travelled far and wide in the warmer parts of America to find insect enemies of the pest, and large consignments were shipped to Australia. They were then placed in special insectaries and tested out on all varieties of prickly pear and also on a large number of important economic plants.

It is interesting to note, as showing the high degree of specialisation attained by cactus-feeding insects, that not one of the many species introduced could be induced to feed on any other kind of plant; indeed, a number of the species would only eat a single variety of *Opuntia* and would not even change to a closely allied and botanically scarcely distinguishable species. A few larvae, faced by the 'starvation test,' made slight attempts to eat unaccustomed plants, but the result in each case was severe indigestion followed by death.

The first *Opuntia*-feeding insect experimented with was the cochineal insect, *Dactylopius indicus*. It entirely destroyed some thousands of acres of one species of prickly pear, *Opuntia monacantha*, but was quite unable to feed upon the allied pest pear, *Opuntia inermis*. A search was therefore made for other species of *Dactylopius*, and finally *Dactylopius tomentosus* was found capable of attacking *O. inermis*. This little insect is now being distributed in enormous quantities through the infested districts, and is doing wonderful work in helping to destroy the pest. Though it does not do equally well in all districts and under all the varying conditions, yet it is now generally admitted that this species will prove one of the chief factors in the control of the pest.

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Of many other species studied, the most promising appear to be the large coreid bug *Chelinidea tabulata*, the moth *Cactoblastis cactorum*, and perhaps the large longicorn beetles of the genus *Moneilema*. Large supplies of these insects are being reared in the insectaries, and it will be interesting to watch the progress of events when they are liberated.

It is of special importance to note that, in spite of the immensity of the insect fauna of eastern Australia, only one enemy has so far made its appearance in the field, namely, our old friend *Cryptolaemus montrouzieri*, the well-known enemy of mealy-bug. This lady-bird beetle has begun to attack *Dactylopius tomentosus*, but, so far, it has been found that the latter can more than hold its own, as it starts earlier and increases more quickly than its rival.

To sum up, it appears to be the general opinion in Australia that this formidable problem is in process of solution by means of the biological control gained by insect enemies over the pest.

This brings me logically to the consideration of the problems of weed-control which brought me to Europe. The most pressing of these for New Zealand, and to a considerable extent for Australia also, is the control of blackberry, *Rubus fruticosus*. The extent of the infestation in New Zealand may be judged by the saying current on the west coast of the South Island that they have only one blackberry bush, and that is 200 miles long. Certain areas in the North Island are almost as badly infested also. Not only does this terrible weed, originally introduced for its luscious fruit, spread vegetatively underground, so that each little plant soon grows into a great thicket, but the introduced European birds, especially the blackbird, feed ravenously on the fruit and so carry the seeds far and wide in their droppings. Nobody who has not seen this pest under the conditions prevailing in New Zealand to-day can really understand the menace that it offers to our civilisation. It seems simple to advocate 'closer settlement' and 'more careful cultivation' as the best methods of control; but when the extent and inaccessibility of the vast mountain fastnesses captured by the blackberry, from which with ever-increasing vigour it is spread far and wide over the richer lands, are realised, it will be understood that the hard-working men who are being driven off their farms after years of toil against this weed demand something more than this kind of advice.

The general insistence on something being done has led the Cawthron Institute to consider the taking up of this admittedly difficult problem on the lines of biological control. The chief difficulty is the central position occupied by the genus *Rubus* in the great natural order Rosaceæ, to which most of our finest economic plants belong. Thus the risk of damage to other valuable plants is appreciably higher than in the case of prickly pear or Lantana, and the safeguards imposed against the chance of such injury must be made correspondingly more severe. We will not even consider the introduction of any insect which is known to

feed on plants other than *Rubus*, and we require very severe testing of these on a long series of native and introduced plants before we can consider their liberation.

Another bad weed which has taken possession of a very large area of ground in New Zealand and parts of Australia is gorse or furze, *Ulex europæus*. It is, however, a useful hedge plant, and, when young, provides good fodder for sheep; also, being leguminous, it improves the soil by the formation of nitrogen nodules. The problem of controlling gorse is therefore one of preventing it seeding, as it is the bursting of the seed-pods which is the main method of spread of this weed. This problem, I am glad to say, appears to have a fairly simple solution, for there are in England two or three insects which live wholly within the seed-pods of gorse and broom, and thus prevent them seeding without doing further injury to the plant.

Ragwort, *Senecio jacobæa*, is a poisonous plant which is becoming exceedingly abundant in New Zealand. When this plant is eaten by horses or cattle, cirrhosis of the liver results, ending in death, and no remedy is known for it. The control of ragwort by its insect enemies appears to be a feasible proposition, and is being undertaken by the Cawthron Institute at the present time.

St. John's wort, *Hypericum perforatum*, would scarcely appear likely to people in England to become a weed of importance. Yet it has so increased in size and vigour in parts of Victoria as to become a very serious menace, and the careful study of the possibility of controlling it by insects is one of the tasks which I have undertaken during my visit to England.

In conclusion, I would like to emphasise again the Imperial point of view in these researches. There are a large number of weeds introduced into various parts of the British Empire which we tolerate without having much idea of how far they rob us of the products of our labour. It has been calculated on a conservative basis that 10 per cent. of the world's crops are lost annually through the depredations of insects. I would like to ask whether anybody has attempted to make an estimate of what percentage of the Empire's crops are lost annually through the encroachments of noxious weeds? Think of the thirty million acres in Australia put entirely out of action by prickly pear, and the huge areas of cultivable land in New Zealand now 'going under' to blackberry and bracken-fern. Moreover, can we say that any weed, tolerated to-day as of no importance, may not in a few years time become a menace as great as the apparently harmless St. John's wort?

I declare emphatically that the menace is a most serious one in many parts of the Empire, and that we run the serious risk of being judged a race unfit to occupy these great areas, to the exclusion of other races, if we are going to allow them to 'go under' in the grip of introduced noxious weeds. The position demands the most careful consideration from those in responsible positions. Nothing less than an Empire-wide campaign will, in my opinion, suffice.