BIOLOGICAL CONTROL OF INSECT PESTS AND NOXIOUS WEEDS

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INTRODUCTION

BIOLOGICAL CONTROL, particularly of insect pests, usually suffers in the public estimation by being considered solely in relation to immediate pest problems. In most cases, these problems are of major importance because of the lack of satisfactory biological controlling agents in the field, and in many cases this lack is caused by man's modification of the environment, producing conditions ideal for the pest but unsuitable for its parasites and predators. Obviously, under these conditions the chances are against successful natural control and close association with such cases can readily conceal the real and inestimable value of biological control in our rural economy.

Because of the urgency of major problems, far too little time has been given and is still being given to a study of the overall benefits of biological control and knowledge in this sphere is lamentably poor. However, what is known leads to wonder at the number and range of potential pests which are of no significance whatever.

The term "biological control" has come to mean the control of a known important pest species by introduced parasites, predators or diseases. This is most misleading, being merely the utilization of a natural process in a single specific instance often outside its normal sphere of activity. Consequently, a more faithful term would be better adopted and for the purpose of this paper the definitive term, "ecological regulation of plant and animal populations" is proposed rather than "biological control".

Another common and false concept is that the chemical and biological methods are irreconcilable. This is far from true and the proponent of either method who considers he can succeed without assistance from and consideration of the other method is indeed foolish. More and more it is being realized that all methods of pest control must be integrated. All have advantages and all have failings. The important thing is to know just what is happening when a method is exercised. It is not sufficient to know what happens to the pest at which control is aimed. It is also necessary to know what is happening to other organisms within the particular environment concerned. Thoughtless use of chemicals can adversely affect host-parasite and other relationships with serious effects. A classic example of this is in the use of organo-chlorines and other insecticides on fruit trees producing an upsurge of red spider mite (*Tetranychus telarius*). In this case, the predaceous species are highly susceptible to the insecticide while the pest species is scarcely susceptible at all. The near-eradication of rabbits in much of the South Island run country has resulted in an alarming increase of sweet brier (*Rosa rubiginosa*). It is now known that the rabbit was a biological regulator of sweet brier population and an attempt must be made to replace it with a non-pest alternative, probably an insect. In the citrus orchards of Rarotonga, every sprayed tree is covered on the trunk with the scale *Parlatoria cineria* whereas

"wild" bush orange trees have virtually none of this scale. It seems fairly obvious that the spray programme in this case eliminates some natural controlling agent. A similar state of affairs appears to occur with citrus rust mite.

It is obvious, then, that some methods of control, particularly chemical, can interfere with the natural or induced ecological regulations of plant and animal populations but this does not constitute grounds for condemnation of chemical control or for favouring of biological control. It merely points to the necessity for an improved understanding of the regulative and other processes of the biological environment before making any major move to eliminate or control any element of that environment.

NATURAL REGULATION OF POPULATIONS

Every organism, whether plant or animal, has a potential for population increase. The factor of increase may be as low as 1:1.5 or as high as 1:10,000 or more per reproductive cycle. In the case of a multivoltine insect, this basic factor must be multiplied by the number of generations per year to give the annual potential factor of population increase.

This high reproductive potential of both plants and animals makes quite clear the almost limitless outbreak or epidemic potential which is present at all times. The physical and biological components of the environment react in such a way that in an ecosystem not interfered with by man a state of reasonable stability exists. Irrespective of reproductive potential, some species will be rare, others dominant. The dominant species will usually harbour a multitude of parasites, predators, commensals, symbionts and other dependants. The rare species will in many cases owe their rarity to an almost too well-adapted controlling agent or to a too selective natural requirement. The relative proportions will vary little from year to year unless some major upset in climatic cycle, fire or other disaster impinges upon the system.

The factors involved in this relatively stable ecological state are numerous. Climate and soil are major physical influences but it is the biological factors which are of most interest. Interspecific and intraspecific competition, predatism, parasitism, disease, food supply and longevity are some of the biological factors operative. It is in a natural undisturbed system such as this that biological control in its true sense can be best studied and appreciated. Unfortunately, so long as no element of the system becomes excessively dominant or until economic requirements demand human interference, lack of economic importance precludes the degree of study of such aboriginal systems as is warranted.

Studies of such undisturbed systems invariably bring to light an almost unbelievable complexity of relationships between plant and plant, plant and animal, and animal and animal.

The introduction of man's mono-cultural methods of commercial plant and animal production completely break down the original ecosystem and no forecast can ever be made as to what will take its place. Replacement of indigenous mixed forest by exotic conifers has already shown some tendency for native insects, both lepidopterous and coleopterous, to adapt themselves in a rather disturbing manner to the new environment and introduced insects have arrived from a balanced ecosystem into the newly-supplied food substrate where their traditional controls are likely to be absent.

The magnificent pastoral areas of New Zealand have been well and truly infiltrated and almost saturated at times by grass-grub (*Costelyira zealandica*) and subterranean grass caterpillar (*Wiseana*

spp.), both insects leaving behind in the tussock and scrubland their normally-associated parasites and predators. In the primitive habitat, populations of both these insects are adequately regulated by various ecological pressures which cannot be obtained under pastoral management conditions.

Perhaps the foregoing remarks indicate little hope for biological control under "improved" production conditions. This is far from the case. In fact, there are good reasons to expect an improvement on the aboriginal condition in some cases.

INDUCED REGULATION OF POPULATIONS

Under this heading is considered the application of natural regulation of populations to suit desired ends. This is the practice of biological control. A little earlier the statement was made that, in some cases, an improvement on the aboriginal conditions could be expected. This is because in many cases it is possible to select controlling agents in such a way that the best possible combinations can be utilized.

A very simple case is the newly introduced gall midge to attack St. John's wort (*Hypericum perforatum*). This midge was located in western Europe as a relatively minor influence on the weed. The fact that it was heavily parasitized indicated that it might be of value if introduced into an area lacking its parasites. On introduction into California and eastern Australia, native parasites of both countries adapted themselves to the midge, reducing its effectiveness. This midge has now been introduced into New Zealand and after several years of observation no parasitism has been observed. Consequently, unless climatic or other factors inhibit its progress, the midge should be much more effective here than in Europe, California or Australia. This midge has in fact caused death of young St. John's wort plants in the field in New Zealand whereas in other areas it is recorded as being effective only in reducing capacity to flower and consequently set seed. New Zealand is similarly at an advantage with the midge introduced to combat Mexican devil weed (*Eupatorium adenophorum*), it also being unhampered by parasites here.

In most cases of induced population regulation, an attempt is being made to control an introduced pest species. In these cases, provided the ecological requirements are adequate, the chances of obtaining better control than in the country of origin are quite good. In the case of a pest such as the oak leaf-miner, apart from climate, the ecological factors would be considered adequate in that they are all within the structure of the tree itself. This is not quite true in fact, as a balance between populations of evergreen and deciduous oaks is important to both the pest and its parasites, as also is the fate of fallen leaves. It is often unexpected factors such as these which cause disappointment in beneficial insect introductions.

In the past, apart from insects introduced from Australia, most biological control activity has been against northern hemisphere pests with northern hemisphere parasites and predators. So far, there has fortunately been little difficulty in synchronization of cycles. It is obvious that some difficulty must arise when insects are imported from the European winter into the New Zealand summer, and vice versa. Some difficulty has been experienced in this regard with parasites of the clover case-bearer moth (*Coleophora* spp.) but no further difficulty is anticipated when controlled environ-

ment facilities are available for this work. Parasites of pear slug (*Caliroa cerasi*) will almost certainly present problems in this regard as probably will insects to attack sweet brier. However, since the pests themselves have overcome this difficulty of synchronization to season without elaborate equipment, their natural enemies should not prove too difficult to handle.

The real problems begin when dealing with indigenous pest species such as the grass-grub or the subterranean grass caterpillar. Although a number of parasites, predators and diseases naturally attack each species, none has any appreciable influence in open pasture land, although probably exercising a regulatory function in the unaltered primitive habitat areas. These two pests provide perfect examples of man's modification of the environment providing ideal conditions for pest existence not only in an almost limitless food source but in elimination of natural enemies. A similar case is represented by the Australian pasture cockchafer which has never been recorded as parasitized in open pasture but which normally suffers 70% to 80% parasitism in the primitive environment. In this case, the junction between primitive and altered environment can show a drop in parasitism of from 80% to nil over a transition zone of less than 10 ft in depth.

When attacking such indigenous insects parasite sources must be sought on related but not identical hosts. This would appear to limit chances of success very greatly but, when one considers how introduced insects are liable to parasitism by species indigenous to the home of adoption and how introduced parasites attack native insects, it is realized that there is always hope of success, and, where pests cause damage as grass-grub and subterranean grass caterpillar do, all avenues offering any hope must be tested.

PAST ATTEMPTS

In the field of noxious weeds control, New Zealand has so far very little to show for the effort involved. Ragwort (*Senecio jacobaea*), pipiriri (*Acaena* spp.) and gorse (*Ulex europaeus*) control have been complete failures while St. John's wort has been partly successful and is still an active project. It is as yet too early to assess control of Mexican devil weed although indications are promising.

It may be mentioned here that an estimate of the area of St. John's wort on Middlehurst Station in the Awatere Valley prior to control attempts was 10,000 acres. It is now limited to one or two hundred acres in small scattered pockets, mostly in and adjacent to the riverbed.

Undoubtedly the most spectacular case of noxious weed control in New Zealand was the advent, without human assistance, of manuka blight (*Eriococcus orariensis*). The spectacular sweep of this scale through the country probably ranks as one of the world's unique cases of biological control and the subsequent succession of events provided, and still does provide, an exceptional object lesson in biological interaction within a relatively simple system. The follow-up of the parasitic fungus, the later regeneration of the manuka (*Leptospermum scoparium*) and the current spread and severe attack by a second scale insect not susceptible to the parasitic fungus present an excellent example of the potential regulatory power of organisms.

Attempts at control of insect pests have been more successful than have those of noxious weeds. Cottony cushion scale (*Icerya purchasi*), golden oak scale (*Asterolecanium variolosum*), woolly aphid (*Eriosoma lanigerum*), pine chermes (*Pineus laevis*), gum

weevil (*Gonipterus scutellatus*), gum scale (*Eriococcus coriaceus*), oak leaf-miner (*Lithocolletis messaniella*), white butterfly (*Pieris rapae*), diamond-back moth (*Plutella maculapennis*), glasshouse white fly (*Trialeurodes vaporariorum*), can all be classified as satisfactory intentional controls, even though odd outbreaks of white butterfly and diamond-back moth still occur.

As with manuka blight, so with some insect pests, accidental controls occur. Two recent cases are chrysanthemum midge and azalea leaf-miner, both of which now appear to be adequately controlled, at least in most areas.

CURRENT AND FUTURE PROJECTS

In the noxious weeds field, most effort is at present being centred on sweet brier, with some exploratory work being conducted on gorse. A very thorough investigation of sweet brier has been conducted throughout western Europe over the past five years and this is still being carried on at high pressure. One insect has been selected for trial immediately facilities are available in New Zealand for adequate quarantine handling of material. One or possibly more insects for trial against gorse have also been selected.

Following on these two major projects, control of various thistles (*Cirsium* spp.) and broom (*Cytisus scoparium*) will probably be attempted. In this work a great deal of background knowledge has already been obtained.

Current projects in insect control are very extensive. Although not an insect, snail control by the predaceous snail *Gonaxis* species obtained from Hawaii can be included here. Also obtained recently from Hawaii are dipterous parasites of green vegetable bug (*Nezara viridula*). Parasites of vegetable weevil (*Listroderes obliquus*) have been obtained from Australia and further supplies are expected very shortly. These three projects have not yet proved successful or otherwise.

Parasites of potato tuber moth (*Gnorimoschema opercuella*) have been introduced but not yet established. Further supplies for direct field release are expected to come to hand from India during the coming few months.

The major insect parasite projects are currently grass-grub and Argentine stem weevil (*Hyperodes bonariensis*), both operative in South America. Pilot consignments of parasites of both pests have been received and bulk consignment and liberation should commence during the coming summer. It is felt by Dr Lloyd, who is responsible for the collection and consignment in South America, that the Argentine stem weevil project holds promise. Following on these projects, the emphasis in South America will shift to subterranean grass caterpillar and white-fringed weevil (*Graphognathus leucolema*).

In Europe, minor work is being conducted on grass-grub control. Currently, larvae are being consigned to Darmstadt where they are being subjected to pathogen tests and to parasitism by diptera. Some subterranean grass caterpillars have been consigned to Oxford for similar pathogen testing.

Clover case-bearer moth parasites have been thoroughly studied in Europe and will be consigned as soon as New Zealand is equipped to handle them. Pear slug is being investigated but few promising parasites have been located as the host has the capacity to encapsulate practically any foreign organism gaining entry to its body.

Two new projects are this year being opened up with the Commonwealth Institute of Biological Control. These are control of

aphids in cereal and crucifer crops and control of houseflies.

In addition to the above, egg parasites and a predator of the passion vine hopper (*Scolypopa australis*) have been obtained from Australia and negotiations are being made to obtain from Nova Scotia predators of orchard pests to attack particularly eggs and young larvae of codlin moth (*Cydia pomonella*), and San Jose scale (*Quadraspidiotus perniciosus*). This last project is in conjunction with a long-term investigation of integrated control prospects, using an apple orchard as a first trial and investigation area.

CONCLUSION

There is much being done in biological control in New Zealand but a great deal, particularly in the field of survey and basic investigation, is being neglected on account of the pressure of economically pressing problems.

The future holds promise for the method, particularly in co-ordination with chemical and other forms of control.