THE EFFECTS OF INSECTS ON NATURAL VEGETATION

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There is a need for a greater awareness of the part which insects play in the determination of the pattern of natural vegetation. While the role of insects as plant pollinators is well known and accepted, ecologists in fields other than entomology have shown little interest in other aspects of insect modification of plant cover. This is reflected in the virtual absence from all the standard texts on plant ecology of discussion on effects caused by insects. While techniques have been developed to determine the roles of larger herbivores and rodents in the modification of vegetation, plant ecologists have no techniques for assessing the effect of the much more selective grazers among the insects (Huffaker 1962). This lack of understanding on the part of plant ecologists continues even though entomologists have clearly demonstrated some of the profound effects which insects can produce on vegetation by numerous successful projects for the biological control of weeds throughout the world. The role of insects in the modification of natural vegetation is much more clearly recognised in the field of forestry than in agriculture. It may be that the need for conservation of natural vegetation is a more firmly established principle in forestry where growth of useful species is often measured in terms of hundreds of years.

Entomologists cannot be absolved from blame in allowing this lack of understanding to continue. For many years prominent entomologists maintained that, except for occasional "outbreaks", phytophagous insects did not affect their host plants in a destructive or devastating manner (Huffaker 1962). Many entomologists have maintained that successful utilisation of insects in the biological control of plants was a million to one chance. This attitude may explain the small volume of literature documenting the impact which insects have on natural vegetation. Two local examples will be referred to later in this paper. In one case there is adequate documentation about the insects involved but little has been written on the resultant changes in the vegetational pattern. In the other case, investigation of the implicated insects has hardly proceeded beyond the stage of preliminary survey and nothing has been written of the effects on the vegetation.

Insects may be either beneficial or destructive in their influence on plants. While many of the effects are obvious and sometimes spectacular, many effects are subtle and not easily detected since they may be both continuing and gradual. In listing some of the ways in which insects affect vegetation no further mention will be made of insect pollination. For convenience these effects are tabulated under two main headings, indirect and direct.

Indirect Effects

(a) Effects operating through the soil.

Several groups of insects, notably the Collembola, play an important role in the formation and breakdown of soil organic matter and thus have an influence on the availability of plant nutrients. Other insects, including considerable numbers of ground inhabiting Coleoptera, move freely through the top layers of the soil and some of this group of insects also ingest soil. These insects have a considerable influence on soil tilth and indirectly on conditions for seedling growth.

(b) Effects through disintegration of dead plant material.

Anyone familiar with either indigenous or exotic forest will be aware of the relatively rapid disintegration of fallen branches and dead trees. The wood boring insects play an important part in this disintegration and thus hasten the return of organic matter to the soil. Removal of standing dead plant material must also affect conditions for seed germination and subsequent growth.

(c) Effects through pressure on other elements in the flora.

The action of a specific defoliating insect, particularly if it is acting on a dominant plant, may allow assumption of dominance by some other plant species in the community. In a forest community, defoliation of canopy trees can lead to marked ecological changes in the understory. Suppression of a weed by means of an insect in a biological control attempt often leads to regeneration of some element or elements of the natural flora of the area. In planning such a control project this aspect must be given considerable attention since it is possible that the plants which replace the weed may be even more difficult to control.

DIRECT EFFECTS

The direct effects of insects on natural vegetation may result either from continuous pressure or from sporadic outbreaks, the so-called insect epidemics. In the case of continuous pressure on a particular plant species the effects are often subtle and extremely difficult to document. In the indigenous forests of New Zealand species of scale insects (Coccoidea: Homoptera) are extremely abundant although they normally occur at low population levels. It is probable that these insects have a marked effect over long periods of time, possibly altering the composition of the forest although they are rarely directly responsible for the death of trees.

Sporadic outbreaks of insects may be caused in a variety of ways. Almost always the basic cause is some change in ecological conditions through the effect of climatic variations; of the activities of other animals; of changes in the physical environment; of the state of development of the vegetation itself, for example overmaturity in forest trees; or of some temporary release of the rate of population increase of the harmful insect species from the controlling influence of its associated parasites and/or predators.

The deliberate introduction of insect parasites of some harmful insect species can, if the attempt is successful, lead to a directly beneficial effect on the host plants. It would appear that the use of biological methods of control coupled with improvement in forest management can be more successful in suppression of sporadic outbreaks of harmful insects in forest areas than the use of insecticides.

The direct effects of insects on natural vegetation can be subdivided on the basis of the origin of the insect species concerned, whether exotic or indigenous. Within both groups the basic cause of effect may be similar or even identical but there is one important difference between the groups. When exotic insects are introduced either accidentally or intentionally to a new area they are not usually accompanied by the complex of parasites and/or predators which have been associated with them in their original habitat. If the host range of any introduced phytophagous insect is wide enough to include elements of the indigenous flora of the new area this lack of controlling factors can be responsible for catastrophic effects on the new host plants.

(a) *The effect of an exotic insect on natural vegetation.*

Within the context of this paper the term "natural" has been taken to mean indigenous as opposed to exotic. This definition has some significance in relation to a discussion of the effect of a scale insect, *Eriococcus orariensis* Hoy on *Leptospermum* species in New Zealand. In the primitive vegetative cover of this country *Leptospermum* played a relatively minor role (Cockayne 1928). The present large areas of *L. scoparium* Forst. have been induced through the activities of man and as such they would not come under the heading of natural vegetation in any restricted use of this term.

Leptospermum species in New Zealand were known to support a number of specific and nonspecific insects but, as far as can be determined, none of these insects were particularly harmful to their host plants. This situation was dramatically changed in a small area in mid-Canterbury in the late 1930's. Plants of *L. scoparium* were reported to be dying in small patches in the upper Orari Gorge. These dead plants had a fire blackened appearance and shortly before death had occurred were observed to be carrying large populations of a scale insect. This insect first attracted national publicity in 1945-46 when it was widely offered for sale by private interests as a controlling agent for *L. scoparium.* At that time it was thought that the insect was a native species which had previously been held in check either by a complex of parasites and predators or by prevailing ecological conditions.

When an investigation of the problem was commenced in 1948 it was established that the insect could exist under a very wide range of ecological conditions and that there was a virtual absence of parasites and predators affecting it. Hoy (1954) described the insect as a new species *(E. orariensis)* and pointed out (1959) that, since it was the most common coccid occurring on *Leptospermum* in south-eastern Australia and Tasmania, the insect was undoubtedly Australian in origin. This discovery heightened research interest in the project, for this provided the opportunity to document the effect of an exotic insect on indigenous vegetation; an opportunity which now occurs relatively rarely due largely to improvements in quarantine techniques.

E. orariensis spread rapidly both naturally and artificially into almost all stands of *Leptospermum* in both the North and South Islands. During the period up to 1956, *E. orariensis* appeared capable of killing *L. scoparium* in any situation where the host plant could grow. In 1956 reports were received from the Wairoa area suggesting that in parts of that district plants of *L. scoparium* were apparently recovering from attack by *E. orariensis*. After prolonged investigation it was established that recovery of plants following infestation was due to the presence of an entomogenous fungus, *Myriangium thwaitesii* Petch, which was parasitic on *E. orariensis*. Surveys conducted throughout both main islands in 1958 (Hoy 1961) indicated that the fungus was present throughout the wetter parts of the North Island and the northern and western portions of the South Island. Wherever the fungus could be detected, populations of *E. orariensis* had declined to low levels and plants of *L. scoparium* were recovering. In addition fresh seedling growth of *L. scoparium* was common. In the remaining area of the South Island, particularly in the drier and cooler parts, population levels of *E. orariensis* remained high, death of surviving plants of *L. scoparium* was common and little regrowth of this species could be found. In some of these South Island areas there had been some increase in the amount of *L. ericoides* A. Rich., a plant which is attacked by *E. orariensis* but rarely killed. This contrast between wet and dry areas has continued to the present time.

Some explanation is necessary as to the method by which *L. scoparium* is killed by *E. orariensis* and the reason for the immunity of *L. ericoides*. Of necessity these aspects have been investigated from an entomological point of view. Death of infested plants of *L. scoparium* occurs only in the presence of large populations of *E. orariensis* and, usually, at a time of some major change in overall ecological conditions such as onset of summer drought or low winter temperatures. It has been postulated (Hoy 1961) that death of *L. scoparium* occurs through failure of a weakened plant to cope with changed conditions, the prime responsibility for death being the action of the insect in removing large amounts of plant sap through direct feeding when present on the plant at high population levels. It has been shown experimentally that no insect-transmitted plant virus is present and that the associated coating of "sooty mould" fungi is not sufficient to seriously interfere with photosynthesis. The immunity of *L. ericoides* arises from two factors; *E. orariensis* is thigmokinetic, requiring a bark crevice for successful establishment on the plant; *L. ericoides* provides fewer crevices than does the bark of *L. scoparium*. In addition, *L. ericoides* exfoliates large papery sheets of bark at frequent intervals thus removing from the plant a proportion of those insects which do succeed in establishing. The net result of these two factors is to ensure that population levels of *E. orariensis* rarely rise to high enough numbers on *L. ericoides* to kill the plant. The presence of small populations of *E. orariensis* on *L. ericoides* particularly in Canterbury has assured the virtual elimination of *L. scoparium* by providing a reservoir of insects for infestation of any seedlings of *L. scoparium* which may appear.

Myriangium thwaitesii may have arrived in New Zealand in association with *E. orariensis* but the fungus was not able to exercise control over the insect until the latter became established in environments more suitable to the growth of the fungus. By holding populations of *E. orariensis* at low levels in the wetter and warmer districts, *M. thwaitesii* has allowed recovery of large areas of *L. scoparium*. The winter generation of *E. orariensis* appears to be little affected by *M. thwaitesii* and some population increase of the insect occurs over the winter period. Thus even in those areas where the entomogenous fungus is now present, populations of *E. orariensis* continue to exert some pressure on *L. scoparium*. It is doubtful whether this plant will ever again be as aggressive as it was before the advent of *E. orariensis*.

(b) Effect of an indigenous insect on natural vegetation.

There is very little documentation of the effects of indigenous insects on natural vegetation in New Zealand. Rawlings (1953) noted sporadic outbreaks of the buprestid beetle, *Nascioides enysi* Sharp in *Nothofagus* forest. These outbreaks were attributed primarily to debility in the host trees due to overcrowding, root injury due to animal trampling, fungal attack on trees, the activities of man and changes in the general ecological conditions from natural causes including earthquakes. Once the beetles were present in large numbers even healthy trees succumbed to attack.

For many years concern has been expressed about death of rata *(Metrosideros)* in protection forest on the steep western slopes of the Southern Alps. As long ago as 1925 (Miller 1925) death of tree rata in this area was attributed to the presence, in large numbers, of an indigenous coccid, *Anoplaspis metrosideri* Mask. In 1955 a group of scientists made a preliminary survey of the situation in Westland. This group included foresters, animal ecologists, pedologists and entomologists. On the basis of this survey Hoy (1958) concluded that insects were not a primary cause of mortality but that a number of indigenous coccid species could possibly be implicated in the death of individual trees which had been weakened by other causes. As in the case of attack on *Nothofagus* by *Nascioides enysi*, these other causes included effects from ground feeding animals; also damage by opossums, overmaturity of trees and earth movements due to the steepness of the slopes involved. It is possible that this 1955 survey was conducted too late to detect the presence of an outbreak of *Anoplaspis metrosideri* since there was a marked disparity between the number of coccids collected and the evidence on the trees of their former presence, many branches being heavily coated with sooty moulds even though few insects could be recovered.

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MODIFICATION OF NEW ZEALAND'S FLORA BY INTRODUCED MAMMALS*

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An undisturbed environment evolved over a long period and composed only of native plants and animals has a well-established stability that is *not* delicately balanced. A change in the density of any one native species of mammal, either by man or some catastrophe, usually does *not* set off a dramatic chain reaction of responses by the other plant and animal components of the community. Even though the balance of nature is dynamic and not static, a fairly stable plant and animal equilibrium exists where man has not disturbed this environment.

Although natural environments are so stable, man can disrupt the animal-plant relationships by introducing exotic plants or by altering the native vegetation through farming, grazing,

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