Entomological Aspects of Yellow-Leaf Disease of Phormium

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THE yellow-leaf disease of *Phormium* has been recognized for at least forty years. In many areas, it has been responsible for the termination of fibre production, and half of those remaining in the North Island are seriously threatened by inroads of the disease. In the South Island the outbreaks have been much less extensive. Both *Phormium tenax* Forst. and *P. colensoi* Hook. f., are affected.

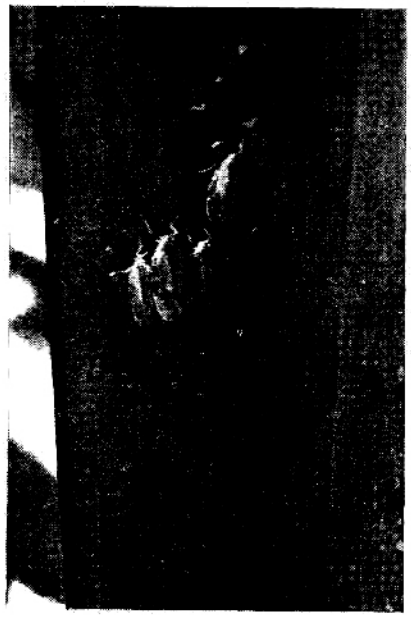
There have been numerous attemps to discover the cause of the yellow-leaf condition. Physiological factors and the question of fungal, bacterial, and virus pathogens have been studied. A. H. Cockayne, in the early stages of his association with the problem, reached the conclusion that the condition was a physiological one, but later the rapid spread of yellow-leaf in some areas convinced him that a pathogen was at work.

Only recently has it been shown that the condition is due to a virus which is transmitted by an insect. Mechanical transmission using the carborundum abrasion technique, and transmission by means of root grafting have also been obtained, and it is suspected that seed transmission may occur (Boyce *et al.* 1951).

Entomological Surveys

Kirk and Cockayne (1909), Cockayne (1915), and Miller (1916, 17, 18, 20, 30) carried out surveys of *Phormium* areas, studying the insects which caused direct injury to stands. More recently (1947), Boyce studied the *Cicada* populations and attempted the transmission of the condition by transferring *Cicada* nymphs from the roots of diseased plants to roots of healthy ones.

An intensive survey of the insect populations of *Phormium* areas was commenced in June, 1949. The purpose of this survey was to ascertain if the yellow-leaf condition might be due to mechanical injury, and also to determine possible vector species which might cause the condition by indirect means or through toxic effects.



Adults of* O. atkinsoni *on a blade of* Phormium tenax. *The lining up of individuals (males on each side of the female) is a very characteristic behaviour prior to mating. As many as five individuals (four males and one female) have been observed in this attitude.

The *Phormium* areas at Moutoa were selected for special study. These include plantation and, in addition, what have been termed "induced areas." These latter comprise those through which *Phormium* has spread following the draining of stagnant swamps. Associated with the *Phormium*, more especially in the induced areas, are a large number of plant species—both native and introduced. The accompanying insect species are likewise of a high order and run to at least 500. Included in these are approximately fifty species of true bugs (Hemiptera) of which about twenty could be considered as possible vector species.

The survey gave no grounds for suspecting that direct injury might be the main causal factor of the yellow-leaf condition, and at an early stage attention was directed to the field of insect transmission. Amongst the insects belonging to the vector group one in particular fell under suspicion because of its almost complete restriction to *Phormium* as a host plant and because of its prevalence in the badly affected areas.

Oliarus atkinsoni Myers—Vector of the Yellow-leaf Disease

J. G. Myers (1924) described a Cixiid bug, *O. atkinsoni*, from a series of specimens collected at Waikanae and Wellington, stating: "This large and sluggish species has gone a step further than *Oliarus oppositus* in its preference for ground herbage as distinct from bushes, and is found only in flax swamps, apparently attached to the flax itself, where it may be found sitting . . . on the shaded side of the leaf." Myers dedicated the species to its discoverer E. H. Atkinson who was engaged on *Phormium* research at this time. But the study of virus diseases was very much in its infancy then, and no importance was attached to the insect. *O. atkinsoni* has been observed in the high country at Mangamuka, North Auckland, feeding as adults on the leaves of *Arundo* sp., and the absence of *Phormium* in the vicinity suggests that there may be host plants in addition to that from which the species was originally described.

In November, 1949, adults of *O. atkinsoni* were discovered at Moutoa, and soon they appeared in considerable numbers—especially in the badly affected yellow-leaf areas. Preliminary experiments showed that bugs caged on 7–8 months old seedlings (in pots) fed readily, and transmission trials were set up early in December. These first trials were entirely successful in incriminating *O. atkinsoni* as a vector of the yellow-leaf disease (Cumber, 1952). A high percentage of transmissions was obtained; excessive yellowing was apparent in from 4 to 7 weeks, and on final examination (May 24, 1951) 16 of the 20 test plants were diseased, and none of the 20 control plants showed any symptoms.

The Ecology of the Vector and Its Relation to the Spread of the Disease

The incrimination of the vector species and the subsequent study of its biology have thrown light on the

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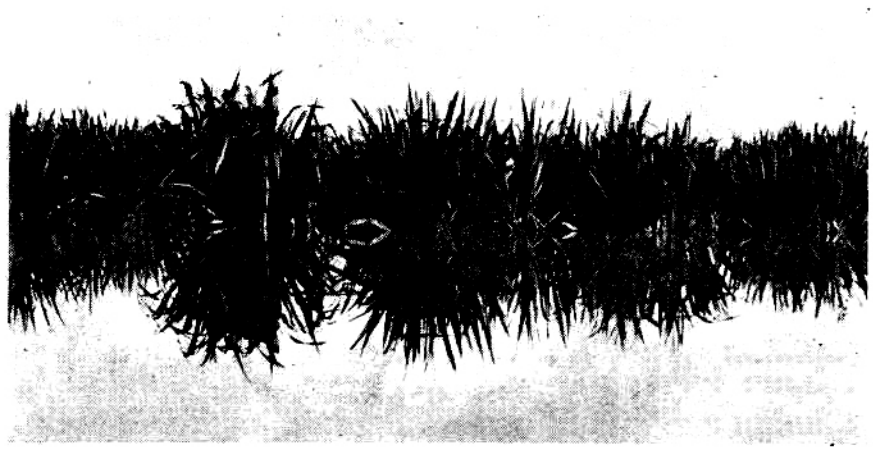
history of yellow-leaf outbreaks. It has been common knowledge for many years that over-draining and stop-banking of rivers have resulted in outbreaks of the disease, and this more especially in those areas which no longer receive the periodical inundations.

Adults of *O. atkinsoni* are present on the upper portions of the plants from November to March. For the remaining months the bugs occur in the nymphal stages only, and as such are restricted to the basal portions of the plants. Here they live in galleries amongst the dead leaf material, feeding upon the roots which pass through or ramify therein. The nymphs secrete a filamentous mealy fluff which issues dorsally from the three posterior abdominal segments. This material is brushed off by the walls of the spaces in which the nymphs live, producing white, fluff-lined galleries where the bugs are protected from predators and also from the weather—the fluff possessing anti-wetting properties.

Laboratory tests have shown that the nymphs possess considerable resistance to submergence, a small percentage being able to survive this for a period of a week. When this period of submergence is doubled, however, a complete kill of all nymphs present is obtained. It is known that the plant can withstand flooding to a depth of 2 to 3 feet for periods of up to 4 weeks during the winter months.

O. atkinsoni has become adapted to the conditions under which *Phormium tenax* occurs naturally—*i.e.*, marginal river and swamp areas—and is able to withstand the periodic floodings which these places receive, provided they are not of too long a duration. Since the plant is able to withstand considerably more inundation than the nymphal populations of the bug, it is anticipated that a satisfactory measure of control of the bug may be obtained by flooding. Thus a basis for the long-held belief that flooding reduces the severity of the outbreaks of yellow-leaf has been found.

Little detailed information is available on the life-history of Cixiid bugs. This no doubt is due partly to the fact that the family to which they belong is not of great economic consequence, and partly to the obscurity in which the greater part of the life-cycle of the bug is spent. The life-history study of *O. atkinsoni* is proving of considerable interest. It appears to occupy two years of which all but one month is spent in the egg and nymphal stages hidden away in complete darkness at the base of the plant, reminding one somewhat of the life-cycle of the cicada. This long nymphal cycle will be an advantage in any attempt to control the bug by flooding, but likewise a disadvantage in any attempt to control the bug by the insecticidal spraying of adults.



Flood waters covering the* Phormium *bushes to a depth of two feet promise some measure of control of the bug. The nymphal stages, which are restricted to the base of the plant, are killed by a submergence lasting 14 days.

The yellow-leaf disease, as stated previously, is present both in the North and South Islands, but is more prevalent in the North. *O. atkinsoni* is very widespread in the North Island, but has not been reported from the South Island.

Some Additional Points of Interest and Further Research

The Cixiidae or plant-hoppers have only once (and this since the present work commenced) been incriminated as a disease-transmitting group of insects. Thus, although the prevalence of the bug in the diseased areas immediately suggested that it might be a vector, the family to which it belonged did not favour the suspicion.

This is the first record in New Zealand both of a virus in an indigenous plant, and of an endemic vector species. It is possible that the virus may prove to be a new one. Should this be so, then the study of how natural *Phormium* areas withstand it should prove of considerable interest. The rate of expression of symptoms may well be affected by genetical constitution and the physiological conditions under which the plant is growing.

Experimental transmission work with *O. atkinsoni* to determine virus-vector relationships is being continued. In addition, seven other insect species are being tested to ascertain if they play any part in the transmission of the disease. These include the other New Zealand Cixiid species, *Oliarus oppositus* (Walk.), which is commonly found on *Phormium* and occurs throughout both North and South Islands on a very wide variety of host plants.

Acknowledgment

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References

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