SIREX NOCTILIO (HYM.) AND ITS PARASITE IN NEW ZEALAND.

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(PLATE II.)

Although on the whole our plantations of exotic conifers, now amounting to some 500,000 acres, have not yet suffered from widespread epidemics, there are certain exotic insects already well established in the country that must be considered as potentially dangerous. Attention is being given to the most important of these.

One species, though not a serious pest of healthy trees, has attracted considerable attention owing to its widespread establishment throughout the Dominion; this is the steel-blue horntail-borer or wood-wasp, *Sirex noctilio*, of Europe, which in this country attacks *Pinus radiata*, *P. ponderosa*, *P. laricio*, *P. muricata*, *P. austriaca*, *P. pinaster*, and *Larix europaea*, whilst on one occasion it was found attempting to oviposit in the native Miro (*Podocarpus ferrugineus*). Attacking suppressed, dying, and dead trees for the most part, this insect is nevertheless an important factor detrimental to forest protection since it may hasten the death of trees that could be utilised, as well as creating conditions favourable to the breeding of the European bark-beetle (*Hylastes ater*, Payk.), now well established in many regions. In this respect it is of importance to note that some large commercial concerns which have established extensive pine forests apparently intend to attempt the management of these upon a sustained yield basis with an extremely short rotation by a system of clear felling at the age of 12–16 years and subsequent replanting. Exotic conifers, maturing very rapidly in New Zealand, present ample pabulum for the larvae of *Sirex* at the above-mentioned ages, and the stumps of such trees attacked by that insect and infested with *Hylastes*, will, after clear felling, be centres from which *Hylastes* will spread and attack the fresh crop of seedlings, as has already been the case. Further, since exotic conifers have been planted somewhat indiscriminately all over the land, often without due consideration of site, some areas, having reached a fairly advanced state, appear to be weakening and becoming susceptible to *Sirex* attack. A further factor contributing to the development of *Sirex* is the lack of suitable plantation management. The basic difficulty is usually the fact that thinning, instead of yielding an intermediate return, such as might be expected under Old World conditions, is in most cases a definite additional capital charge, since small sizes of the timbers grown can only on rare occasions be profitably utilised. It is therefore not surprising that the average plantation owner avoids thinning, even when he realises that trees have to be farmed, as has any other crop, with the result that suppressed, broken, and dead trees comprising dense thickets are common.

Although suppression, breakage, and poor site are the most frequent causes inducing *Sirex* attack, the influence of fire and fungi cannot be overlooked. Very few plantations, outside those owned by the State and large commercial concerns, are adequately protected from fire, and it is no uncommon sight to see a considerable area of valuable trees irreparably damaged by accidental fires; this is particularly so when the plantations are situated along main highways or in the vicinity of settlements. Fire-killed trees, provided they are dried out, are not favourable for the breeding of *Sirex*, but in the case of light ground fires which cause the tree to wilt and to die gradually, the insect finds an excellent breeding ground. In the case of fungi, *Botryodiplodia pinea*, Cur., is found to attack several species of *Pinus*, and appears in some cases to be linked to the presence of *Sirex*. It has been shown that the wood infested by *S. noctilio* larvae contains a fungus, possibly *Stereum sanguinolentum*, which may influence the insect's ability to exist in timber—a subject still under investigation.

There is no doubt in the minds of the authors that the prevalence of *S. noctilio* is due to the rapid expansion of afforestation, unfavourable site selection, fire, fungi, the lack of ordinary forest management, or its faulty application, and that the difference in forestry conditions between Europe and New Zealand gives a greater prominence to the insect in the latter country.

S. noctilio has been present in the Dominion for a considerable time ; as far back as 1900 the insect was found in the Wairarapa district of the North Island. For many years it was by no means a common species, but with the development and extension of areas under exotic conifers it has correspondingly increased and is now one of the commonest species met with amongst our insects of economic importance.

The wood-wasp reached New Zealand direct from England and Europe in shipments of lumber or in manufactured products ; in recent years we have records of the adults emerging from lumber in transit and on arrival, while there is the case of a piano from which emergences took place some time after the instrument had been sold in this country. It is of interest to note here that the giant wood-wasp (*S. gigas*) has reached New Zealand on rare occasions, while other species of the genus are sometimes met with in shipments in Californian redwood and in other timbers from the Pacific Coast of the United States.

Importation of Rhyssa persuasoria.

Owing to the abnormal abundance of *S. noctilio* in the plantations of exotic conifers steps were taken in 1927 to locate and introduce a parasite for its control. Adverse opinions were expressed upon the venture, since it was assumed that any attempt to introduce and establish a parasite of a wood-boring insect would fail. Why this should be so in the case of wood-borer parasites more than in the case of other insects, we failed to see ; and as the results to date have shown, the assumption was unfounded and demonstrates that one cannot definitely foretell the success or failure of any project connected with the biological control of insects.

In 1927, Sir Guy A. K. Marshall, Director of the Imperial Institute of Entomology, was communicated with for the purpose of securing supplies of *Rhyssa persuasoria*, known to parasitise *S. noctilio* in England, for shipment to New Zealand. The problem was placed in the hands of Dr. W. R. Thompson, Superintendent of the Farnham House Laboratory, and in December 1928 the first shipment of *Rhyssa* was received in New Zealand ; during the course of the researches in England another parasite, *Ibalia leucospoides*, was studied and some material sent to us, but nothing came of this second parasite.

As with the biological control of many other destructive insects, so in the case of *S. noctilio*, the opportunities for an introduced parasite becoming outstandingly effective are very favourable in New Zealand, since there are so many gaps in the insect parasite fauna of the country that can be judiciously filled without much fear of having their activities interfered with by related forms. Furthermore, in this particular instance there are no indigenous SIRICIDAE, and only one indigenous species of *Rhyssa*, *R. fractinervis*, which has for its host the larvae of the native so-called elephant beetle (*Rhynchodes ursus*), and which is confined to the natural forests of the country. It is just possible, however, that *R. fractinervis*, which has been found in *Pinus radiata* plantations, may extend its host range to *S. noctilio*, though the exotic conifers in which the latter breed are a totally different type of tree from the host trees of *R. ursus*. No hyperparasite of *R. fractinervis* is known, but if such occurs, there may be a chance of *R. persuasoria* being influenced by it.

The importation of *Rhyssa persuasoria* was carried out between December 1928 and April 1929, and again between March and August 1931 ; during these periods

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nineteen consignments totalling 7,830 individuals were sent us from Farnham Royal. The insect was shipped in the larval stage under cool store conditions, and packed in gelatine capsules or corked glass tubes, a single larva to each receptacle. In some cases larvae had pupated and in others adults developed during the voyage. The shipments were, however, satisfactory, except where glass tubes were used, moulds doing considerable damage to the larvae under such conditions. The consignments were as follows :—Living individuals are marked (+) and dead or diseased (—).

Consignment	Received	Number	Condition on arrival			
			Larvae	Pupae	Adults	Per cent. alive
1st	8.xii.28	51	47(+) 4(—)	—	—	92·16
2nd	7.i.29	150	148(+) 2(—)	—	—	98·66
3rd	9.i.29	143	111(+) 31(—)	1(+)	—	78·32
4th	15.i.29	147	120(+) 15(—)	12(+)	—	89·75
5th	12.ii.29	100	45(+) 42(—)	9(+)	4(+)	58
6th	14.ii.29	147	57(+) 29(—)	5(—)	56(—)	38·77
7th	20.ii.29	228	78(+) 23(—)	16(+)	52(+) 59(—)	64·03
8th	7.iii.29	207	82(+) 56(—)	2(+)	67(—)	40·57
9th	13.iii.29	184	89(+) 26(—)	5(—)	13(+) 51(—)	55·43
10th	14.iv.29	96	37(+) 11(—)	7(—)	3(+) 38(—)	41·66
11th	6.iii.31	610	515(+) 43(—)	52(+)	—	92·95
12th	19.iii.31	690	568(+) 36(—)	86(+)	—	94·87
13th	24.iii.31	556	392(+) 31(—)	133(+)	—	94·42
14th	8.iv.31	248	135(+) 45(—)	68(+)	—	81·85
15th	13.iv.31	337	251(+) 35(—)	51(+)	—	74·48
16th	21.iv.31	1,200	966(+) 39(—)	195(+)	—	96·75
17th	14.iv.31	1,043	696(+) 100(—)	247(+)	—	90·41
18th	16.iv.31	1,242	813(+) 200(—)	229(+)	—	83·09
19th	6.viii.31	451	233(+) 112(—)	105(+)	1(+)	75·12

Some 160 parasite larvae of the 1928–29 consignments were sent in glass tubes, but in all other shipments gelatine capsules were used. The glass tubes were not a success owing to the accumulation of moisture and the development of mould upon the larvae. Many of these mould-affected larvae were saved by brushing with a very fine brush dipped in a saturated solution of boracic powder in cold water. This treatment was effective in removing the mould and allowed about 40 per cent. of the infected larvae to pupate, but the adults emerging from these were in poor condition. The capsules and tubes of the 1928–29 consignments were packed in cottonwool and those of 1931 in sawdust; both methods gave equally satisfactory results, though the sawdust apparently ensured more suitable conditions of moisture and temperature. In some cases sawdust was placed in the capsule with the insect, but no marked difference resulted.

Method of handling Parasites.

In the case of the parasites arriving in the 1928–29 season, upon arrival all were placed in suitable conditions in order to obtain emergences as quickly as possible. The parasites were unpacked, the dead and diseased insects removed and the healthy larvae or pupae placed in rearing boxes in a cool part of the laboratory. The first emergences were obtained in January 1929 and continued until May 1929. Further adults obtained from larvae which carried over the winter emerged from September 1929 to January 1930.

With regard to the consignments arriving during 1931 the pupae and prepupae of the first and part of the second consignment were allowed to develop under normal conditions of temperature, but owing to the lateness of the season the whole of the remaining consignments were placed in a cool store having a constant temperature of 41°F. for the purpose of retarding development till the spring. A number of pupae and prepupae from the second and third consignments were used for experimental purposes to observe the effect of low temperatures upon development. It was found that development could not be arrested in all cases by the application of a temperature of 41°F., it being noted that the retardation of development depended to some extent upon the amount of development which had already taken place. Thus it was found that some pupae even though packed in a metal container and placed directly upon a block of ice still continued their development and ultimately emerged in apparently good condition. The parasites arriving during 1931 were placed in the cool store still in their original containers, having been repacked after the usual examination had taken place upon arrival.

Although adults emerged when in cool store (41°F.), most of the larvae and pupae responded to low temperatures and were removed to ordinary temperatures in the spring (October). It was found that by far the greater number of adults were males (approximately two-thirds), while many of the females emerged with damaged ovipositors. Though these aborted females (in several cases no wings developed) mated readily enough with the males, they were unable to oviposit. Attempts were made to rectify the difficulty by treating the ovipositor in various ways but without success. One method consisted of placing the pupae in artificial burrows in pine wood to give the insect an opportunity of emerging under more or less natural conditions, this was of little use. However, if the females were given the freedom of a large insectary in which to fly immediately after emergence, it was found that in many cases the ovipositor assumed a normal state. Temperature had a direct influence upon the adults; at 40°F. they were sluggish, but became activated as the temperature rose; at 56°F. the insect will feed and at 60°F. become normally active, short flights being taken; copulation was noted at 64°F., while above that temperature maximum activity was reached. Conditions in New Zealand are thus favourable for acclimatising the insect. On the approach of winter any larvae and pupae remaining were held in cool store until the spring.

Liberation of Parasites.

Adults on emerging were allowed to mate in the insectary, after which some were liberated in *Sirex*-infested plantations, while others were retained for rearing purposes under insectary conditions. The females liberated in the plantations were observed to commence ovipositing almost immediately. The field liberations were as follows :—

Adults liberated from 1928—29 *Consignments.*

1929.

January	Marlborough	4 females, 8 males.
,, ...	Wairau	4 females, 4 males.
February	,, ...	6 females, 4 males.
,, ...	Hanmer Springs ...	18 females, 12 males.
March	Palmerston North ...	2 females, 2 males.
April	Hanmer Springs ...	5 females, 5 males.
October	,, ,, ...	3 females, — males.
December	,, ,, ...	6 females, 5 males.

Adults liberated from 1931 *Consignments.*

1931

September ...	Tasman	12 females, — males.
October	,, ...	25 females, 5 males.
,, ...	Wairakei	12 females, — males.
,, ...	Moutere	9 females, — males.
December	Hanmer Springs ...	32 females, 7 males.
,, ...	Moutere	15 females, — males.

When only females were liberated these had been mated in the insectary. By the end of December 1931 emergence had ceased, and 365 larvae remained to over-winter. The mortality amongst these larvae was very high, but a few emergences were secured in the spring of 1932, and the following liberations were made :—

October	Ashburton	6 females, — males.
November	Braeburn	8 females, — males.
December	,, ...	12 females, — males.

Insectary Rearings.

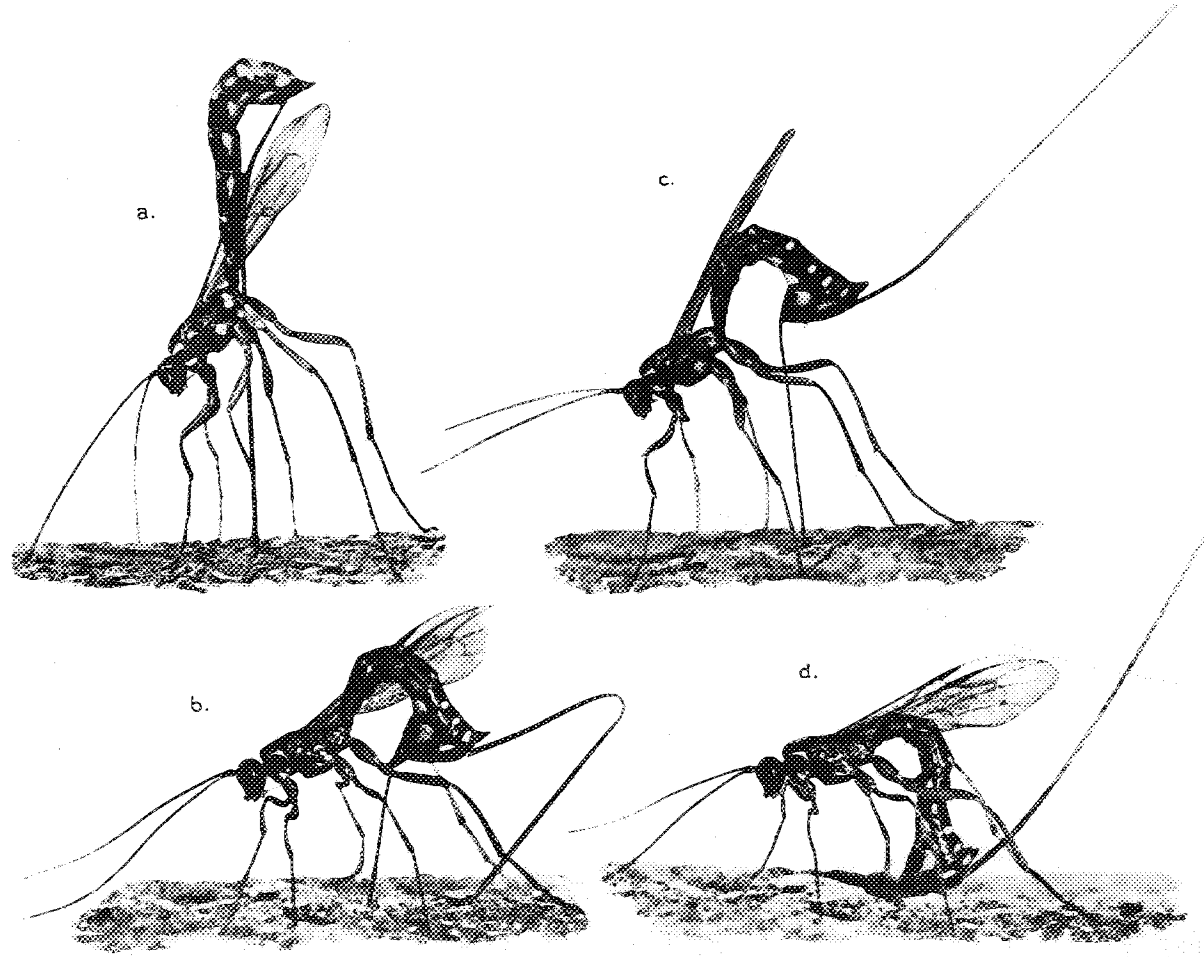
In order to keep a supply of *Rhyssa* in Nelson it was decided in 1931 to attempt the rearing of the parasite in the insectary. Logs infested by *S. noctilio* were brought from the field and stacked across trestles. Gravid females were placed with these, and oviposition was secured without any difficulty. The first New Zealand generation emerged in September 1932, a period of 10½ months, having completed the cycle of the earliest emergences. A second New Zealand generation was similarly produced in September and October of 1933. In no case was other than a perfect insect produced, and while the first generation was uniformly larger than the English stock from which it was bred, the second generation was larger still, a number of very fine females being produced. The largest of these had a body length of 1·3 inches and the ovipositor 1·7 inches. It would appear that this increase in size of *Rhyssa* is in keeping with that recorded by the host, *S. noctilio*, in New Zealand. In both generations males predominated, this being in keeping with the results obtained from imported stock.

Ibalia.

From the 21 imported *Ibalia* larvae no results were secured, though one male emerged. This is a more difficult insect than *Rhyssa* with which to deal.

Conclusion.

Judging from the development of *Rhyssa* in the insectary and from the fact that the insect readily oviposits under plantation conditions, there is every reason to expect that the parasite is now developing in the field, though recoveries from that source have not yet been seriously attempted. Field observers report the presence of the insect at several points of liberation, but this cannot be accepted with complete confidence.



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RHYSSA PERSUASORIA, STAGES IN PROCESS OF OVIPOSITION.