

FACTORS INFLUENCING POPULATION LEVELS OF *Scolypopa australis* Walker (HEMIPTERA-HOMOPTERA: RICANIIDAE) IN NEW ZEALAND

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Summary

The Australian ricaniid *Scolypopa australis* Walker, which has been in New Zealand for at least 90 years, is a pest of a great number of plants in warmer areas, and is sometimes responsible for the production of toxic honey.

A survey of factors influencing the existing population levels commenced in 1962. The purpose of this was to gain information on the New Zealand complex prior to searches in Australia for further biological control agents.

Studies involved an examination of the egg, nymphal and adult stages from throughout its range. Only one parasite of significance, the newly described egg parasite, *Centrodora scolypopae* Valentine (1966) (Aphelinidae) was revealed. Additional biological and ecological factors are considered.

INTRODUCTION

The ricaniid bug, *Scolypopa australis* Walker (Fig. 1), commonly known as the passion-vine hopper, is an Australian species first recorded in our literature some 90 years ago, but the date of arrival is not known. It may have reached New Zealand on a number of occasions and most probably arrived as overwintering eggs inserted in the stems of imported shrubs.

The passion-vine, *Passiflora edulis* Sims, is only one of many favoured host plants. A great number of garden plants and shrubs are commonly infested, and native forest shrubs in marginal areas, ferns of various types, *Phormium*, etc., often carry high populations. Both the nymphs, which are characterised by white fluffy tails, and the adults, feed continuously for long periods and produce copious quantities of honey-dew. They withdraw sap from the more succulent growing portions of the plants causing general debility, stunting, and wilting.

The species is of further importance because of its role in the production of poisonous honey. Over the years there have been a number of cases of suspected honey poisoning more especially in the Bay of Plenty region. Investigations following an outbreak in this area in 1945 (Palmer-Jones *et al.*, 1947) showed that *S. australis* was involved. When populations of late stage nymphs and adults are high on the endemic plant *Coriaria arborea* Lindsay (commonly known as "tutu"), the production of honey-dew is quite considerable, and this may concentrate to a denser sticky consistency where it is caught by the leaves. If floral nectar is in short supply, bees may collect the honey-dew and store it with the honey which then may produce severe reactions in man when taken in quite small quantities.

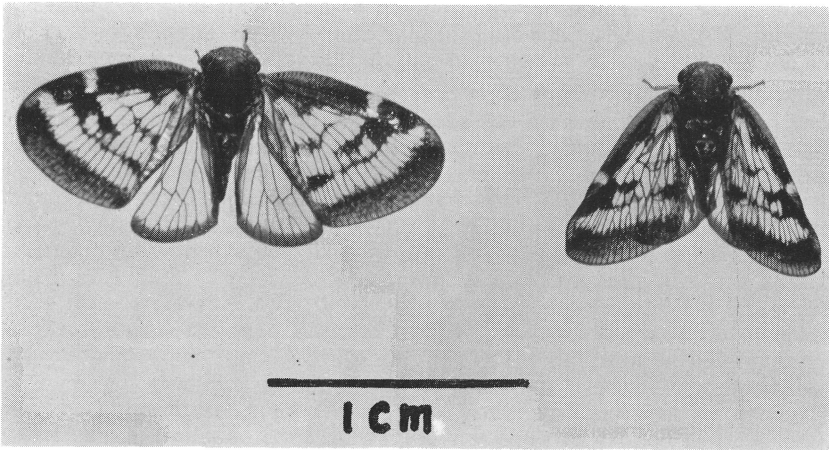


FIG. 1.—Adults of the passion-vine hopper, *S. australis*.

On the Australian scene *S. australis* does not occur in the great numbers commonly encountered in New Zealand, and it is probable that beneficial controlling species occur there. A survey of the factors influencing population levels in New Zealand commenced in 1962, before making a search for parasites and predators in Australia.

DISTRIBUTION

S. australis is restricted to the warmer parts of New Zealand (Fig. 2).

In the North Island it occurs from North Cape to Levin and doubtless is present in warmer sheltered localities in the vicinity of Wellington. In the South Island it is present in warmer parts of the Nelson district and occasionally reaches high populations there. Within this approximate 600 miles of north-south range *S. australis* is noticeably absent from higher altitudes where the bleak winter periods become the limiting factor. It has not been detected, for example, in the Taupo area, although its presence in sheltered home gardens is not beyond possibility. Similarly there is a zone in the southern shadow of Mt Egmont where it is either absent or present only in very small numbers. North of Auckland, however, altitudes of over 600 ft and the attendant moderately heavy winter frosts appear to have little effect on distribution. The highest populations are encountered in North Auckland in warmer sheltered eastern localities.

LIFE CYCLE

There is only one generation each year. In general, October, November, and December are the months of nymphal emergence and development, and January, February, and March those of adult activity. Nymphal emergence



FIG. 2.—Distribution of *S. australis* in New Zealand.

is delayed in southern areas and adults disappear earlier. In the far north the occasional adult survives until mid-May. For the remaining six months only the egg stage is present, but this may occupy several months longer depending on when it was laid and prevailing weather conditions.

The presence of an obligatory diapause has been demonstrated and this synchronises hatching in the following spring. Field oviposition materials were collected from a number of North Auckland localities at intervals from March until November 1963. These were held in corked, glass, 4 in. X 1 in. tubes at normal laboratory temperatures, and examined periodically for the presence of living nymphs. The information from two typical sites is illustrated in Fig. 3. The *Coriaria* samples were taken from the one shrub, while those from *Pteridium* were taken from a short length of a fence-line thicket. Samples collected prior to the end of June produced no nymphs. It is possible that the relatively dry artificial conditions of holding may have played some part in the death of eggs, but it seems more probable that the temperature requirements of diapause were not met by the early collections. Samples collected from mid-July onwards yielded nymphs after varying holding periods, these periods becoming progressively shorter as the season progressed until early October when normal field emergence commenced. Nymphs may thus be obtained as early as mid-August by collection of eggs at the appropriate period.

Oviposition (Figs 4 and 5) occurs on a great number of plants and often on the host plant which provides most of the nymphal and adult nourishment. The eggs are inserted for the most part into relatively soft stems in longitudinal rows. The sharp ovipositor prepares a hole, and following

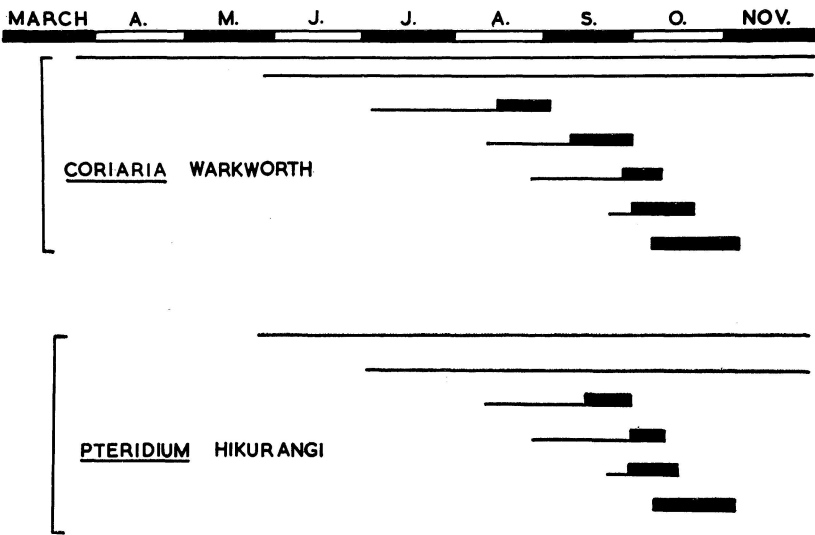


FIG. 3—Laboratory life of unfed *S. australis* first instar nymphs emerging from field collected oviposition material. Sample collection date is indicated by the commencement of lines, nymphal life by the solid bars.

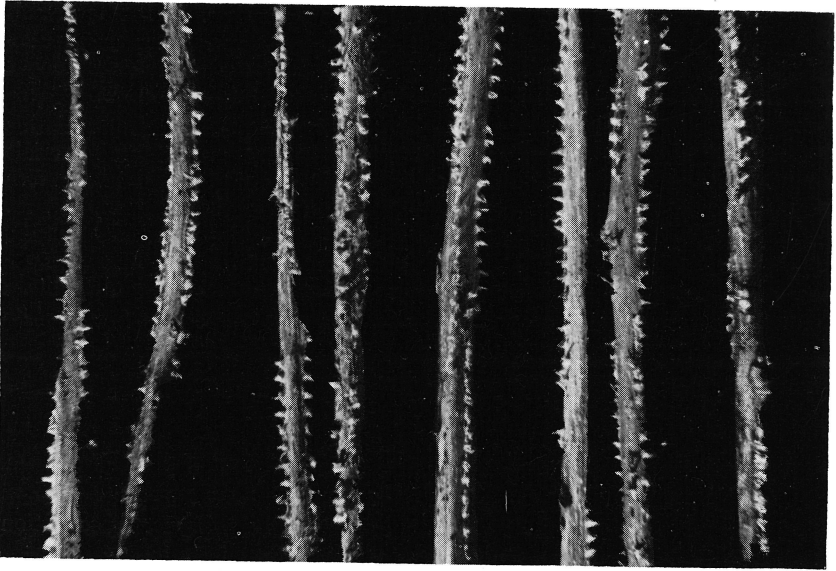


FIG. 4—Oviposition scars on twigs of *Fuchsia* taken in the Waipoua Kauri forest.

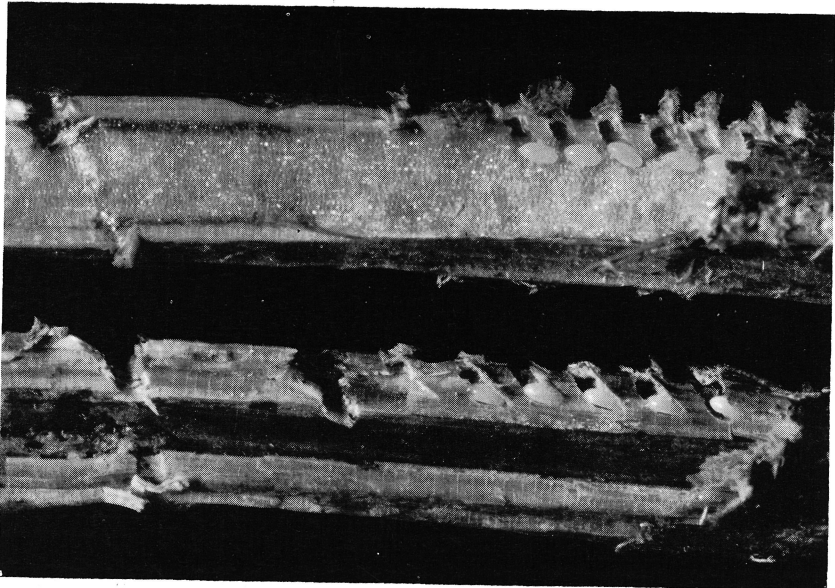


FIG. 5—Twigs split open to show implanted eggs of *S. australis*. Note protective pulped caps over egg chambers. The egg is approximately 1 mm in length.

deposition of the egg the pulped material at the entrance is compacted to form a protecting plug. Some projecting fibres usually remain obvious at the site of implantation. The variety of selected materials may be illustrated by the trailing stems of *Lycopodium* on the one hand, and angular wooden fencing battens on the other. The selection does not involve only dead or dying materials since oviposition has been known to occur on the mid-rib of green *Coriaria* leaves, and on green *Rhabdothamnus* stems. Whether an adult usually selects twigs in which the sap flow has, or is decreasing, or whether sap withdrawal and oviposition are primarily responsible for the subsequent die back is not always clear, but it seems probable that both factors operate.

The newly emerged nymphs (Fig. 6) move to succulent shoots and often congregate at a short distance from the tips where they circle the stems and feed almost continuously. The five nymphal instars occupy almost three months. The younger stages move little, but the older ones probably disperse for moderate distances in search of more suitable feeding sites.

The earliest adults appear late in December or early January in northern areas. Maturity is reached in about two weeks. Mating commences at dusk and oviposition occurs for the most part during the late afternoon and evening.

SURVEY PROCEDURES AND RESULTS

The factors influencing population levels may be physical or biological. In the first instance climatic variation both geographic and local may be important as already indicated under distribution, and secondly, there are factors such as parasites and predators which affect the egg, nymphal or adult stages. It is the latter which are mainly concerned here.

THE EGG COMPLEX

During October and November 1962, collections of twigs and stems containing oviposition punctures were taken from more than 100 sites throughout the North Island as far south as Palmerston North, and in Nelson. The Spirits Bay region in the extreme north was visited early in February 1963. Samples as collected were placed in large paper envelopes and protected from the direct rays of the sun. Subsequently, dissection of more than 16,000 eggs was carried out and a further portion was placed in 3 in. \times 1 in. glass tubes with corks, to await parasite emergence. The information obtained is shown in Tables 1 and 2.

Physical Considerations

Stability in selected oviposition materials is highly desirable. Green succulent stems dry out and twist or shrivel thus producing strains within the tissue, and this may damage or expose eggs to the elements. A rigid drier twig possesses a stability which is far more likely to ensure successful overwintering, but it must also be soft enough to allow the eggs to be buried adequately.

TABLE 1—Data from Examination and Emergence of *Scolypopa* Egg Samples

Sample No.	Locality	Date	Host Plant	Total Eggs Examined	Normal Eggs (%)	Parasitised <i>Centrodora</i> (%)	<i>Pymotes</i> Predation (%)	Destroyed By Stem-boring Larvae (%)	Shrivelled Eggs (%)	Infertile (%)	Sample Total <i>Centrodora</i> Emergence	Males (%)	Females (%)
1	Riverhead	16.10.62	<i>Pteridium</i>	112	5	48	—	—	47	—	15	20	80
2	Waiwera	16.10.62	<i>Coriaria</i>	139	32	53	—	5	10	—	84	40	60
3	Wellsford	16.10.62	<i>Coriaria</i>	112	15	61	—	—	24	—	54	40	60
			<i>Hypericum</i>	92	36	17	—	—	48	—	78	36	64
4	Warkworth	16.10.62	<i>Coriaria</i>	124	41	48	—	—	11	—	126	41	59
			<i>Suttonia</i>	94	16	28	—	—	56	—	27	34	66
5	Dome Valley	16.10.62	<i>Hypericum</i>	32	3	31	—	—	66	—	80	32	68
			<i>Lycopodium</i>	49	26	—	—	—	74	—	5	40	60
			<i>Fuchsia</i>	46	74	10	—	—	16	—	34	26	74
			<i>Aristotelia</i>	58	66	20	—	—	14	—	137	35	65
6	Waipu S.	16.10.62	<i>Pteridium</i>	108	1	59	—	—	40	—	12	25	75
7	Waipu N.	16.10.62	<i>Pteridium</i>	136	4	81	—	—	15	—	67	27	73
8	Onerahi	16.10.62	<i>Coriaria</i>	153	36	52	1	—	10	—	122	31	69
9	Hukerenui	16.10.62	<i>Pteridium</i>	155	14	50	—	—	36	—	3	67	33
10	Kerikeri	17.10.62	<i>Tacoma</i>	23	13	30	—	44	13	—	?	?	?
			<i>Pteridium</i>	84	14	35	—	—	51	—	3	67	33
11	Kaeo	17.10.62	<i>Pteridium</i>	58	4	65	—	—	31	—	?	?	?
			<i>Rhopalostylis</i>	45	31	9	—	—	60	—	?	?	?
			<i>Meliccytus</i>	72	10	38	—	—	52	—	?	?	?
			<i>Fuchsia</i>	62	27	37	—	—	36	—	?	?	?
			<i>Lonicera</i>	43	63	26	—	—	11	—	?	?	?
12	Whangaroa	17.10.62	<i>Geniostoma</i>	132	58	21	—	—	21	—	29	45	55
13	Oruaiti	17.10.62	<i>Pteridium</i>	47	23	30	—	—	47	—	8	25	75
			<i>Rhabdotbamus</i>	72	10	81	—	—	9	—	4	25	75
			<i>Coriaria</i>	59	44	53	—	—	3	—	—	—	—
14	Kaiangaroa (Awanui)	17.10.62	<i>Pteridium</i>	105	28	61	—	—	11	—	8	25	75
14A	Spirits' Bay	3.2.63	<i>Muehlenbeckia</i>	91	82	13	—	—	5	—	3	33	67
15	Kaitaia	17.10.62	<i>Pteridium</i>	106	18	42	—	—	40	—	6	16	84
			<i>Ligustrum</i>	53	30	32	—	—	38	—	38	29	71
16	Victoria Valley	17.10.62	<i>Lonicera</i>	108	17	70	—	—	12	1	4	50	50

17	Mangamuka Gorge	17.10.62	<i>Lotus</i>	80	59	10	—	10	—	21	—	24	33	67
			<i>Coriaria</i>	84	51	1	—	48	—	?	—	?	?	?
18	Rangiahua	17.10.62	<i>Pteridium</i>	121	7	87	1	—	—	5	—	?	?	?
19	Te Ahuahua	17.10.62	<i>Pteridium</i>	158	42	47	—	—	6	—	—	?	?	?
20	Ngawha	19.10.62	<i>Pteridium</i>	133	39	56	—	—	1	4	—	81	28	72
21	Taheke	19.10.62	<i>Verbena</i>	108	25	54	—	—	—	21	—	260	37	63
			<i>Pteridium</i>	84	4	77	—	—	—	19	—	?	?	?
22	Waimea	19.10.62	<i>Coriaria</i>	159	33	28	—	—	—	33	—	59	31	69
23	Opononi	19.10.62	<i>Coprosma</i>	83	7	59	—	—	—	34	—	26	31	69
			<i>Pteridium</i>	43	30	60	—	—	—	10	—	?	?	?
24	Omapere	19.10.62	<i>Coprosma</i>	51	14	74	—	—	—	12	—	?	?	?
			<i>Coriaria</i>	75	22	27	3	40	—	9	—	—	—	—
25	Waimamaku	19.10.62	<i>Pteridium</i>	107	10	54	—	2	—	34	—	42	19	81
			<i>Fuchsia</i>	51	41	53	—	6	—	6	—	73	38	62
26	Waipoua F.	19.10.62	<i>Pteridium</i>	49	33	61	—	—	—	6	—	?	?	?
27	Waipoua Strm	19.10.62	<i>Fuchsia</i>	186	26	3	—	—	—	71	—	67	42	58
			<i>Coriaria</i>	79	53	5	—	11	—	31	—	?	50	50
28	Kaihu	19.10.62	<i>Lonicera</i>	129	61	18	—	2	2	17	—	?	?	?
29	Dargaville	19.10.62	<i>Coprosma</i>	104	79	17	—	—	—	4	—	40	33	67
			<i>Muehlenbeckia</i>	41	68	26	—	—	—	5	—	?	?	?
30	Tangowahine	19.10.62	<i>Coprosma</i>	83	14	44	—	—	—	41	—	?	?	?
			<i>Muehlenbeckia</i>	90	3	17	—	—	—	79	—	?	?	?
31	Kirikopuni	19.10.62	<i>Pteridium</i>	53	55	34	—	—	—	11	—	?	?	?
			<i>Lonicera</i>	43	19	12	—	—	—	65	—	24	46	54
			<i>Coprosma</i>	25	12	32	—	—	—	56	—	?	?	?
32	Parakao	19.10.62	<i>Coriaria</i>	190	20	52	—	13	1	14	—	9	44	56
33	Nukutawhiti	19.10.62	<i>Pteridium</i>	100	11	54	12	—	—	23	—	1	—	100
			<i>Geniostoma</i>	69	23	2	—	29	—	46	—	—	—	—
34	Tautoro	19.10.62	<i>Geniostoma</i>	161	34	28	—	—	—	37	1	—	25	75
35	Paithia (1)	21.10.62	<i>Geniostoma</i>	174	24	63	—	8	—	5	—	59	30	70
36	Paithia (2)	22.10.62	<i>Pteridium</i>	127	14	31	12	—	—	43	—	?	?	?
37	Bombay Hill	11.11.62	<i>Pteridium</i>	155	20	59	—	—	—	21	—	233	33	67
38	Pokeno	11.11.62	<i>Pteridium</i>	117	4	70	—	—	—	25	—	22	32	68
39	Mercer	11.11.62	<i>Pteridium</i>	144	22	44	—	—	—	33	—	50	24	76
40	Te Kauwhata	11.11.62	<i>Pteridium</i>	144	8	73	—	—	—	17	2	?	?	?
41	Huntly (1)	11.11.62	<i>Pteridium</i>	139	9	43	—	—	—	46	2	48	29	71
42	Huntly (2)	11.11.62	<i>Pteridium</i>	137	18	44	—	—	—	33	2	?	?	?
43	Hamilton	11.11.62	<i>Pteridium</i>	160	32	19	—	38	—	11	—	29	35	65
			<i>Rubus</i>	114	38	—	—	—	—	61	1	—	—	—

TABLE 1—continued

Sample No.	Locality	Date	Host Plant	Total Eggs Examined	Normal Eggs (%)	Parasitised <i>Centrodora</i> (%)	<i>Pymotes</i> Predation (%)	Destroyed By Stem-boring Larvae (%)	Shriveled Eggs (%)	Infertile (%)	Sample Total <i>Centrodora</i> Emergence	Males (%)	Females (%)
44	Cambridge	11.11.62	<i>Pteridium</i>	133	38	50	—	—	11	1}	173	31	69
			<i>Rubus</i>	117	49	20	—	—	31	—}			
45	Karapiro	11.11.62	<i>Rubus</i>	99	—	—	—	62	38	—	—	—	—
			<i>Coriaria</i>	120	84	6	—	—	8	2	118	34	66
46	Tirau	11.11.62	<i>Pteridium</i>	190	30	42	—	11	15	2	56	50	50
47	Lichfield	11.11.62	<i>Pteridium</i>	138	52	41	—	—	6	1	22	41	59
48	Tokoroa—Taupo—Rotorua: 8 sites no <i>Scolypopa</i> oviposition encountered												
49	Rotorua	12.11.62	<i>Cytisus</i>	151	93	—	—	—	7	—	—	—	—
50	Rotoiti	12.11.62	<i>Coriaria</i>	164	80	8	—	—	11	1	47	32	68
51	Rotoma	12.11.62	<i>Fuchsia</i>	103	14	1	—	—	85	—	—	—	—
			<i>Coriaria</i>	108	64	6	—	7	23	—	89	44	56
52	Kawerau	12.11.62	<i>Coriaria</i>	165	72	4	—	—	24	—	9	33	67
53	Whakatane (1)	12.11.62	<i>Coriaria</i>	174	40	37	—	—	22	1	231	36	64
54	Whakatane (2)	12.11.62	<i>Pteridium</i>	200	12	52	—	5	31	—	260	35	65
55	Kutarere	12.11.62	<i>Pteridium</i>	215	28	38	—	—	33	1	132	27	73
56	Omarumutu	12.11.62	<i>Pteridium</i>	201	39	42	—	11	8	—	130	42	58
57	Te Kaha	12.11.62	<i>Pteridium</i>	187	18	45	—	5	31	—	8	36	64
58	Maraenui	12.11.62	<i>Pteridium</i>	205	19	25	—	17	39	—	33	30	70
59	Waihou Bay	13.11.62	<i>Coriaria</i>	172	39	34	—	17	8	2	32	31	69
60	Oruaiti Beach	13.11.62	<i>Muehlenbeckia</i>	109	70	10	—	—	10	10	?	?	?
			<i>Pteridium</i>	121	28	54	—	—	17	1	8	37	63
			<i>Rubus</i>	99	65	16	7	—	12	—	?	?	?
61	Potaka	13.11.62	<i>Pteridium</i>	75	5	10	—	—	85	—	?	?	?
			<i>Coriaria</i>	51	20	49	—	—	29	2	?	?	?
62	Te Araroa (1)	13.11.62	<i>Pteridium</i>	155	22	60	—	—	18	—	21	25	75
63	Te Araroa (2)	13.11.62	<i>Suttonia</i>	171	21	33	—	—	45	1	27	19	81
64	Ruatoria	14.11.62	<i>Coriaria</i>	139	88	3	—	—	4	5	—	—	—
65	Te Puia	14.11.62	<i>Pteridium</i>	109	64	30	—	—	4	2	?	?	?
66	Tolaga Bay (1)	14.11.62	<i>Coriaria</i>	117	20	50	—	1	26	3	7	29	71
			<i>Pteridium</i>	86	14	53	—	—	33	—	?	?	?

67	Tolaga Bay (2)	14.11.62	<i>Coriaria</i>	127	42	21	—	13	24	—	?	?	?
68	Gisborne	15.11.62	<i>Pteridium</i>	241	80	12	—	—	11	2	93	34	66
69	Muriwai	15.11.62	<i>Pteridium</i>	105	19	61	—	—	18	2	?	?	?
70	Wharerata Hill	15.11.62	<i>Coriaria</i>	152	34	52	—	—	11	3	22	23	77
71	Morere	15.11.62	<i>Pteridium</i>	116	28	36	—	—	36	—	10	40	60
72	Wairoa (1)	15.11.62	<i>Pteridium</i>	136	28	44	—	—	37	1	3	33	67
73	Wairoa (2)	15.11.62	<i>Coriaria</i>	205	80	9	—	—	10	1	60	20	80
74	Mohaka	15.11.62	<i>Coriaria</i>	209	43	40	—	—	16	1	254	38	62
75	Kotemaori	15.11.62	<i>Coriaria</i>	170	93	—	—	—	7	—	—	—	—
76	Tutira	15.11.62	<i>Pteridium</i>	195	95	—	—	—	5	—	—	—	—
77	Tangoio	15.11.62	<i>Coriaria</i>	124	34	46	—	3	17	—	163	31	69
78	Napier	15.11.62	<i>Rubus</i>	157	68	18	—	8	5	1	87	37	63
79	Te Aute	15.11.62	<i>Pteridium</i>	107	90	8	—	—	2	—	1	—	100
Ormondville district: no <i>Scolytopa</i> oviposition encountered													
80	Palmerston												
	North	16.11.62	<i>Passiflora</i>	111	—	—	—	—	100	Probably effect of insecticide			
81	Bulls	16.11.62	<i>Pteridium</i>	108	99	—	—	—	—	1	—	—	—
82	Wangaehu	16.11.62	<i>Pteridium</i>	127	95	—	—	—	5	—	—	—	—
83	Wanganui	16.11.62	<i>Pteridium</i>	202	75	3	—	—	21	1	—	—	—
84	Kai Iwi	16.11.62	<i>Pteridium</i>	223	95	—	—	—	5	—	—	—	—
85	Patea	16.11.62	<i>Pteridium</i>	114	95	—	—	—	5	—	—	—	—
Patea – Inglewood: no <i>Scolytopa</i> oviposition encountered													
86	Inglewood	17.11.62	<i>Pteridium</i>	133	97	—	—	—	2	1	—	—	—
87	Urenui	17.11.62	<i>Pteridium</i>	217	90	1	—	5	5	—	—	—	—
88	Uruti	17.11.62	<i>Pteridium</i>	134	44	—	—	2	54	—	—	—	—
89	Ahititi	17.11.62	<i>Pteridium</i>	124	24	51	—	—	25	—	43	35	65
90	Awakino	17.11.62	<i>Muehlenbeckia</i>	170	14	58	—	—	26	2	294	31	69
91	Mahoenui	17.11.62	<i>Pteridium</i>	208	18	67	—	—	15	—	151	35	65
92	Piopio	17.11.62	<i>Pteridium</i>	215	76	12	—	—	11	1	19	47	53
93	Te Kuiti	17.11.62	<i>Pteridium</i>	181	36	16	—	—	48	—	56	32	68
94	Te Awamutu	17.11.62	<i>Pteridium</i>	130	3	45	—	—	52	—	?	?	?
95	Ohaupo	17.11.62	<i>Pteridium</i>	147	8	63	—	12	14	3	118	26	74

SOUTH ISLAND

96	Nelson (1)	19.11.62	<i>Lantana</i>	136	95	—	—	1	2	2	—	—	—
97	Nelson (2)	19.11.62	<i>Pandora</i>	179	95	—	—	1	4	—	—	—	—
98	Nelson (3)	19.11.62	<i>Coprosma</i>	176	83	—	—	—	17	—	—	—	—

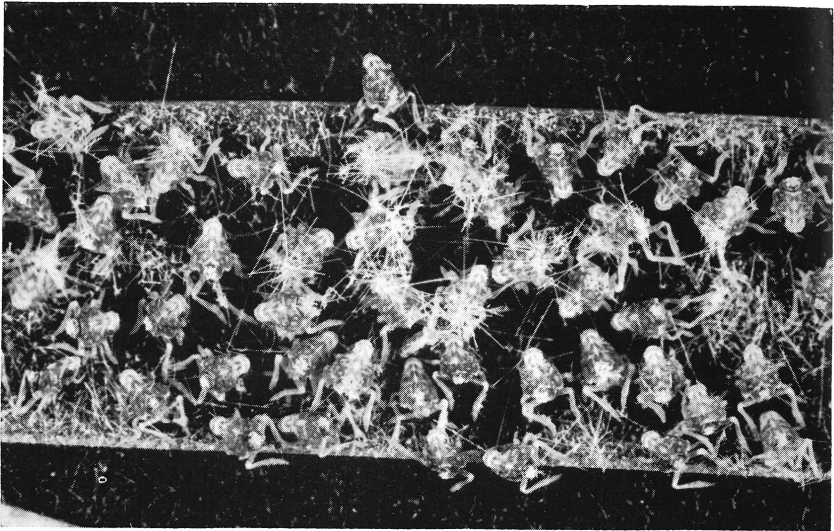


FIG. 6—Newly emerged nymphs of *S. australis* caught on cellotape.

The aspect of materials selected for oviposition varies quite considerably. When populations of the bug are very high the rather random oviposition would lead one to suppose that the requirements were not so specialised. Usually, however, small inner sheltered twigs are selected. These may range in height from ground level to perhaps 20 ft. The avoidance of excess moisture at all times, and of excess heat during late summer assist egg survival. Survival as indicated by numbers of shrivelled eggs is poor in low growing stems of *Lycopodium* and *Lotus*, as is that in the twigs of peach trees where thinning foliage increases exposure to the direct sunlight. Flooding of low-lying areas must destroy many eggs. In contrast to these conditions, survival of eggs in the stems of *Pteridium* growing up through hedges, or in the centrally placed twigs of the evergreen *Geniostoma* bushes, is high.

Biological Considerations

A number of varied biological features have emerged from the study of oviposition materials.

PARASITISATION BY *Centrodora scolypopae* VAL. (APHELINIDAE) (Fig. 7)

This parasite was first detected in eggs collected at Paihia, Bay of Islands, in August 1962. The species presents a number of interesting features. The female is considerably larger than the male. Host eggs nourish from one to four individuals, but for the most part two are present, male and female issuing from the one egg. The overall emergence ratio approaches two to one in favour of the females.

The eggs that have been parasitised are easily distinguished by their general darkening and the darker lines defining the larval boundaries. In

TABLE 2—Summarised Data on Fate of *Scolypopa* Eggs
(Overall percentages and samples range)

Area	No. of Sites	No. of Eggs	Normal Emergence	Parasitised By <i>Centrodora</i>	Shriveled Various Causes	Destroyed By Tunnelling Larvae	Infertile
North of Auckland	36	5517	27 (1-79)	39 (2-87)	30 (3-84)	2 (0-48)	<1 (0-6)
Auckland to Palmerston North	66	9784	46 (3-99)	28 (0-73)	22 (2-85)	3 (0-62)	<1 (0-10)
Nelson	3	491	90 (83-95)	Nil	3 (2-4)	6 (1-16)	<1 (0-2)

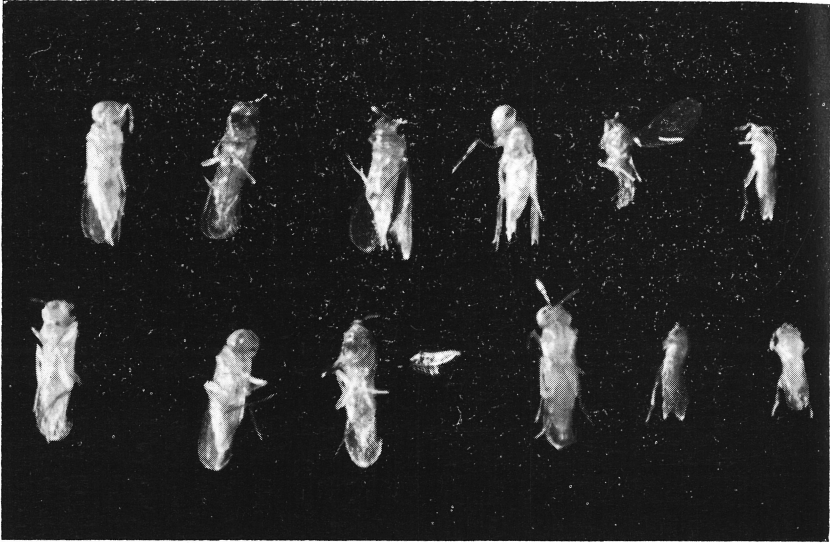


FIG. 7.—Adults of the aphelinid wasp *Centrodora scolyopae*. The four smaller individuals on the right are males. The females are less than 1 mm in length.

addition a transverse dark band appears on one side of the egg at about two-thirds of the distance from the micropylar end. A dark spot indicating the point of parasite ovipositor insertion is also usually evident on the outer portion of the egg (Fig. 8).

The development of the parasite egg in that of the host soon follows its implantation whereas the unparasitised host egg undergoes a period of diapause. However, in order that the adult parasite emergence will coincide with the appearance of the new season's eggs, there is a period of arrested larval development during spring and early summer. The stages in the development of the parasite larvae may be seen quite clearly when host eggs are immersed in 90% alcohol (Fig. 9). As many as four larvae are apparently successfully nourished, but numbers of developing embryos in excess of this have been detected within eggs.

There can be no doubt that this parasite exerts a very considerable influence on the populations of *S. australis*. In areas north of Auckland parasitised eggs may reach 87% as seen in *Pteridium* from the Rangiahua district. The parasite is absent from the Nelson district. If the distribution range of *S. australis* is divided into six approximately North to South zones and the percentage parasitism calculated for each zone, it is seen that these form a latitudinal gradient with percentages falling off rapidly at about the 38th parallel near the southern range of the parasite (Fig. 10). The southernmost record of *Centrodora* is from Wanganui where a very low percentage of parasitism was detected.

S. australis is absent from many of the cooler parts of the North Island south of Auckland. Where host populations are low the parasite is either

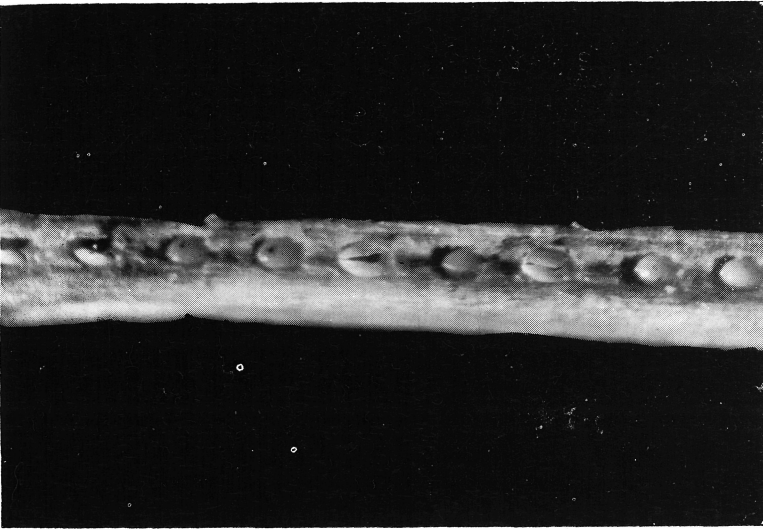


FIG. 8—Eggs of *S. australis* in situ. Those with ruptured ends indicate a normal nymphal emergence. The unhatched eggs have been parasitised by *Centrodora scolypopae*. The dark spot indicates the point of parasite ovipositor insertion.



FIG. 9—Eggs of *S. australis* immersed in 90% alcohol. Many of the parasitised eggs, which are white in contrast to those that are unparasitised, show a dark line of demarcation between the larger, female-producing, and smaller, male-producing larva.

absent or it is present in small numbers. Conversely it is generally true that the percentages of parasitism rise in higher host-population areas. The only anomaly here appears to be the Nelson district which occasionally experiences high populations of *S. australis*. It is possible that the lower temperature threshold for the parasite is passed during most winters, or that by chance the parasite has never reached the South Island. In view of the percentage parasitism gradient the first explanation is probably correct.

The zonal percentages of parasitisation in Fig. 10 are based on an examination of eggs taken from a variety of host plants. Gradients of differing steepness are obtained, however, if single host plants are considered. That based on an examination of bracken-fern (*Pteridium*), for example, commences in the north at the relatively high level of 54% compared with the general level of 39%. *Pteridium* stems are suitable for oviposition in several successive years—a condition apparently favouring the parasite.

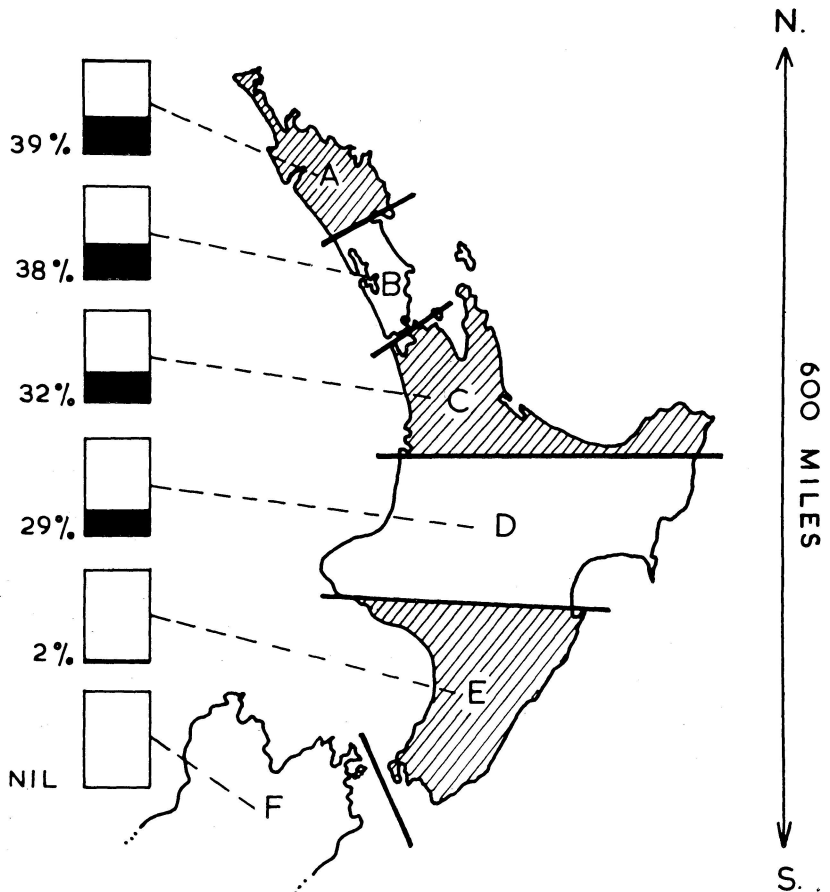


FIG. 10.—Zonal percentages of parasitisation of *S. australis* eggs by the aphelinid *Centrodora scolypopae*, from all host plants.

PREDATION BY *Pyemotes* sp. (PYEMOTIDAE) (Fig. 11)

A small percentage of eggs is destroyed by a pyemotid mite, which was present in five samples taken north of Whangarei and at one East Cape site. A level of 12% was found in samples from *Pteridium* taken at Paihia and Nukutawhiti. This species appears to be *Pyemotes ventricosus* (Newport) which is cosmopolitan and generally regarded as beneficial since it preys on a number of injurious insects. On occasions it turns its attention to man and livestock, which activities have earned it the name of "straw itch mite".

The young mite gains access to the *S. australis* egg via the implantation scar which although normally closed by ovipositor pulped tissue, is not always proof against very small creatures. On reaching the outer end of the egg it pierces the chorion and commences a sedentary existence. As its abdomen swells it is accommodated by a corresponding dent in the egg which takes on a yellowish tinge as feeding proceeds. Further shrivelling of the egg is accompanied by enormous distension of the mite abdomen through the walls of which developing eggs may be seen quite clearly. Females are fertilised by attendant males immediately they are born, and then wander off in search of hosts.

S. australis eggs which have been parasitised by *Centrodora*, as indicated by the typical darkening, are also subject to attack by *Pyemotes* as are those unparasitised eggs which have reached a stage of development in which the red eye-spots of the nymphs are clearly visible.



FIG. 11—Pyemotid mite on the end of an egg of *S. australis*. The abdomen is grossly distended.

DESTRUCTION BY STEM-BORING LARVAE (Fig. 12)

The eggs of *S. australis* are often deposited within the outer shell of harder tissue and come to be enclosed in the central pithy portion of the stem. This is the normal habitat of many species of stem-boring larvae of Lepidoptera and Coleoptera. It seems probable that the oviposition punctures assist the entry of such larvae. The larvae tunnel their way along the stems, pausing periodically to moult, and leaving increasing amounts of frass as they grow larger. A stage is often reached where the stem cavity is completely filled with frass and chewed fragments. Any eggs that lie in the path of such larvae are destroyed, and it is quite common to find series of egg groups completely wiped out in this manner. In a *Rubus* sample taken at Karapiro, 62% of the eggs were destroyed. The overall destruction of eggs, however, is not very great (Tables 1 and 2). Areas and host plants as a whole seldom show more than 5% egg destruction from this cause.

SHRIVELLING OF EGGS FROM VARIOUS CAUSES

A very considerable percentage of eggs is destroyed by agencies which leave them in a collapsed, shrivelled condition, usually with relatively solid contents, the whole at times being blackened with fungus (Tables 1 and 2). This latter for the most part involves a saprophytic species of *Cladosporium*.

When high populations of adults are present, oviposition becomes somewhat indiscriminate and the subsequent exposure of stems to direct sunlight may result in cooking of many eggs. Mention has also been made of oviposition in stems which on drying out become twisted and shrunk. Excessive moisture alternating with relative dryness may also occur in low oviposition sites and contribute to shrivelling and fungus invasion.

These factors are somewhat different from those in which shrivelling is the direct result of damage by insect feeding, parasite oviposition, etc.

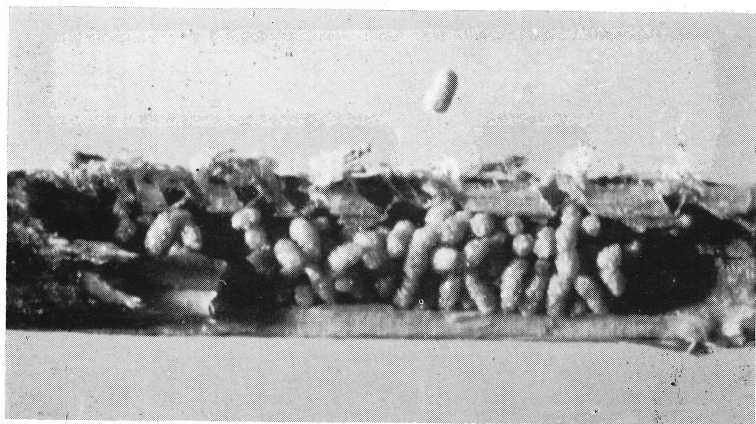


FIG. 12—Larvae of Lepidoptera boring along the stems destroy any eggs of *S. australis* that lie in their path. The lumen of the stem remains packed with frass.

Shrinking following *Pyemotes* attack has been mentioned above. There is also the possibility of desiccation or fungus attack following parasitisation by *Centrodora*. In addition a number of undetermined species of mites may play a minor part. Predaceous bugs, e.g., *Nabis* spp. and thrips may be responsible in cases where little of the egg contents remain.

In areas of bug abundance, adults may inadvertently destroy their own eggs. When competition for suitable twigs is high, cross-implantation often results in the ovipositor striking eggs already implanted from points adjacent and opposite. This may account for 50% of the eggs in some samples (Fig. 13).

In areas north of Auckland shrivelling from various causes ranged from 3–84% with an overall 30%. Between Auckland and Palmerston North equivalent figures were 2–85% and 22%. The Nelson samples showed 3% of shrivelled eggs.

INFERTILITY

A small number of eggs—usually fewer than 1% have been classified as infertile. Their contents remain clear when normal embryological development should have produced a cloudy appearance. There is usually some measure of shrinking.

Egg Survival

The study of the egg complex occupied a period extending beyond nymphal emergence. At no stage, however, was there any doubt as to the fate of eggs. In the earlier examinations full eggs were classified as normal when there were no discolorations or dark markings typical of the parasitised egg. Later the normal egg showed the distinctly red eyespots of the develop-

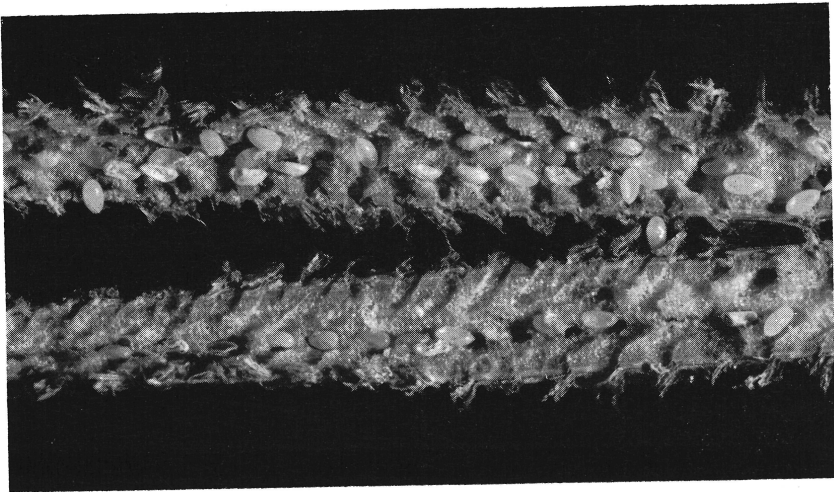


FIG. 13—Gross oviposition by *S. australis* in *Buddleia* sp. has resulted in the "spearing" and destruction of many eggs.

ing nymph. Still later, when nymphs were emerging, the egg which had produced a nymph was quite easily distinguished from that which had produced a parasite. In the former case the chorion remains quite white, the end is characteristically ruptured by the emerging nymph, and in addition the exuvia shed immediately following emergence is usually evident at the site. In the latter case the chorion is darkened, the end of the egg shows that a cap has been chewed off leaving a rather jagged edge, and brownish mecomium products may be seen adhering to the inner side of the egg.

Egg survival in areas north of Auckland ranged from 1–79% with an overall 27%. South of Auckland the North Island figures were 3–99% and 46%. In three Nelson samples (South Island) overall emergence was 90%. Fig. 14 indicates average percentages of successful nymphal emergence when the north-south distribution is divided into three zones. This ranges from 27% in the northernmost to 93% in the southernmost.

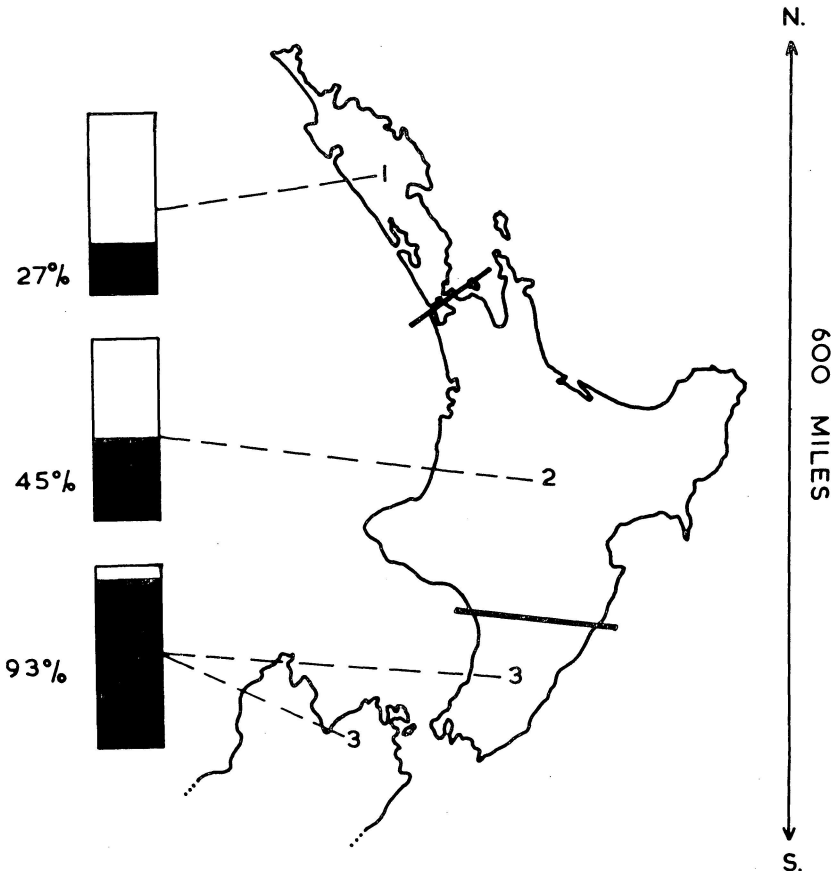


FIG. 14—Percentages of successful egg survival in *S. australis* for three north-south zones.

THE NYMPHAL COMPLEX

Collections of nymphs at various stages of development were made from many localities during the 1963–64 season and preserved in alcohol until detailed examinations were carried out. Field observations were also made during this period.

One minor cause of nymphal mortality was observed during the examination of eggs. When eggs are laid in the tissue surrounding the lumen of hollow stems the cap of macerated material made over the egg following oviposition may offer more resistance than the tissue surrounding the lumen of the stem. Nymphs attempting to emerge work inwards rather than outwards and die imprisoned. In normal oviposition there is some mortality during the struggle to reach the exterior.

Some older nymphs showed lateral abdominal scars. The consistent positioning of these indicated that they were self-inflicted rather than caused by some predator. Apparently the spines on the hind legs may come in contact with the body wall when the larger and fatter individuals are forced to leap from one position to another.

Dissections of nymphs gave no indication of any parasitic species, and no abnormalities such as might be caused by fungus or bacterial diseases were observed.

In the field nymphs were occasionally found in spider webs, and jumping spiders were observed preying on nymphs of various sizes (*Dolomedes. Trite, Sidymella* spp.). The importance of these predators is difficult to assess.

THE ADULT COMPLEX

Collection of adults were made from a number of localities in North Auckland areas during the summer of 1963–64. An examination of these failed to give evidence of any attack by parasites. A few individuals were found infected by fungi (*Trichothecium, Hymenostilbe, and Hirsutella* spp.). Adults were occasionally taken from spider webs. The German wasp *Vespa germanica* F. was observed attacking adults. After removal of the wings the body is chewed up and rolled into a ball before its transport back to the nest. Sparrows were also observed collecting the adults from garden plants.

DISCUSSION

When attempts are made to control an introduced species by means of biological control, the assessment of controlling agents already influencing existing populations in their new habitat is too often neglected. Subsequent attempts to evaluate introductions prove difficult if the original status of the pest is not clearly determined. The present work is essentially preparatory to the study and introduction of parasites and predators from Australia.

The accurate estimation of populations, especially in an insect such as *S. australis* with its wide geographic range and choice of host plant, is extremely difficult and time consuming. The incidence will also vary from

year to year. However, an attempt to illustrate any future significant reductions in populations is being made using the degree of oviposition as an index of population. The counting of oviposition punctures on vine tendrils—passion-vine and grapes—during the first week in April has commenced at a selected northern site which is known to be free from the effects of any spray programme.

There can be no doubt that the populations of *S. australis* occurring in its more favourable habitats in New Zealand far exceeds those which occur in Australia. Although a number of controlling agents are already operating in this country only one, the egg parasite *Centroдора*, has any significant effect, and this does not reduce numbers to an acceptable level. The presence of this parasite, which is almost certainly of Australian origin, strengthens the probability that *S. australis* has reached New Zealand as eggs implanted in the stems of imported shrubs.

The considerably higher egg survival experienced in the more southern populations of *S. australis* does not mean that populations are correspondingly great, for a latitudinal range which covers the southernmost extension of the species is involved. However, high populations are not excluded from the southern areas of distribution. Populations are consistently high in northern areas, whereas in the south there appears to be a periodic abundance dependent upon the conditions prevailing in successions of seasons.

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