Francisco. Mr. Leech not only named any beetles I sent him, but ever since his student days at this University, has given me insects of many Orders for our collections. In the one year that he was a student here in 1956-57, Hugh's son Robin carried on in his father's beetling footsteps. We owe a great deal to this father and son team and acknowledge it with pleasure and gratitude.

Many students also, over the years, have given us specimens we lacked or those of which we had very small series.

On 11 March, 1952 the beetle collection was counted by five senior students in Entomology and again on 18 October, 1957 by Michael J. Daniels, a graduate student in Zoology: the totals are shown below.

	March 1952	October 1957
Number of families		80
Total specimens	24484	30616
Duplicates only	10084	10231
No. of B. C. species	1138	1538
Total species	1864*	2211

* Errors, omissions and additions excepted.

The gain in five and one half years is exactly 400 species and 6132 specimens, a pleasing total. There is still a long way to go to catch up to Mr. Gordon Stace-Smith who has over 2400 B.C. species and an unknown number of specimens. On the other hand, considering that there was not ONE SINGLE beetle here when I arrived, these totals are gratifying especially when one considers the other orders I have assembled, *e.g.*, some 6000 specimens each of Hymenoptera and Hemiptera, about 4000 Orthoptera, 12000 Diptera and minor Orders in proportion.

These figures emphasize what I have pointed out repeatedly, namely, that British Columbia is an entomologist's paradise.

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TRITHION AS AN ORCHARD INSECTICIDE[1]

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Trithion[3], formerly known as Compound R-1303, is the brand name of a material containing *O, O*-diethyl *S*-(*p*-chlorophenylthiomethyl) phosphorodithioate (Stauffer Chemical Company, 1956).

This paper is a summary of the main, or typical, findings of experiments that we carried out with Trithion in the Okanagan Valley of British Columbia from 1955 to 1957. Though otherwise excellent, this material has a shortcoming indicated herein, that precludes its recommendation for use in British Columbia orchards.

Trithion has been available as a 25 per cent (by weight) wettable powder and as a "flowable" material, an aqueous emulsion containing 4 pounds of the technical chemical per U.S. gallon. We do not know the nature of the so-called inert materials in either formulation.

The compound interested us as a general insecticide comparable with Diazinon [*O, O*-diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate] in having "wide-spectrum" effectiveness against several groups of orchard insects and mites (Pielou and Proverbs, 1958) and was compared directly with Diazinon in many of our orchard trials.

Method of Application and Deposits on Leaves

The material was applied in two ways. First, large blocks of trees were sprayed with a standard air-blast concentrate machine moving at one mile per hour and applying 75 gallons of liquid per acre. This amount, in a mature orchard, gives full foliar coverage with practically no leaf-drip. With this method the insecticide was usually applied at 8 pounds of 25 per cent wettable powder per acre (concentration of active ingredient in

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water in the sprayer tank, approximately 0.27 per cent by weight). Secondly, the insecticide was applied as a high-volume, dilute spray with a gun machine, or, to small trees, with a hand-operated barrel sprayer. In either case spray was applied until all leaves were dripping. Normal dilutions were one or two pounds of 25 per cent wettable powder or equivalent emulsion in 100 gallons of water (concentration of active ingredient in water approximately 0.025 and 0.05 per cent by weight respectively).

Chemical analysis of leaves immediately after the spray had dried showed that concentrate application at the standard 8-pound rate results in deposits averaging 3.05 micrograms Trithion per square centimetre. Dilute application at the one- and two-pound rates gave deposits averaging 2.33 and 5.70 micrograms per square centimetre respectively (Pielou and K. Williams, unpublished observations).

Control of the Codling Moth

The codling moth, *Carpocapsa pomonella* (L.), is the most serious apple pest in British Columbia. For a number of years it has been assumed that control of this species could only be attained if there is a persistent deposit, above a certain minimum value, of a suitable insecticide on leaves and apples during the period of emergence and oviposition of the first brood (approximately from the end of May to the end of June) and, sometimes of the second brood (approximately the first two weeks in August). DDT has been a standard material (Marshall, 1953) for such "cover" sprays in British Columbia for the last twelve years and is used as a reference material in testing new insecticides. Though DDT is satisfactory the possibility of the appearance of DDT-resistant strains of the codling moth in British Columbia warrants search for new insecticides.

In 1956, plots in an orchard of Red Delicious apples were treated with four cover sprays on May 25, June 11 and 27, and July 30. Application was made with an efficient air-blast concentrate sprayer travelling at one mile per hour. The materials compared were 50 per cent DDT wettable powder at 6 pounds per acre (*i.e.* 3 pounds active material) and 25 per cent Trithion wettable powder at 9 pounds per acre (*i.e.* 2¼ pounds active material). No sign of spray injury was seen though the residue of Trithion had a rather objectionable, spotty appearance. At harvest, 500 apples were picked from each of five trees for each treatment. The percentages of wormy fruit for the treatments were: DDT, 10.7; Trithion, 9.0. The corresponding percentages for "stings" (unsuccessful larval attacks) were 3.3 and 2.2. The difference is not statistically significant in either case.

In 1957 the experiment was repeated on Red Delicious, Golden Delicious and McIntosh apples. The layout of the orchards did not permit randomization of varieties, so comparisons are only possible between the two materials within varieties. On Red Delicious at harvest the percentages of wormy fruit for the treatments were: DDT, 6.6; Trithion, 10.8. On Golden Delicious: DDT, 12.5; Trithion, 17.5. On McIntosh: DDT, 8.4; Trithion, 7.7. These would be high figures in commercial control but we deliberately choose heavily infested orchards, so initial population was high. None of the differences are statistically significant. Trithion appears, therefore, as equal to DDT for control of the codling moth.

Considerable foliar damage occurred with Trithion in 1957; this is referred to later.

Control of the Eye-Spotted Bud Moth

The larva of the eye-spotted bud moth, *Spilonota ocellana* (D. & S.), does not damage the fruit in the serious way that the codling moth larva does, but the superficial injury is a blemish, which, with the present premium on surface finish, downgrades the fruit. In the 1956 trials against the codling moth, the eye-spotted bud moth was also common in the experimental plots.

Bud moth injury affected only 1.0 per cent of the fruit in the Trithion plots but was 10.2 per cent on the DDT plots. In another experiment an infestation of bud moth on cherry was totally destroyed with Trithion.

Control of the Apple Aphid

We have compared Trithion with other aphicides for the three years that trials have been in progress. Malathion [*S*-(1, 2-dicarbethoxyethyl)-*O, O*-dimethyl phosphorothithioate] has been used as the reference material because it is the recommended aphicide for British Columbia. The apple aphid, *Aphis pomi* DeG., has become, after the codling moth, the most serious pest of apple in British Columbia.

The state of affairs, and the effectiveness of Trithion, may be illustrated by the following examples:

1. A good commercial orchard of McIntosh and Red Delicious apples under sprinkler irrigation and with permanent grass cover crop was moderately infested with aphids. The trees in this orchard were up to 18 feet high, well pruned, at the peak of production, and not overfertilized. Separate plots of 17 to 23 trees each were sprayed in late July with Trithion and Malathion emulsions. Application was at the rate of 4 pounds of active ingredient per acre, with an air-blast concentrate sprayer applying 75 gallons of liquid per acre. On three occasions after application ten terminal twigs were cut at random from each of ten trees for each treatment. As apple aphids tend to congregate on the uppermost leaves of a twig, the five terminal leaves on each twig were closely examined for living aphids. In all, 500 leaves per treatment were examined on each occasion. Results are shown in Table I where the figures indicate total aphids per 500 leaves. It will be seen from the table that re-infestation was almost complete within three weeks. Trithion and malathion were approximately equally effective.

TABLE I

Days after application	4	10	20
Trithion plots	3	21	161
Malathion plots	6	30	198
Untreated plots	320	282	265

2. When five-year-old Red Delicious trees, growing very vigorously, were sprayed with the two materials at the same rates, somewhat different results were obtained. These trees had, initially, a much heavier infestation (over 100 aphids on some leaves) than those in the preceding example. Three days after application almost complete kill was noted on exposed, uncurled leaves with both materials. When the young leaves of the growing points of twigs were unfolded, however, eight survivors were found per terminal with the malathion treatment and three for the Trithion treatment. In view of the many small branches that were involved, this meant a considerable total of living aphids on each tree. Considering the great reproductive potential of the apple aphid these constituted a ready source of infestation. The difference with the two materials is just statistically significant.

3. We have carried out extensive experiments on dwarf apple trees (growing on Malling IX dwarfing rootstock). On these trees insecticide was applied as a conventional, dilute spray at 0.5 pounds of active ingredient per 100 gallons. These experiments, as a whole, showed that Trithion was significantly better against the apple aphid than malathion: On these well-growing, much branched and well-fertilized small trees, survival of aphids on uncurled leaves after treatment with malathion was approximately five per cent on the average. On such leaves complete mortality was nearly always achieved with Trithion. However, when the tightly curled

young leaves at the tips of the terminals were examined, survivors were found with both materials. The percentage of survivors varied in different experiments but there were significantly fewer with Trithion in nearly every case.

At this point it is noteworthy that other work at the Summerland laboratory (Pielou and K. Williams, unpublished) showed that although Trithion has a persistent residue, chemically detectable after three weeks, the residue is ineffective in preventing reinfestation by the apple aphid. This is because the fall-off in deposit, to a level insufficient to affect aphids, is very rapid in the first three days. However, the small residual deposit appears to be effective against the European red mite, *Metatetranychus ulmi* (Koch), about two weeks after application (Downing, 1958).

Only a few years ago, fruit growers applied special spray treatment to control the apple aphid; at most, a single application per season of one of the older aphicides such as nicotine kept this aphid at a subeconomic level. However, in recent years infestations have increased, and they have persisted for a longer part of the season. Several applications of aphicides have often been necessary and there have been many complaints from growers that malathion was ineffective and some contention that the insect had developed strains resistant to this material. However, we have no evidence for development of strains resistant to malathion and our experience suggests an alternative hypothesis. As indicated above, where mature, reasonably fertilized trees with not much succulent new growth, have been sprayed with malathion we have achieved almost perfect control, as we have done also with newer organic phosphate materials. Admittedly, reinfestation by winged aphids from other sources has often taken place within two to four weeks. However, when malathion has been applied to young, vigorously growing trees with plently of succulent growth arising from plentiful watering and nitrogenous fertilizer, we have not achieved satisfactory control. Such trees are apt to support a very high population of the apple aphid; these aphids have a strong preference for the terminal growing tips of the twigs. There, large numbers of aphids cause leaf curling and consequently are well protected; although malathion destroys nearly all aphids on exposed leaves there are always a considerable number of survivors in the curled terminal leaves. Better results were achieved with Trithion but perfect control was rare.

Apart from the mechanical protection afforded by curled leaves, together with the very high populations that offer a greater chance for some survival, the experiments described above suggest that aphids on such young, vigorous trees are more difficult to kill than those on mature trees. Aphids surviving on such trees provide a source of reinfestation for all trees.

Changes in cultural practices in the last decade, rather than destruction of predators by DDT, seem to have brought about the overall increase in apple aphid populations. Use of high-nitrogen fertilizers, such as ammonium nitrate, has increased without any reduction in the total quantity of fertilizer applied per acre. And there has been a change from furrow irrigation to sprinkler irrigation with consequent greater use of water. Along with the change to sprinkler irrigation clean cultivation has been abandoned in favour of permanent or semi-permanent cover crops. The vigorous, succulent growth induced in trees, especially young trees, and the general increase in moisture and humidity appear to have created ideal conditions for what can only be described as the culture of aphids in orchards. This is the most probable explanation of present high aphid populations, of the ready reinfestation after control and of the impossibility of achieving seasonal control with a single application of any of the current insecticides.

Control of Other Aphids

Trithion at two pounds of 25 per cent wettable powder per 100 gallons applied with a high-volume sprayer gave almost perfect control of the thistle aphid, *Anuraphis cardui* (L.), on prunes and of the mealy plum aphid, *Hyalopterus pruni* (Geof.) (=*H. arundinis* (F.)), on prunes and apricots. After a single application in the summer it was difficult to find any living aphids. Reinfestation with either of these species is generally not a problem if the entire orchard is sprayed. The mealy plum aphid on old apricot trees over 20 feet high was also effectively controlled by a single application of Trithion, at eight pounds of 25 per cent wettable powder per acre, with a concentrate sprayer.

Because of the lack of infestations only a few tests were carried out on the black cherry aphid, *Myzus cerasi* (F.) and these were on very small trees. At two pounds of 25 per cent wettable powder per 100 gallons 100 per cent mortality was achieved. A difficulty in controlling the black cherry aphid is that cherry foliage is particularly susceptible to injury from malathion and there are objections to other common aphicides (Pielou and Proverbs, 1958). Trithion caused some foliar damage (vide infra) but less than malathion. However, Diazinon, the material now recommended, is practically harmless to cherry foliage (Pielou and Proverbs, 1958).

We have not done any work with the green peach aphid, *Myzus persicae* (Sulz.), an occasionally troublesome pest of peaches. This aphid has been present only at a low level in the Okanagan Valley in the last three years. However, experiments elsewhere suggest that Trithion gives only indifferent control of this aphid.

Control of Lecanium Scales

Scale insects of the genus *lecanium* have become a serious problem on peaches and apricots in the Okanagan Valley in the last few years. Trithion applied in the dormant stage at 2.4 pounds of 25 per cent wettable powder, as a dilute spray from a handgun machine controlled these insects. But application four weeks later, when the buds were showing pink, was less effective. Malathion application at the latter date and rate was decidedly inferior to Trithion. However, Trithion, at this stage of plant development, was inferior to Sevin [N-methyl-1-naphthyl carbamate; Union Carbide Chemical Company, White Plains, N.Y.] which gave excellent results. In July the average numbers of surviving scales per 50 leaves were: Sevin, 64; Trithion, 228; malathion, 349; untreated, 1580.

Control of the European Red Mite

Some data have been recorded on the effect of Trithion on the European red mite, *Metatetranychus ulmi* (Koch), in comparison with other materials (Downing, 1958). Trithion, when applied at the pink-bud stage, gave good control of the mite on apple. After application by air-blast concentrate sprayer at the rather high rate of 16 pounds of 25 per cent wettable powder per acre on Red Delicious trees in early May, the density of mites was 0.10 per leaf in early June and 0.81 per leaf in early August. Comparable figures on plots that received no treatment were 0.27 and 19.8 per leaf.

As a summer spray, Trithion was also effective. Trithion was applied to Winesap apples in mid-July at the rate just mentioned. At the end of July the average number of mites was 1.74 per leaf; by mid-August, 0.46 per leaf. The comparable figure on untreated trees was 21.8 per leaf by the end of July, the population being so high that these control trees had to be sprayed to satisfy the grower.

Control of Brown Mite

Trithion, applied as a dilute spray in summer at one pound of 25 per cent wettable powder per 100 gallons, reduced populations of the brown mite, *Bryobia arborea* M. & A. from 21.6 per leaf of 8.6 in ten days and to zero in six weeks. The comparable figures on untreated trees were 22.0, 5.6 and 13.4. Trithion was also significantly superior to the specific miticide, sulphenone [*p*-chlorophenyl phenyl sulphone; Stauffer Chemical Company, Mountain View, California] recommended for the brown mite in British Columbia.

Control of the McDaniel Spider Mite

Application of Trithion by air-blast concentrate sprayer in summer at the somewhat high rate of 12 pounds of 25 per cent wettable powder per acre reduced the number of the McDaniel spider mite, *Tetranychus mcdanieli* McG., to an average of 1.6 per leaf in eight days and to 1.2 per leaf in 21 days. With application at eight pounds per acre the figures were 4.6 and 2.7. The comparable figures for untreated trees were 24.2 and 25.4. Control of the McDaniel mite with Trithion was as good as with the miticides now recommended.

Control of the Apple Rust Mite

The apple rust mite, *Vasates schlechtendali* (Nal.) has been controlled with Trithion. On Italian prunes, application of a dilute spray with a gun-type machine reduced the number of mites from 203 to less than one per leaf in 26 days. As the rust mite is much smaller than those previously mentioned, this reduction in numbers is regarded as evidence of adequate control. On untreated trees in this experiment there was some reduction from natural causes, but there were still 64 rust mites per leaf after 26 days.

Trithion was ineffective against another common eriophyid, the pear leaf blister mite, *Eriophyes pyri* (Pgst.).

Phytotoxicity

Although in 1955 and 1956 Trithion had produced no signs of leaf or fruit damage when applied either as dilute or concentrate sprays, in 1957 damage from this material was evident in several orchards. On Golden Delicious apple the damage was particularly bad. Two weeks after the second cover spray, yellowing and necrosis of many leaves were apparent and defoliation was beginning; another two weeks later, defoliation was extensive. In some plots, further application of Trithion had to be discontinued for fear of total defoliation. At harvest time, the apples showed some russetting and were smaller than those from trees that had been sprayed with DDT. On Red Delicious, there was no serious defoliation but the leaves showed numerous purple spots that later became necrotic. Up to 50 per cent of the leaf area was affected in this way. McIntosh foliage showed least injury although some leaf spotting was eviden in the lower branches.

Some yellowing of leaves and slight defoliation were evident on apricot and cherry trees to which dilute sprays of Trithion had been applied. Severe defoliation of cherry occurred after application of concentrate spray as a drench. Trithion also caused some yellowing of the foliage of strawberries, ornamentals, and certain vegetables.

Both wettable powder and emulsion formulations of Trithion caused injury in 1957. It was first thought that the damage might have been due to a change in formulation. Tests of phytotoxicity therefore were carried out with some of the material supplied in 1956. Again, serious leaf spotting and defoliation were apparent, particularly on the variety Golden Delicious. It seems probable, therefore, that the technical material itself is responsible for the damage and that growing conditions (1957 was a late season with cool summer) were particularly favourable for damage. Alternately, perhaps, climate conditions favoured weathering of Trithion to some particularly phytotoxic breakdown product in 1957. In any case, in view of the importance of the varieties, Red Delicious and McIntosh, and the rapid increase in plantings of Golden Delicious, we considered that Trithion, in spite of its great insecticidal potency and the fact that it caused damage only in one year out of three, could not be recommended to the growers. Moreover, there are reports of damage in Trithion trials from Washington State (Anthon, 1958) and from Australia (G. Miller, Tasmania Dept. of Agriculture, private communication).

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ERADICATION PROCEDURES FOR ORIENTAL FRUIT MOTH IN THE OKANAGAN VALLEY OF BRITISH COLUMBIA

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In 1957 plans were outlined for the eradication of a potential infestation of oriental fruit moth in the Southern Okanagan Valley (1). It is now intended to report on what was done and the results as noted to date.

In the fall of 1956 the ripening rooms of the two canneries involved were fumigated with methyl bromide. This served as an immediate check on the most probable locations of infestation as the fruit had been placed in these rooms on arrival and before going into cold storage until processed.

Extensive organization by federal and provincial authorities resulted in an early spring and summer program of insect elimination. This included cannery fumigation, removal of trees and fumigation of the orchard land where possible infested fruit waste had been scattered, fumigation of other waste dump areas, spraying of orchards adjacent to canneries and compensation for any losses, and trapping for possible recovery of adult oriental fruit moths throughout the Southern Okanagan Valley.

Early in the year fumigation matters were attended to and a deadline date of April 6, 1957, was set. After contracting for the fumigation of the canneries and certain land areas, it was necessary to assemble a great deal of material, including electric gas analyzers, polyethylene tubing, thermometers, leak detectors, test insects, cages, extension cords, etc. A mobile laboratory was obtained to house the gas analysis equipment. The fumigators, Columbia Pest Control, Ontario, California, supplied their own tarpaulins to cover the areas and, on March 13th, started to cover the cannery of York Farms, Osoyoos. This was completed in one day. The area fumigated was 333,015 cubic feet. In this same vicinity it was required to fumigate a junk pile of 11,000 cubic feet, settling pits of 13,000 cubic feet, and a fruit refuse dump area of 4,500 cubic feet.

On March 18th the operators moved to Barkwill Cannery at West Summerland. The area involved in the cannery fumigation was 298,000 cubic feet, an adjacent hillside 10,000 cubic feet, the orchard area 423,600 cubic feet, with a re-fumigation of 16,800

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