SOIL SAMPLING AND EXTRACTION METHODS WITH POSSIBLE APPLICATION TO PEAR THRIPS (THYSANOPTERA: THRIPIDAE)

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Abstract

Techniques are described for the sampling and extraction of microarthropods from soil and the potential of these methods to extract the larval stages of the pear thrips, *Taeniothrips inconsequens* (Uzel), from soil cores taken in sugar maple stands. Also described is a design for an emergence trap that could be used to estimate adult thrips populations as they move from the forest floor into the tree canopy.

Introduction

The pear thrips, *T. inconsequens*, was introduced around 1904 from Europe to America where it became established on such hosts as maple, basswood, birch, beech, ash, and black cherry (Simons 1985). Since 1984 there has been a dramatic rise in the number of pear thrips infesting sugar maple trees such that the resulting damage has become a major concern among sugarmakers in the major syrup producing regions in the northeastern United States.

Very little documented work is available on pear thrips (Skinner 1988) particularly with regard to its economic importance on sugar maple. One of the problems facing workers is to develop a reliable monitoring system that will enable establishment of a threshold value for damage. Once this is determined it may be possible to monitor the number of viable larvae at emergence and warn sugarmakers of the likelihood of damage and its severity. This will allow farmers to take the recommended action against the pest before serious economic damage is done to the sugar maples.

Adult thrips attack the sugar maple at the bud stage, damaging the bud and causing the characteristic deformation of newly opening leaves. Eggs are laid in veins of the foliage and in the stem. Newly hatched larvae feed for a short time and then drop to the ground. A large proportion of their life cycle is spent below the soil surface prior to pupation and emergence of new adults the following season (Fig. 1). At this stage it is possible to use techniques currently employed in the extraction of soil arthropods, to obtain the larvae from soil cores taken in sugar maple stands. The number of larvae obtained from these soil cores can be used to assess overwintering mortality and the number of viable larvae that will become the next season's pest. In conjunction with sampling the population of adult thrips present in the tree, it may be possible, over a number of seasons, to calculate an "economic damage threshold value."

Simultaneously these techniques will enable researchers to obtain valuable qualitative and quantitative data on the soil mesofauna for use in the development of a "Total Forest Ecosystem Monitoring Program" (Teillon 1988). This would be especially important if chemical methods of thrips control, eg. carbaryl, are used because the effects of such chemicals on beneficial, as well as, non-beneficial soil arthropods may be significant.

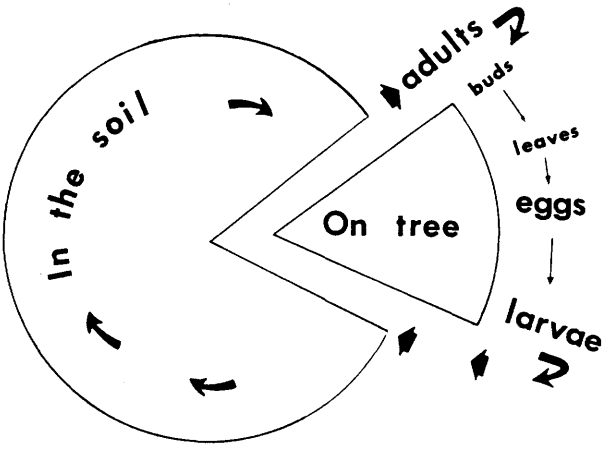

Figure 1. Probable life cycle of pear thrips in Vermont sugar maple stands (from Parker et al. 1988). For more specific life cycle information, see Skinner & Parker, poster presentation, this proceedings.

Materials and Methods

Soil Sampling and Extraction of Microarthropods

The large acreages of sugar maple that are infested will require many soil samples to obtain accurate data on numbers of viable larvae present. A sampling pattern must be designed that is statistically sound with a standardized sample size. This is usually a 5 cm diameter, 15 cm deep soil core, which is about 250-300 ml of soil. Commercial equipment is available to take the soil cores, eg. golf course hole cutters and bulb planters, both of which are relatively inexpensive and easy to use (material suppliers listed on page 173).

To extract a large number of soil cores efficiently and quickly requires specialized methods and equipment. A number of options are available such as heat extraction, flotation and grease film extractions (Table 1).

Table 1. List of dry funnel and flotation methods of extraction of soil arthropods (after Edwards & Fletcher 1971)

Dry Funnel	Flotation
Simple plastic funnels (Edwards & Fletcher 1970)	Simple brine flotation (Edwards & Fletcher 1970)
Rothamsted controlled gradient funnels without heat (Edwards & Fletcher 1971)	Salt and Hollick flotation (Salt & Hollick 1944)
Rothamsted controlled gradient funnels with heat (Edwards & Fletcher 1970)	Mechanized flotation (Edwards & Heath 1963)
Split funnels (Murphy 1962)	Grease film extractor (Aucamp & Ryke 1964)
High-gradient funnels (moist regime) (MacFadyen 1962)	
High-gradient cylinder extractor (MacFadyen 1962)	
Infra-red extractor (Kempson et al. 1963)	

In 1971, eleven of the most commonly used techniques were compared (Edwards & Fletcher 1971) and data were collected on the efficiency of these methods to extract soil arthropods, including Thysanoptera (Table 2). Of these eleven methods the controlled-gradient (with heat) extraction technique proved to be the most efficient for retrieving the major groups of arthropods and thrips. This method is used by many soil ecologists today.

Two controlled-gradient extractors are currently in use at the Ohio Agricultural Research and Development Center (O.A.R.D.C.), Wooster, Ohio. The first extractor built was a self-contained 80-sample

Table 2. Comparison of methods of extracting Thysanoptera from clay-loam soil under three types of management (after Edwards & Fletcher 1970, from Lewis 1973) [Mean number of thrips per soil core (10 cm diam x 5 cm deep) is expressed as log (N+1).]

	Method[a]													
	Dry funnel							Flotation						
	A	B	C	D	E	F	G	H	I	J	K	s.e.[b]	l.s.d.[b]	Variance ratio
Woodland	0.029	0.048	0.000	0.000	0.067	0.048	0.056	0.086	0.019	0.322	0.111	0.042	0.110	4.436[c]
Pasture	0.000	0.019	0.019	0.029	0.019	0.000	0.056	0.000	0.169	0.481	0.000	0.044	0.116	11.270[c]
Fallow	0.000	0.000	0.000	0.000	0.019	0.000	0.038	0.086	0.094	0.056	0.049	0.026	0.068	1.799

[a] A. Simple plastic funnels (Edwards & Fletcher 1970)
B. Rothamsted controlled gradient funnels without heat (Edwards & Fletcher 1970)
C. Rothamsted controlled gradient funnels with heat (Edwards & Fletcher 1970)
D. Split funnels (Murphy 1962)
E. High-gradient funnel (moist regime) (MacFadyen 1962)
F. High-gradient cylinder extractor (MacFadyen 1962)
G. Infra-red extractor (Kempson et al. 1963)
H. Simple brine flotation (Edwards & Fletcher 1970)
I. Salt and Hollick flotation (Salt & Hollick 1944)
J. Mechanized flotation (Edwards & Heath 1963)
K. Grease film extractor (Aucamp & Ryke 1964).

[b] s.e. = standard error of means. l.s.d. = least significant difference.

[c] Significantly different at 0.01% level.

machine, which generates and maintains a heat gradient within the soil sample using a compressor, heat exchanger and pump to provide cooling to the bottom of the sample and electric light bulbs (25 watt) to supply heat to the top of the sample. A heat-gradient of about 15°C between the top and bottom of the soil sample gives the best results. A smaller 36-sample extractor was also constructed and housed in a controlled temperature room to provide cooling (21°C). Electric light bulbs (15 watt) provide heat (38°C) at the top of the sample. This heat gradient causes the soil sample to dry out from the top downwards. The arthropods respond by moving down the sample to avoid desiccation, eventually moving out of the sample, falling through the mesh bottom of the sample holder where they are collected in vials containing a mixture of 70% ethanol, 5% glycerol and 25% water.

Trials have shown that both machines operate at similar efficiencies. The major difference between the two is cost. The self-contained extractor can be constructed at a cost of $3,500, the major expense (about $2,500) being the compressor, heat exchanger and pump. The smaller 36-sample extractor can be built for $160 (about $320 for a machine capable of extracting 72 samples) but this does require a temperature-controlled room. Both machines are suitable for extracting Thysanoptera.

Emergence Trap

Trap design. Information needed to help develop a monitoring program for pear thrips can be obtained from the numbers of adult thrips emerging from the soil in the spring and migrating to the maple trees. To obtain these data, a suitable emergence trap is required. A number of methods have been evaluated with some success (Laudermilch 1988). The following emergence trap design would enable researchers to obtain data on emerging thrips as well as other soil arthropods in one operation.

Due to the large numbers of samples required, low cost and ease of use in the field and laboratory were key elements in the design. The trap consists of two parts: a soil unit which is a mesh cylinder capable of holding a soil core, and a trapping unit which is attached to the top of the mesh cylinder. Materials and method of construction are shown in Figure 2.

Some positive aspects of this design are:

1. The soil core is kept in as natural a condition as possible during the trapping period. The mesh cylinder and perforated bottom allow gasses, moisture and arthropods normal movement in and out of the soil core.

2. The whole unit is relatively inexpensive and easy to assemble using readily available laboratory equipment.

3. The unit is durable and lightweight so large numbers of traps can be carried to the experimental site with little effort, and should last for a number of trapping seasons.

4. Both the soil core and emergence catch can be transported to the laboratory easily and the catch quickly dispensed for storage or sorting.

5. Set out and retrieval of traps can be carried out easily by one person.

6. Traps are reusable and are easily dismantled, cleaned and stored.

Apart from the cylinder mesh which can be purchased at most hardware stores, all other components are readily available from biological suppliers. The total cost of a single trap is $7.00, but this can be reduced if funnels and bottles are bought in bulk.

Key to Figure 2

1. Perforated stopper.

2. 2 1/2" (6.25 cm) Nalgene powder funnel. Press on or glue in place to the Nalgene bottle.

3. 4 oz (125 ml) Nalgene bottle. Cut hole in bottom to make a tight fit with funnel spout.

4. 2 1/2" (6.25 cm) plastic funnel with 1/4" diam.-tapering spout. Cut down spout so that when in position 1/4" protrudes through the bottom of bottle (3).

5. Cap from 4 oz (125 ml) Nalgene bottle. Cut out center using a hot scalpel blade. Heat seal mesh to outer surface, ensuring threads are facing away from mesh cylinder.

6 & 7. 1.5 x 1.8 mm fiberglass window screen. Form into tube and heat seal seam with soldering iron fitted with a flat tip. The diameter should be 2" and the length can be cut to suit specific experimental needs.

8. Heat seal mesh to outer surface of lid. For extra strength use pipe clips on both caps.

9. Cap from 4 oz/125 ml Nalgene bottle. Perforate with small holes for drainage.

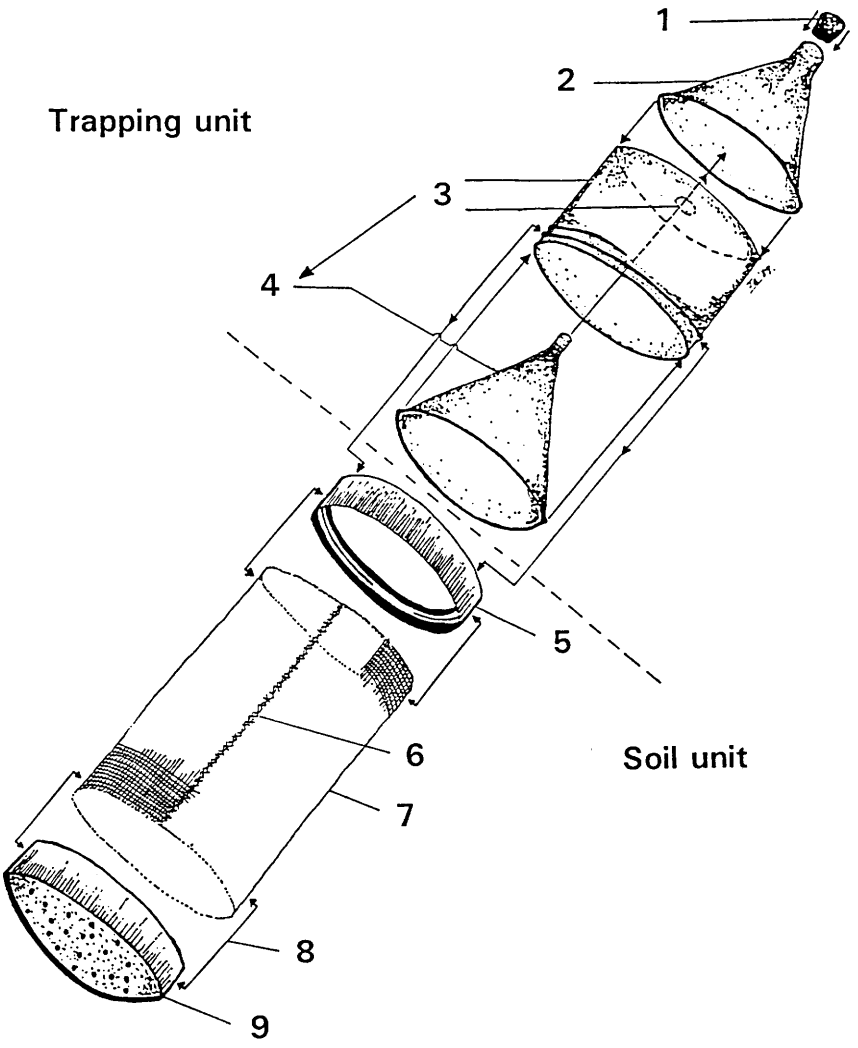

Figure 2. Diagram showing assembly of emergence trap.

Trap operation. A suitable size soil core is taken and placed surface side up in the mesh cylinder. This unit is then put back into the hole left by the soil core having the top flush with the soil surface. The trapping unit is then screwed into place on top of the soil unit and left for the desired trapping period. To retrieve the catch, the trapping unit is unscrewed and capped quickly with an intact bottle lid. A new unit may be attached to the mesh cylinder or it may be capped off for retrieval of the soil core. Both units can now be returned to the laboratory for processing.

The trapping unit should be inverted and placed in a cold room to immobilize the catch. To dispense catch, the stopper is removed allowing the catch to fall into storage vials or counting dish. The soil core is removed from the mesh cylinder and processed by the controlled-gradient extraction method described earlier. This will yield viable soil arthropod numbers and any remaining viable thrips. The soil core can be further processed to obtain dead arthropods, pupae, and eggs, data which the controlled-gradient extraction cannot provide. This is best accomplished using a heptane flotation method (Walter et al. 1987).

Results

The emergence trap is currently being evaluated in the field so no data is available at this time. If the method proves successful, the following data will be obtained from a single soil core:

A. Emerging adult thrips

B. Process soil core by controlled-gradient extraction method to obtain any remaining live thrips and all other live soil arthropods.

C. Final extraction of the soil core by the heptane flotation method will yield dead soil arthropods including thrips as well as pupae and possibly eggs.

These data will provide valuable input into a "Total Forest Ecosystem Management Program."

Material Suppliers

Soil augers: Bulb planter (short handle and wide) any garden supplier
Bulb planters (2" diam, 6" deep, long handle)

Smith & Hawkens
55 Sunnyside
Mill Valley, California

Nalgene bottles: 4 oz (125 ml) with 70 mm cap diam
(cat. # 11-823-30)

Fisher Scientific
461 Riverside Ave.
P.O. Box 376
Medford, Massachusetts

Plastic funnels: Nalgene PF 65 (cat. # 10-348A)
PF 45 (cat. # 10-347D)
Fisher Scientific

Cylinder mesh: 1.5 x 1.8 mm fiberglass window screen available at most hardware stores

References Cited

Aucamp, J. L. & P. A. J. Ryke. 1964. A preliminary report on a grease film extraction method for soil microarthropods. Pedobiologia 4: 77-79.

Edwards, C. A. & K. E. Fletcher. 1970. The assessment of terrestrial invertebrate populations, pp. 57-66. Methods of study in soil ecology. Proc. U.N.E.S.C.O. and I.B.P. Symp. Paris.

Edwards, C. A. & K. E. Fletcher. 1971. A comparison of extraction methods for terrestrial arthropods, pp. 150-185. *In* J. Phillipson [ed.], Methods of study in quantitative soil ecology, population, production and energy flow. I.B.P. Handbook No. 18, Blackwell Scientific Publications, Oxford, UK.

Edwards, C. A. & G. W. Heath. 1963. Improved methods of extracting arthropods from soil. Rep. Rothamsted Exp. Stn. 57: 158.

Kempson, D., M. Lloyd & R. Ghelardi. 1963. A new extractor for woodland litter. Pedobiologia 3: 1-21.

Laudermilch, G. 1988. Thrips in Pennsylvania, pp. 36-62. *In* B. L. Parker, M. Skinner & H. B. Teillon [eds.], Proceedings, Regional Meeting: "The 1988 thrips infestation of sugar maple." Bennington, VT June 23. Vt. Agr. Exp. Sta. Bull. 696 Univ. Vt., Burlington. 113 pp.

Lewis, T. 1973. Thrips: their biology, ecology and economic importance. Academic Press, London and New York. 349 pp.

MacFadyen, A. 1962. Control of humidity in three funnel-type extractors for soil arthropods, pp. 158-168. *In* P. W. Murphy [ed.], Progress in soil zoology. Butterworths, London.

Murphy, P. W. 1962. Extraction methods for soil animals. I. Dynamic methods with particular reference to funnel processes, pp. 75-114. *In* P. W. Murphy [ed.], Progress in soil zoology. Butterworths, London.

Parker, B. L., M. Skinner & H. B. Teillon. 1988. Proceedings, Regional Meeting: "The 1988 thrips infestation of sugar maple". Bennington, VT June 23. Vt. Agr. Exp. Sta. Bull. 696 Univ. Vt., Burlington. 113 pp.

Salt G. & F. S. J. Hollick. 1944. Studies of wireworm populations. 1. A census of wireworms in pasture. Ann. Appl. Biol. 31: 53-64.

Simons, E. E. 1985. Intra-departmental Memo: January 21. Division of Forest Pest Management. Commonwealth of Pennsylvania.

Skinner, M. 1988. The Vermont Plan-Research, pp. 63-69. *In* B. L. Parker, M. Skinner & H. B. Teillon [eds.], Proceedings, Regional Meeting: "The 1988 thrips infestation of sugar maple". Bennington, VT June 23. Vt. Agr. Exp. Sta. Bull. 696 Univ. Vt., Burlington. 113 pp.

Teillon, B. 1988. The Vermont Plan-Management, pp. 70-79. *In* B. L. Parker, M. Skinner & H. B. Teillon [eds.], Proceedings, Regional Meeting: "The 1988 thrips infestation of sugar maple". Bennington, VT June 23. Vt. Agr. Exp. Sta. Bull. 696 Univ. Vt., Burlington. 113 pp.

Walter, D. E., J. Kethley & J. C. Moore. 1987. A heptane flotation method for recovering microarthropods from arid soils, with comparisons to the Merchant-Crossley, high-gradient extraction method and estimates of microarthropod biomass. Pedobiologia 30: 221-232.