THE USE OF SUCTION TRAPS FOR DETECTION OF UNWANTED INVASIVE INSECTS AND OTHER INVERTEBRATES

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ABSTRACT

This paper reviews the potential for using suction traps, especially existing networks, to detect unwanted exotic insects and invertebrates invading new locations. Suction traps are thought to sample small, fragile, slow and weak flying insects better than other methods. Suction traps over 6 m high have been shown to catch invertebrates from at least 13 different insect orders and 87 different insect families as well as Acari (mites) and Araneae (spiders). Suction traps have provided the first location records for a number of aphid species and new records of invasive species. Several issues require attention if suction traps are to become established tools for detection of unwanted invasive organisms. These include minimising the cost of traps, developing rapid identification methods, establishing the optimum location of the traps and investigating the ability of suction traps to catch species in time for remedial action.

Keywords: New Zealand, unwanted organism, invasive organism, insect, suction trap, detection method, biosecurity.

INTRODUCTION

Suction trap networks consist of a number of suction traps placed at strategic locations that continuously sample invertebrates from a fixed height above ground level. Samples are collected after a defined interval (e.g. days or weeks) and selected insects are sorted, counted and data collated. In New Zealand, six 7.5 m high suction traps have been erected at two sites in the North Island (Ngatarawa in Hawke's Bay and Pukekohe in South Auckland) and four sites in the South Island (Lincoln, Hilton, Rokeby and Courtenay, all in Canterbury) (Teulon et al. 2004). Funding for the installation and running of these suction traps has largely come from the wheat, squash, potato and lettuce industries. Not all suction traps have been running continuously since they were installed.

Extensive suction trap networks have been erected in Europe (12.2 m high, 73 traps in 19 countries) (Anon. 2006a), western North America (8 m high, 60 traps in 9 US states and one Canadian province) (Halbert et al. 1990) and north-central USA (6 m high, 34 traps in eight states) (Anon. 2006b). In New Zealand and elsewhere, aphid flight data and forecasts for likely crop damage are made available to interested parties (e.g. growers, crop consultants) through linked information systems (e.g. Anon. 2000; Anon. 2006b). The data collected from suction traps, especially aphid flight data, are being used to research insect dispersal, long-term population trends and climate change (Anon. 2006a).

The infrastructure and expertise provided by existing suction trap networks could form the basis for a surveillance network for unwanted aerial invasive insects and other invertebrates. In this paper 'unwanted' means species that are unwanted in a particular location because of their actual or potential pest status, and 'invasive' means species that have the potential to arrive, establish and spread to and within a new location.

OPERATION OF SUCTION TRAPS

How do suction traps work?

Suction traps suck a standardised volume of air from a given height above ground and extract insects and other small airborne organisms from that air into a collecting device. For most existing networks, suction traps are placed at several metres above ground level to reduce the localised variation of insect density due to surrounding host plants. Insect densities within the air are known to decrease exponentially with altitude (Southwood 1966) but 'high' suction traps (>6 m above ground) are thought to be representative of flight activity for aphids over a radius of around 30-80 km (Halbert et al. 1990; Harrington & Pickup 2006; University of Illonois 2006). Additionally, insects flying at higher levels above the ground are unlikely to be flying short distances and are thought to provide information on long-range dispersal (Cochrane & Thornhill 1987). Wind speed and insect size are the main factors influencing the efficiency of suction traps but these are mostly a concern where absolute measurements of insect abundance are required (Southwood 1966).

What variety of organisms do suction traps catch?

The target organism for most suction trap networks has been airborne aphids. However, suction traps are effective tools for trapping other small, fragile, slow and weak flying insects. Indeed, suction traps are thought to sample these insects better than other methods (Marshall et al. 1994). Furthermore, the vast majority of alate individuals are very small (Johnson 1957) so suction traps are likely to be an effective tool for sampling a significant proportion of the airborne fauna. There have been few studies detailing the range of organisms caught in suction traps. An internet and database search (i.e. XtraMSN Search, CABI, Web of Knowledge) was therefore undertaken for studies listing organisms caught in suction traps (especially those traps over 6 m high) (Table 1). Search terms included various combinations of the following words: high, 12 m, suction trap, Rothamsted, new record, and new species. The results indicated that 'high' suction traps catch invertebrates from at least 13 different insect orders and 87 different insect families, as well as Acari (mites) and Araneae (spiders) (Table 1). A number of different species are likely to be represented for each family so it is clear that a large number of insect species are caught in these suction traps.

For New Zealand, seven insect orders were found in samples from one 7.5 m suction trap, which was located at Lincoln and sampled for 1 week in each of spring, summer, autumn and winter during 2003-04 (James & Teulon 2005). Additionally, up to 50 aphid species have been found in the same Lincoln suction trap (D.A.J. Teulon, unpubl. data) and more than 10 terebrantian thrips species were found in three New Zealand suction traps in 2002-03 (Nielsen et al. 2004).

SUCTION TRAPS FOR DETECTION OF INVASIVE SPECIES

Do suction traps catch invasive organisms?

A critical factor determining whether suction traps can be used for surveillance is whether or not suction traps catch unwanted invasive organisms. Most reports listing the range of organisms caught in suction traps give little indication as to the proportion of invasive or non-invasive species found. However, the range of insect groups caught in suction traps (including aphids, thrips, bark beetles, mosquitos and vespid wasps) almost certainly includes species that are unwanted in New Zealand. No indigenous aphids have ever been reported from New Zealand suction traps. All aphid species trapped are exotic and many are unwanted pests (D.A.J. Teulon, unpubl. data). Similarly, no indigenous terebrantian thrips have been reported from New Zealand suction traps (Nielsen et al. 2004) with most of those caught being unwanted thrips pests. This probably reflects the placement of these traps in agricultural landscapes.

Do suction traps catch newly invaded organisms?

At least two reports specifically state that 'high' suction traps are used for detecting newly introduced exotic species or pests (Anon. 2006f). There are also a number of instances where suction traps (all heights) have provided the first record for a number of mostly aphid species for given locations (Table 2). It is likely that some of these records are for species that have been overlooked previously (e.g. Limonta & Colombo 1991) but some records clearly relate to species that have recently invaded a new location

(Harrington 1998). In New Zealand, Teulon & Stufkens (2002) noted that up to 50% of new aphid records between 1981 and 2002, mostly unwanted invasive species, were from the Lincoln suction trap (see also Table 2).

TABLE 1: Invertebrate orders and families recorded from 'high' (> 6m) suction traps.

Order	Family	References
Coleoptera[1]	29 families including: Carabidae, Cryptophagidae, Curculionidae, Scolytidae, Staphylinidae	Forsse & Solbreck 1985; Lacman 1986; Cochrane & Thornhill 1987; Benton et al. 2002; Moore et al. 2004
Collembola	None specified	Benton et al. 2002; Moore et al. 2004
Dermaptera	2 families	Moore et al. 2004
Diptera[1] [Brachycera] [Nematocera]	27 families: Anisopodidae, Anthomyiidae, Bibionidae, Calliphoridae, Camillidae, Cecidomyiidae, Chironomidae, Chloropidae, Coelopidae, Culicidae, Dixidae, Dolichopodidae, Empididae, Muscidae, Mycetophilidae, Lauxaniidae, Lonchopteridae, Phoridae, Psychodidae, Ptychopteridae, Scathophagidae, Scatopsidae, Sciaridae, Sphaeroceridae, Simulidae, Syrphidae, Tipulidae	Gillies & Wilkes 1976; Bayon et al. 1983; Linblad & Solbreck 1998; Benton et al. 2002; Moore et al. 2004; Shortall et al. 2006; Anon. 2006c, d
Ephemeroptera	None specified	Benton et al. 2002
Hemiptera[1] [Heteroptera] [Homoptera]	12 families including Aphididae	Benton et al. 2002; Moore et al. 2004; Anon. 2006e
Hymenoptera[1]	4 families: Apidae, Megachilidae, Sphecidae, Vespidae	Benton et al. 2002; Harrington et al. 2003; Moore et al. 2004
Lepidoptera[1] Macro & micro	Noctuidae	Benton et al. 2002; Harrington et al. 2003; Moore et al. 2004
Neuroptera[1]	2 families: Chrysopidae, Coniopterygidae	Bowden 1981; Marshall et al. 1994; Benton et al. 2002; Moore et al. 2004
Plecoptera	None specified	Benton et al. 2002
Psocoptera	5 families: Caeciliidae, Lachesillidae, Peripsocidae, Psocidae, Elipsocidae	Locatelli & Limonta 1994; Benton et al. 2002; Moore et al. 2004; Anon. 2006f
Thysanoptera[1]	Thripidae	Benton et al. 2002; Nielsen et al. 2004; Anon. 2006c
Trichoptera	None specified	Moore et al. 2004
Acari	None specified	Benton et al. 2002; Moore et al. 2004
Aranea	4 families including Linyphiidae	Blandier & Furst 1998; Thorbek et al. 2002; Benton et al. 2002; Moore et al. 2004; Anon. 2006f

[1]Order reported from Lincoln suction trap (7.5 m) by James & Teulon (2005).

TABLE 2: First records for insect species for a given location from suction traps.

No. species	Year	Suction trap height	Trap location	Comments	Reference
Aphididae					
1	1981	7.5 m	Canterbury, NZ	First record for NZ	Sunde 1984
1	1981	7.5 m	Canterbury, NZ	First record for South Island, NZ	Sunde 1984
3	1983-1985	Not stated	Lombardy, Italy	New records for Italy	Limonta & Colombo 1991
3	1986-88	8 m	Idaho, USA	First records for Idaho and North America	Halbert et al. 1990, Halbert & Pike 1990
1	1992	7.5 m	Canterbury, NZ	First record for NZ	Eastop pers. comm.[1]
1	1992-1993	12.2 m[2]	Valtellina, Italy	First record for Italy	Limonta & Binazzi 2000
6	1992-1993	Not stated	Valtellina, Italy	New records for Italy	Limonta 2001
13[3]	1996-1998	12.2 m[2]	Croatia	First records in Croatia	Gotlin Culjak et al. 2002
1	1998	12.2 m	Britain	First record in Britain	Harrington 1998
1	1998	Not stated	Florida, USA	First record in Western hemisphere	Halbert et al. 2002
5	2001	12.2 m[2]	Belgium	Records new to the region	Jansen & Warnier 2002
1	2002	7.5 m	Canterbury, NZ	First record in NZ	Stufkens & Teulon 2002
3		Not stated	Friuli-Venezia Giulia region, Italy	First records for Italy	Coceano & Petrovic-Obradovic 2006
Heteroptera: Dipsocoridae					
1	2001	Not stated	Florida, USA	First record in Florida	Halbert & Brambila 2002
Psocoptera: Elipsocidae/Lachesillidae					
2[4]	1992-1993	12.2 m	Valtellina, Italy	First records for Italy	Locatelli & Limonta 1994

[1]*Amphorophora rubi.*
[2]These traps are described as Rothamsted traps, which are usually 12.2 m high.
[3]It is not clear if all species were caught in a suction trap.
[4] One species from each family.

There appear to be no studies examining at what stage suction traps catch invasive organisms in relation to their initial population size and geographic distribution. Halbert (2003) considered that detections of new exotic aphid species in suction traps indicated that the insects were likely to be already established. However, Harrington (1998) judged that that a new aphid found in two traps in England could have come from southern Europe on the wind. In New Zealand, lettuce aphids were found in the Lincoln suction trap earlier than they were found in lettuce crops in Marshlands approximately 20 km away, although they had probably been established in Marshlands for some time.

DISCUSSION

Outstanding issues

As with many surveillance methods, suction trap networks rely on the accurate identification of the species caught. For detection of unwanted organisms the sooner this is achieved the better. Quick and accurate identification may be possible where insect monitoring of particular groups is regularly carried out for another reason (e.g. pest management, pest forecasting) but this is unlikely to occur with the vast majority of insect groups that contain unwanted organisms. Quick, accurate and cheap methods for insect identification will be required. Traditionally, identification of newly invaded and other unwanted small insects has relied on the external morphological features of adult life stages. Additionally, intercepted pest specimens are sometimes immature and may also be damaged, which can prevent correct identification. Molecular tools now enable precise and rapid identification, irrespective of the developmental stage and condition of the sample (Frey & Pfunder 2006). Real time PCR and microarrays are two high-throughput DNA-based technologies that provide a likely way forward (e.g. Yu et al. 2004, 2005; Walsh et al. 2005, Pfunder & Frey 2005). However, broad adoption of either of these methodologies in the area of biosecurity has been slow because of the initial expenditure required to develop the techniques.

Suction trap networks need investment to install, to run and to support the skilled technical expertise required for insect identification. Until the value of suction trap networks for detecting unwanted organisms has been established, it seems likely that suction traps will be not be used in this capacity alone. Rather, they are likely to rely on existing aphid monitoring networks with suction traps located sub-optimally for detecting unwanted organisms. 'High' suction traps in New Zealand are currently located in major agricultural areas, with traps near some major ports and on research stations.

Suction traps and biosecurity

Suction traps have proved useful for establishing the range of insects in a given location. In a number of instances, suction traps have provided the first record of an aphid species as it invades new territory. It would seem likely that this would be true for other insects, given the range that has been identified from suction traps. This alone contributes greatly to knowledge of invasive pest species (Halbert 2003). Suction traps would also be useful for delimiting the distribution of a newly invading species within a country. Where the use of suction traps has yet to be proven is in their ability to detect unwanted invasive organisms in time to reduce their impact or eradicate them.

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