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OBSERVATIONS ON COLLECTING SCALE INSECTS (HEMIPTERA: COCCOIDEA).

ABSTRACT

OBSERVATIONS ON COLLECTING SCALE INSECTS (HEMIPTERA: COCCOIDEA).

Scale insects have been primarily collected visually. Because scales are usually firmly attached to the host substrate, most mass-collecting techniques are ineffective. This paper provides information on the use of Berlese funnels, DVAC suction, pit-fall traps, sweeping, beating and screening for collecting scale insects and provides observations on how these methods compare with visual collecting methods.

Key words: collecting methods, visual methods, pheromone traps, suction traps, lights, vicarious collecting, herbaria specimens, Margarodidae, Ortheziidae, Pseudococcidae, Eriococcidae, Hungary, Africa.

INTRODUCTION

Mass-collecting techniques for sampling insects have been developed and refined so that many museums currently are unable to process the large number of specimens that are collected using these methods. Pit-fall traps, Malaise traps, canopy fogging, Berlese funnels and other such collecting methods have been important tools for sampling and understanding the extent of some components of insect biodiversity. Unfortunately, most mass-sampling techniques are unsuitable for scale-insect studies because generally scales are sessile, are firmly attached to their host and therefore remain on the host rather than being taken in the sampling device.

The purpose of this paper is to summarize information on scale-insect collecting methods and to provide new observations on the subject.

MATERIALS AND METHODS

A sampling survey was made in the Sashegy Nature Reserve and in the Körös-Maros National Park in Hungary, comparing a hand-held DVAC suction system (Samu & Sárospataki 1995), visual observations and pitfall traps. We are reporting on the results for the scale collections only, although many different kinds of organisms were sampled in the survey. For pitfall traps, 25

traps were placed in each collecting site; the traps were 70mm in diam., were filled with ethylene glycol, and were changed every three weeks from April through October in 1995, 1996 and 1997. Visual surveys were made by two individuals five times each year and at least 6 hours were spent looking for scales on each sampling excursion. The diameter of the DVAC was 0.01 square meters and collections were carried out once each month. In each location, 5 different habitats were sampled by running a transect in each habitat. Each transect was comprised of 15 samples.

RESULTS AND DISCUSSION

Review of collecting methods

Scale-insect collecting strategies have been discussed in a general way by several authors including: McKenzie (1967), Kosztarab & Kozár (1988), Kozár (1990), Wilkey (1990), Kosztarab (1996) and others, but no definitive work has been written which compares the effectiveness of current available methods.

Berlese funnels: are effective for collecting species of soil inhabiting mealybugs, such as *Rhizoecus* (McKenzie, 1967) and *Eumyrmococcus* (Williams, 1998). Morrison (1952) indicated that Berlese funnels had been used to collect species of ortheziids infesting moss or soil litter. Ramona Beshear (retired from the University of Georgia) used this technology to collect additional specimens once she had visually located specimens in the field (personal communication). This method was particularly important for collecting eriococcids in the south-eastern U.S. and is mentioned in Miller *et al.* (1992) as a collecting strategy for locating specimens of *Eriococcus droserae* Miller, Liu & Howell. The first author has recently discovered a "treasure trove" of scale-insect material in Berlese samples that were initially collected by acarologists. Mahunka (Budapest, Hungary) and his colleagues ran Berlese samples in nearly all areas of the world and, after removing the mites of interest, kept the samples for future use by colleagues studying other groups (for more information see Mahunka & Mahunka-Papp, 1992). From Africa alone, 856 samples were examined and ortheziids and mealybugs were the predominant scale insects. Eighty-six samples contained ortheziids, including 225 adult females and 276 immatures. The number of adult female specimens in each genus were as follows: 129 *Orthezíola,* 64 *Newsteadia*, 31 *Nipponorthezia* and 1 *Orthezia*. A series of papers are planned that will describe this adult female ortheziid material, of which the first paper is

complete (Kozár & Miller, 2000).

The **beating sheet** is an under-utilized collecting method that can be quite effective for collecting mealybugs (McKenzie, 1967), ortheziids, margarodids and eriococcids. The second author has used this method for collecting such mealybugs as *Spilococcus larreae* Ferris and *Pseudococcus beardsleyi* Miller & McKenzie, and eriococcids such as *Eriococcus macrobactrus* (Miller & Miller) and *Eriococcus quercus* (Comstock) when the mealybugs or eriococcids were scattered on abundant host-plant material.

The use of **sifting screens** is another method that has been used in a limited way for collecting scale insects. McKenzie (1967) discussed the use of a series of screens with differing sizes of wire mesh for locating mealybugs in soil samples, and this strategy also is effective for sifting through soil litter and moss. When the first author was searching for ortheziids in South Africa, he had the opportunity to examine 601 samples that were collected by Endrödy-Younga (Transvaal Museum, Pretoria, South Africa). Ortheziids were present in about 5% (31) of these samples, with 60 specimens of *Ortheziola* in 14 samples, 61 specimens of *Newsteadia* in 16 samples and 1 specimen of *Orthezia* in one sample.

Visual collecting is a particularly useful and common collecting strategy, but it is worth mentioning some techniques that sometimes will make this method more effective. All parts of the plant should be examined whenever possible. Undersides of leaves, particularly in concealed areas near the veins, are good settling sites for scales. Young branches and stems also are favoured by many coccoids. Perhaps the most under-collected areas of the host are the upper canopy and the root system of trees. For small plants, the subterranean area can be examined using a shovel, but coccidologists should take advantage of situations where areas of land are being cleared and examine the recently upended trees, both on the roots and in the upper parts of the trees. For large trees, it is often productive to pull off pieces of the loose bark where scales like to settle. Also cracks in the bark and scar areas are preferred settling sites of many scales. After studying the root system of a plant, it can be productive to pull the crown area apart, since often scales are found at the bases of branches or in open cavities in the centre of the crown. Ants frequently give a clue that some sap-feeding insect is present, so plant material with ants on it should be carefully examined. Many coccidologists locate large samples of field collected host material that is likely to contain scale insects and transport it back to the laboratory where it is examined with a dissecting microscope. This is a very effective way of collecting species that can only be found when examining the host carefully at high magnification.

Some miscellaneous collecting methods include collecting with a **sweep**

net which was used in sampling for an eriococcid, armoured scale and mealybug by Denno (1977). The sample sizes of *Eriococcus dennoi* (Miller & Miller) were large enough to give a general idea of its life history. Raupp and Denno (1979) also used a **DVAC** to sample other "homopterans" and scales in their studies in the salt marshes of New Jersey, but indicated that it was not very efficient. **Canopy fogging** has been done extensively in recent years, but the only life-history stages that appear in samples with any degree of frequency are adult males (T. Erwin, Department of Entomology, National Museum of Natural History, Washington, DC, personal communication), and they are difficult or impossible to determine without associated females. **Pheromone traps** have been used to attract males of a particular species of scale insect, but this method is currently unsuitable for collecting a diversity of scale-insect species. A **suction trap** was developed to collect males and parasitoids of the San José scale by Kozár (1976) and coloured sticky boards were used to collect males of various scales and parasitoids (Kozár, 1973; Sheble & Kozár, 1995). In some instances **lights** are attractive to scale insects. A recent example is when adult males, adult females and immatures of a rare margarodid (*Palaeococcus fuscipennis* Burmeister) were attracted in large numbers to a black light placed in the field by a lepidopterist (Kozár *et al.*, 1994).

It also is worth mentioning "vicarious collecting," i.e., when scientists collect specimens of interest to them and at the same time inadvertently collect and preserve scale insects. An interesting example is that of Russell (1943, 1945) when she was searching for whiteflies on *Coccoloba* in the Caribbean. Rather than going to the Caribbean for time-consuming field work, she went to the herbarium of the Smithsonian's Botany Department and was rewarded with hundreds of specimens of whiteflies and armoured scales that had inadvertently been collected and pressed by field botanists. In fact, this material served as the basis for not only the papers by Russell, but also a revision of the armoured scale genus *Crenulaspidiotus* by Miller & Davidson (1981). Additional examples include studies by Hoy (1962) and Miller & González (1975) who vicariously collected Chilean eriococcids in herbaria.

A Collecting Experiment in Hungary

Although the experiment comparing three collecting methods was designed to examine other groups of insects, the first author was able to compare the scale-insect catches with visual examinations at the two locations where the traps were placed. Results are summarized in the following tables.

These results were unexpected and demonstrate that the specialized DVAC

Table 1. Number and percentage of species collected by three collection techniques at two localities in Hungary (i) using one method only and (ii) by more than one method.

Locality	No. of species (%) found by 1 method only			No. spp (%) collected by >1 method	Total No. spp.
	DVAC	Visual	Pitfall		
Körös-Maros	12(50%)	7(29%)	0	5(21%)	24
Sashegy	13(30%)	15(34%)	2(4%)	14(32%)	44
Total	25(37%)	22(32%)	2(3%)	19(28%)	68

Table 2. Total number of species collected at each of two sites in Hungary, regardless of the collection method.

Locality	Total no. of Species Collected		
	DVAC	Visual	Pitfall
Körös-Maros	17	12	0
Sashegy	26	29	5
Total	43	41	5

These results were unexpected and demonstrate that the specialized DVAC suction machine used in this study was just as effective at collecting scale insects as by visual inspection, which had been considered would be the most productive method. Thus, of the Pseudococcidae collected at Sashegy, 12 species were collected by DVAC but only nine visually (Table 3). The first author was surprised, even frustrated, by the number of species that were collected with the DVAC that he could not locate visually at exactly the same sampling site. However, it should be remembered that members of all families could probably be found as dead insects on the soil surface.

Table 3. Number of species in six coccoid families collected at Sashegy by either DVAC or by visual collection.

Coccoid families	DVAC	Visual	Total no. species collected
Ortheziidae	2	2	2
Pseudococcidae	12	9	15
Eriococcidae	3	4	4
Coccidae	4	7	11
Asterolecaniidae	0	1	1
Diaspididae	5	7	9
Total	26	30	42

Note: the total number of species collected at Sashegy was actually 44 - 2 additional species were collected by pitfall traps. Also note that no two species of Coccidae collected by these two methods were the same.

Another interesting result was that about 70% of the species were collected by one method only and that only slightly less than half of the species were collected visually. This suggests that collectors of scale insects should spend more time and effort using such methods as Berlese funnels and DVAC if they wish to find a high percentage of the world species of scale insects.

CONCLUSIONS

Many strategies for collecting scale insects have not been tested extensively. There is a tendency within the coccidology community to use the "tried and tested" methods of visual collection and not to experiment with methods that might prove more effective. For some scale insects that are permanently attached to their host, such as armoured scales, methods other than visual inspection are not effective. However, although most species adhere tightly to their host, most can retract their stylets and move from their settling site if given enough time. The use of fogging technologies kills the scales before they can move, but the slow heat of a Berlese funnel allows the scales time to move into the collection container. Methods such as beating sheets and sweeping have rarely been tried for scale collecting, but they may have much more potential than previously realized.

where we never considered looking previously. Our current knowledge of the genus *Crenulaspidiotus* received major enhancement because of the herbarium collecting done by Louise Russell. The new knowledge that is being accumulated about ortheziids in moss and soil litter habitats around the world is due to the first author's examination of Berlese and wire mesh screening samples that were already present in museums. Clearly there are many more herbaria specimens and alcohol samples with valuable scale-insect specimens just waiting for extraction.

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