rough estimate of the volume of beetles present in the third week of June was 5000 cm^3.

It is apprent from this investigation that *H. oregonensis* is of no value as a predator of aphids on cultivated crops because of its restricted distribution. It may be important in the natural control of aphids on subalpine and alpine ranges. *H. caseyi* may be of value, however, as a predator of aphids on cultivated crops, particularly alfalfa.

This investigation also suggests that the availability of suitable aggregation sites may be a limiting factor in the natural abundance of *H. caseyi*. The number of mountains of sufficient altitude and with features suitable for aggregation sites for *H. caseyi* are limited and the area comprising the five mountain top aggregation sites is very small compared with the total of the whole study area. It is hoped that this report will stimulate further investigation into the feasibility of manipulating *H. caseyi* populations to benefit aphid control on agricultural crops in south-central British Columbia.

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INNERVATION OF THE STYLETS OF THE PEAR PSYLLA, *PSYLLA PYRICOLA* (HOMOPTERA: PSYLLIDAE), AND THE GREENHOUSE WHITEFLY, *TRIALEURODES VAPORARIORUM* (HOMOPTERA: ALEYRODIDAE)[1]

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ABSTRACT

The fine structure of the stylets of the pear psylla, **Psylla pyricola** Foerster, and the greenhouse whitefly, **Trialeurodes vaporariorum** (Westwood), is described from sections studied in the electron microscope. Their mandibular stylets are innervated, each containing two dendrites.

INTRODUCTION

The discovery of nerves in the stylets of aphids (Forbes, 1966, 1969; Parrish, 1967; Saxena and Chada, 1971), an adelgid (Forbes and Mullick, 1970), a leafhopper (Forbes and Raine, in press), and in *Rhodnius* (Pinet, 1963, 1968) suggested that the stylets of all the Hemiptera-Homoptera may be innervated. The present paper demonstrates nerves in the stylets of a representative of each of the Psylloidea and Aleyrodoidea, two superfamilies of the Homoptera in which innervation of the stylets has not previously been shown.

The pear psylla, *Psylla pyricola* Foerster, and the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), are the subjects of the present report.

MATERIALS AND METHODS

Adult pear psylla were from pear and adult greenhouse whiteflies were from fuschia. The heads were dissected from the insects, fixed in 5% glutaraldehyde, post-fixed in 1% osmium tetroxide, and dehydrated in a graded series of ethanol. The pear psylla heads were embedded in Spurr Low-Viscosity Embedding Medium (Polysciences, Inc., Warrington, Penna.). The whitefly heads were embedded in Epon 812 by the method of Luft (1961). Sections were cut with glass knives on an LKB Ultrotome III, mounted on grids with carbon-colloidion supporting films, and subsequently stained

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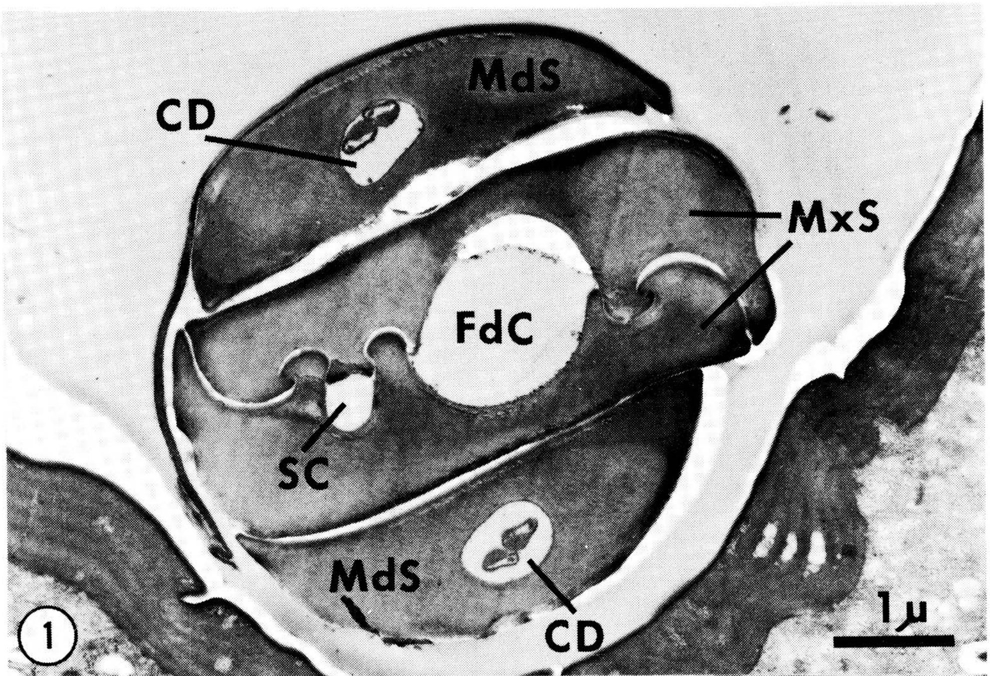

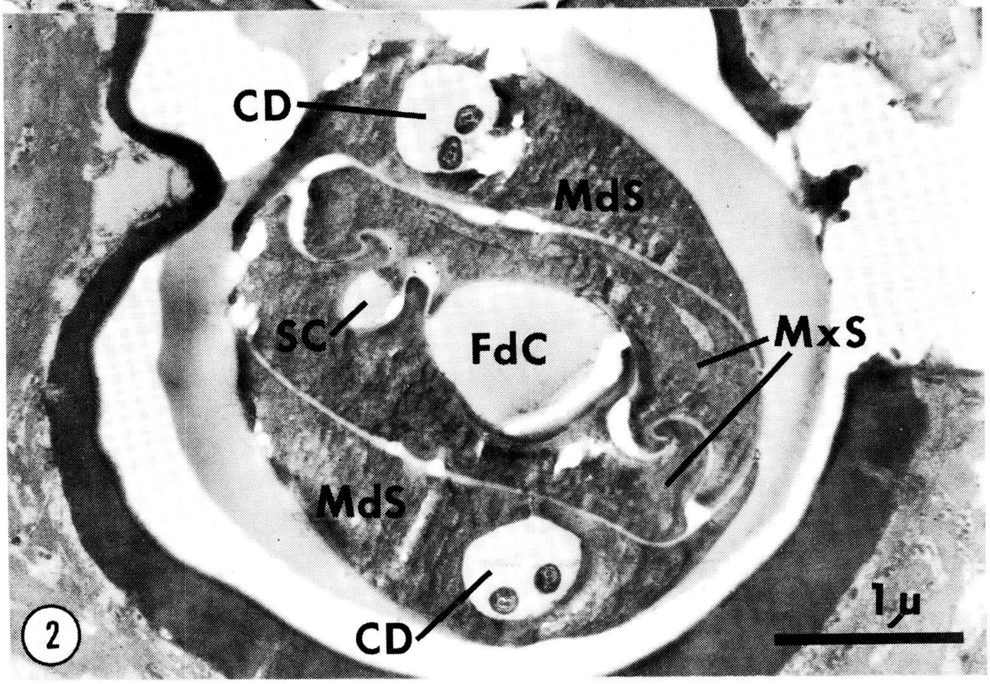

Fig. 1. Electron micrograph of a cross-section of the stylet bundle of a pear psylla, **Psylla pyricola** (Foerster). Each central duct contains two dendrites. CD, central duct; FdC, food canal; MdS, mandibular stylet; MxS, maxillary stylet; SC, salivary canal.

Fig. 2. Electron micrograph of a cross-section of the stylet bundle of a greenhouse whitefly, **Trialeurodes vaporariorum** (Westwold). Each central duct contains two dendrites. The cell membranes and pair of neurotubles of each dendrite are clearly visible, as is the cuticular sheath surrounding the dendrities. Abbreviations as in Fig. 1.

with uranyl acetate and lead citrate. They were examined in a Philips 200 electron microscope.

RESULTS AND DISCUSSION

The mouthparts of the pear psylla and greenhouse whitefly are similar to those of other Homoptera, a fact undoubtedly associated with the uniform piercing and sucking phytophagous feeding habits of the group. The mouthparts consist of two pairs of chitinous needle-like stylets, a labium, and a labrum. The stylets are well adapted for piercing plant tissue and for extracting juices.

The basic structure of the stylets of the pear psylla and the greenhouse whitefly is remarkably similar. In cross sections of their stylet bundles (Figs. 1 & 2), the outer pair is the mandibular stylets; the inner is the maxillary stylets. The whole stylet bundle is compact since the inner surfaces of the mandibular stylets are contoured to conform with the outer surfaces of the maxillary stylets. In the greenhouse whitefly, marked projections at the margins of the mandibular stylets wrap around the maxillary stylets to aid in the coaptation of the stylet bundle. The maxillary stylets of both are interlocked by a series of ridges and grooves to form the larger food canal and the smaller salivary canal between their apposed inner surfaces. The maxillary stylets are not bilaterally symmetrical. The salivary canal is contained almost entirely in one stylet, the other forming only the closing wall. The food canal is centrally located, formed by the apposition of the food canals in both maxillary stylets. Midway in the stylet bundle of the pear psylla, the salivary canal is approximately 0.5μ in diameter and the food canal is approximately 1.5μ in diameter. In the greenhouse whitefly the salivary and food canals are smaller, measuring 0.25μ and 0.9μ respectively. When the insects feed, saliva is pumped down the salivary canal and plant sap is sucked up the food canal. The functional mouth, then, is at the tip of the maxillary stylets.

The mandibular stylets have a central duct running from the base to near the tip. Midway in the stylet, the diameter of this duct is approximately 0.75μ in the pear psylla and 0.6μ in the greenhouse whitefly. The central duct in each mandibular stylet contains two dendrites. Each dendrite consists of a cell membrane, neurotubules, and a structureless material, probably a fluid, which surrounds the neurotubules. The dendrite itself is closely surrounded by a cuticular sheath. The central duct is probably filled with fluid in life, but appears empty in fixed sections. The fine structure of the dendrites is particularly clear in the section of the stylet bundle of the greenhouse whitefly (Fig. 2). The maxillary stylets do not contain nerves.

For many years, stylets of the Hemiptera-Homoptera were generally considered to be needle-like non-living, chitinous bristles. The existence of central ducts in the mandibular stylets was known, but nerves were not associated with them until Pinet (1963) showed bipolar neurons in the bases and nerves running into the shafts of both the mandibular and maxillary stylets of *Rhodnius prolixus* Stål. Forbes (1966, 1969) later traced two dendrites from the base to near the tip of the mandibular stylets of the green peach aphid, *Myzus persicae* (Sulzer). There were several previous indications of the existence of these nerves in aphids. Bradley (1960, 1962) found that amputating the tip of a mandibular stylet or inserting the intact stylet tip into various solutions prevented feeding but greatly increased larviposition. He suggested that this response demonstrated the presence of nerves in the stylets and observed that their central duct contained material that could be pulled as a thread from the cut end of the stylet. Wensler (1962) showed that the cabbage aphid, *Brevicoryne brassicae* (L.), perceives the specific feeding stimulus, sinigrin, with the stylets after they have penetrated the leaf surface.

The nerves in the stylets are undoubtedly of fundamental importance in the selection of hosts and feeding sites and in otherwise monitoring substrates at the stylet tips. Probing and feeding behavior, which has been well studied in aphids, indicates that these nerves supply contact chemoreceptors. Indeed, the work of Wensler (1962) mentioned above seems to confirm this concept.

Both the pear psylla and greenhouse whitefly are virus vectors. Their stylets and method of feeding are ideally suited for the acquisition and transmission of plant viruses. The pear psylla has been shown to transmit pear decline virus (Jensen *et al.* 1964) and the greenhouse whitefly is the vector of beet pseudo-yellows virus in California (Duffus, 1965). More than 25 other plant virus diseases are transmitted by other whiteflies (Costa, 1969).

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