ARTHROPOD SPECIES COLLECTED FROM PEACH TREES IN SOUTH CAROLINA UTILIZING A WHOLE-TREE SAMPLING METHOD[1,2]

C. S. Gorsuch, G. T. Lee[3] and D. R. Alverson
Department of Entomology
Clemson University
Clemson, SC 29634-0365
(Accepted for publication 20 May 1989)

ABSTRACT

A closed-canopy sampling apparatus consisting of a galvanized conduit frame and a polyethylene tree cover and ground cover was designed to encompass a mature peach tree. A pyrethrin-piperonyl butoxide aerosol was used to knock down arthropods for collection. The apparatus was relatively easy to use and the technique was efficient in sampling fauna from all surface microhabitats in the tree canopy. A total of 583 species representing 14 orders was collected.

Key Words: Peach, peach tree, arthropods, insects, whole-tree sampling.

J. Agric. Entomol. 6(4): 233-255 (October 1989)

The advent of integrated pest management (IPM) strategies has increased interest in holistic approaches to the study of arthropod communities in various cropping systems. These approaches require intensive sampling techniques and improved statistical tools (Morris 1960). This fact is particularly true for absolute sampling in orchard and forest studies. The magnitude of sampling error, sampling difficulties when populations are low, and the complexities of factors affecting natural populations discourage field studies. The degree of precision necessary in sampling is debatable and may depend upon whether a management decision or an ecological study is involved. Southwood (1978) and Lord (1968) discussed the various problems inherent with intensive sampling of arthropods in plant foliage.

A number of sampling techniques have been used to sample arthropods in orchards and forest trees. These include placing individual branches in various types of shaker-tumblers (Lord 1965) to dislodge specimens and by introducing a mixture of pyrethrin-piperonyl butoxide-carbon dioxide (Ives 1967) to aid in removing the insects. The intrinsic variability and mechanical difficulties associated with quantitative estimates of predator populations on apple trees were discussed by Lord (1965).

Chemical knockdown agents and various types of groundsheets and traps have been used to provide estimates of the seasonal abundance of arthropods in the tree canopy (Cleveland and Hamilton 1958, Gibbs et al. 1968, Polles and Payne 1973, Collyer 1951, Muir and Gambrill 1960). Muir and Gambrill (1960) estimated a 47% to 77% recovery rate of released insects with their sampling apparatus.

[1] Technical Contribution No. 2811 of the South Carolina Agricultural Experiment Station, Clemson University.

[2] Research supported in part by USDA, SEA Extension funds.

[3] Present address: Route 1, Box 55, Paris, TN 38242.

Jarring also has been used to dislodge arthropods, such as lepidopterous larvae, plum curculios and spiders from apple trees (Legner and Oatman 1962, McCaffrey and Horsburgh 1980, Bastanian and Herne 1980). Putnam (1967) stated that jarring, although an effective method, was impractical on fruiting trees since jarring sufficient enough to remove arthropods also dislodged fruit.

To date no general species study of the arthropod fauna on peach trees has been reported. Intensive sampling of arthropods in the peach tree canopy requires a technique that allows for absolute recovery of species in the entire canopy. Comparative studies must allow for replication involving whole tree sampling units and eliminate the need for field identification and quantification. The advantages and disadvantages of a sampling unit, apparatus, and sampling technique devised for this purpose are discussed.

MATERIALS AND METHODS

The sampling apparatus consisted of a metal frame, polyethylene tree and ground covers and spring clamps. The metal frame was constructed from 3.0 m sections of 1.9 cm E.M.T. galvanized conduit. Two flattened arches were made from three sections of conduit jointed by setscrew-type couplings. The arches were joined by crossbars and stabilized at the corners by diagonal connecting bars. This structure provided a sturdy frame encompassing a volume of approximately 27 m^3. Polyethylene film (0.1 mm thick) was used for the tree cover (12 × 12 m) and ground sheet (6 × 6 m). The ground sheet was slit to the center and a circular opening cut for the tree trunk. The edge of the opening was reinforced with duct tape to facilitate clamping around the tree.

The ground cover was placed under the tree and clamped around the trunk and along the slit. The frame was lifted and placed around the tree with the legs securing the cover near each corner, where the sheet was reinforced with duct tape (Fig. 1). The tree cover, folded toward the middle, was lifted onto the frame and unfolded to encompass the tree. The edges of the tree cover were rolled inside the ground cover and clamped. The enclosed tree was then sprayed with Cessco 7® aerosol (0.7% pyrethrin and 3.5% piperonyl butoxide) until a fog permeated the canopy. To ensure good coverage, dense foliage and major branches were sprayed directly from inside the system, beginning at one corner and exiting from the opposite one to eliminate trampling of fallen arthropods.

After about 15 minutes, the tree cover was unclamped, shaken to dislodge any specimens, and removed. The tree was also jarred to dislodge any remaining arthropods. Spiders hanging from silk strands were removed manually. All material on the ground cloth was channeled and brushed to a collecting area where excess debris was removed. The arthropods were funneled into a solution of 95% ethanol and glycerin for preservation and stored for future counting and identification.

A 13-year old orchard of 'Loring' cv. peaches at the Simpson Agricultural Experiment Station in Anderson County, South Carolina, was used to determine absolute numbers of arthropods using the closed canopy technique. The orchard was divided into two, 2 ha blocks, one of which received a conventional pesticide spray program of parathion, captan, and benomyl and the other receiving no sprays. Samples were taken approximately every 2 weeks. Two or three trees, distributed uniformly within each block, were sampled each time. The efficiency of the technique was determined by calculating the coefficient of variation for two

selected arthropod species. Combined data from both blocks are presented in this paper.

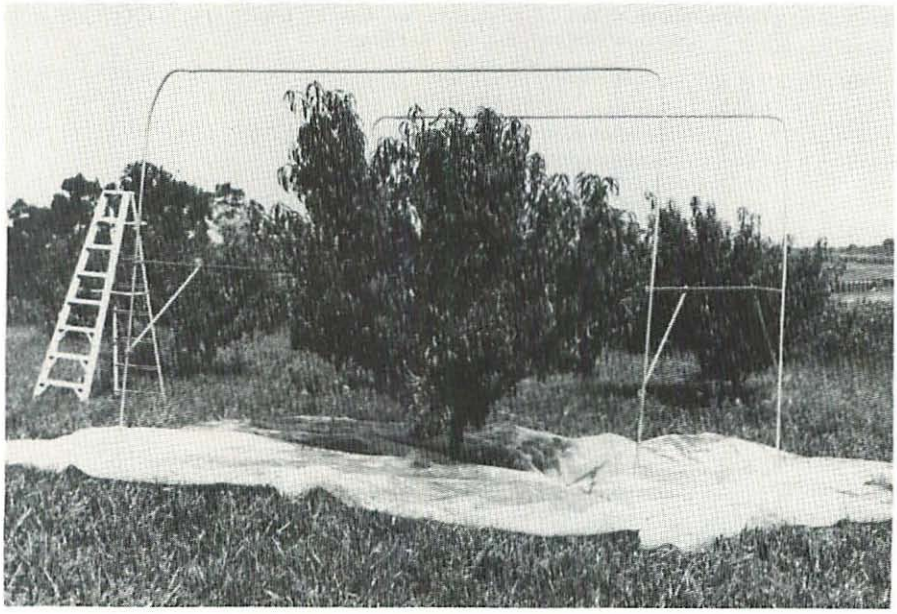

Fig. 1. Sampling apparatus showing conduit frame and groundsheet in position around tree canopy.

Voucher specimens are deposited in the Clemson University Insect Museum.

RESULTS AND DISCUSSION

Arthropod Species Composition

A total of 583 species of arthropods was collected from the peach orchard using the whole tree sampling method (Table 1). The following is an account of the major groups of arthopods and their ecological and economic importance to the peach tree and fruit. The most abundant species within each group are discussed.

Order Collembola - Springtails were incidental in the canopy. Very few were collected during the two-year study.

Order Odonata - These predators were observed flying around trees in search of prey and guarding territorial space. Their abundance in an orchard would be dependent on the proximity of water. Their influence in an orchard situation was negligible.

Orders Ephemeroptera, Plecoptera, Trichoptera - These orders consist of aquatic species and were incidental in the peach orchard.

Table 1. Arthropod species collected in South Carolina peach orchards.

Class INSECTA
- Order Collembola
  - Family Entomobryidae
    - *Orchesella ainsliei* Folsom
  - Family Poduridae
    - Genus spp.
  - Family Sminthuridae
    - *Deuterosminthurus yumanensis* Wray
- Order Odonata
  - Family Libellulidae
    - *Perithemis tenera* Say
  - Family Coenagrionidae
    - *Enallagma signatum* Hagen
    - *Ischnura posita* Hagen
- Order Ephemeroptera
  - Family Hexageniidae
    - *Hexagenia* sp.
  - Family Baetidae
    - *Baetis* sp.
- Order Plecoptera
  - Family Perlidae
    - *Perlesta frisoni* Ricker
- Order Isoptera
  - Family Rhinotermitidae
    - *Reticulitermes virginicus* (Banks)
- Order Orthoptera
  - Family Acrididae
    - *Melanoplus femurrubrum propinquus* Scudder
  - Family Gryllidae
    - *Cyrtoxipha columbiana* Caudell
    - *Oecanthus celerinictus* Walker
    - *Phyllopalpus pulchellus* (Uhler)
  - Family Mantidae
    - *Stigmomantis carolina* (Johanssen)
  - Family Tettigoniidae
    - *Conocephalus fasciatus* (De Geer)
    - *Conocephalus strictus* (Scudder)
    - *Neoconocephalus triops* (L.)
    - *Orchelimum vulgare* (Harris)
    - *Pyrgocorypha uncinata* (Harris)
    - *Scudderia furcata* Brunner
- Order Thysanoptera
  - Family Aeolothripidae
    - *Aeolothrips melaleucus* Haliday
  - Family Phlaeothripidae
    - *Elaphrothrips tuberculatus* (Hood)
    - *Haplothrips faurei* Hood
    - *Haplothrips mali* (Fitch)
    - *Hoplandrothrips* sp.
    - *Hoplothrips japonicus* Karny
    - *Neurothrips magnafemoralis* Hinds

Family Thripidae
Frankliniella fusca (Hinds)
Frankliniella occidentalis (Pergande)
Frankliniella tritici (Fitch)
Limothrips cerealium (Haliday)
Sericothrips variabilis (Beach)

Order Psocoptera
Family Amphipsocidae
Graphopsocus cruciatus (L.)
Polypsocus corruptus (Hagen)
Teliapsocus conterminus (Walsh)
Family Caeciliidae
Caecillius flavidus (Stephens)
Family Ectopsocidae
Ectopsocops cryptomeriae (Enderlein)
Ectopsocus meridionalis Ribaga
Family Lepidopsocidae
Echmepteryx hageni (Packard)
Family Philotarsidae
Aaroniella certmoedi Mockford
Family Psocidae
Blastopsocus lithinus (Chapman)
Cerastipsocus trifasciatus (Provancher)
Metylophorus novascotiae (Walker)
Metylophorus purus (Aaron)

Order Hemiptera
Family Alydidae
Alydus pilosulus
Family Anthocoridae
Calliodis temnostethoides (Reuter)
Cardiastethus sp.
Lyctocoris sp.
Orius insidiosus (Say)
Family Coreidae
Anasa armigera (Say)
Leptoglossus oppositus (Say)
Family Corimelaenidae
Sehirus cinctus cinctus (Palisot de Beauvois)
Family Gerridae
Trepobates sp.
Family Lygaeidae
Eremocoris ferus (Say)
Geocoris punctipes (Say)
Geocoris uliginosus (Say)
Myodocha serripes Oliver
Ortholomus scolopax (Say)
Pachybracha basalis (Dallus)
Pachybracha bilobata (Say)
Paromius longulus (Dallus)
Family Miridae
Barberiella formicoides Poppius
Deraeocoris nebulosus (Uhler)
Halticus bractatus (Say)
Hyaliodes harti Knight
Lopidea heidemanni Knight
Lygocoris geneseensis (Knight)
Lygus lineolaris (Palisot de Beauvois)

Phytocoris near *husseyi* Knight
Phytocoris pennipectus Knight
Phytocoris tibalis Reuter
Polymerus basalis (Reuter)
Pseudoxenetus scutellatus Uhler
Spanogonicus albofasciatus (Reuter)
Trigonotylus doddi Distant

Family Nabidae
Nabis americoferus Carayon
Nabis capsiformis Germar
Nabis sp.

Family Pentatomidae
Apeteticus cinicus (Say)
Acrosternum hilare (Say)
Brochymena quadripustulata (Fabricius)
Euschistus servus (Say)
Euschistus tristigmus (Say)
Holeostethus limbolarius (Stal)
Murgantia histrionica (Hahn)
Podisus maculiventris (Say)
Stiretrus anchargo (Fabricius)
Thyanta calceata (Say)

Family Piesmidae
Piesma cinera (Say)

Family Reduviidae
Arilus cristatus (L.)
Diadema spinipes (Fabricius)
Empicoris culciformis (De Geer)
Empicoris errabundus (Say)
Zelus exsanguis (Stal)

Family Rhopalidae
Aehyssus lateralis (Say)
Hormostes reflexulus (Say)
Kleidocerys residae (Panzer)
Niesthreia lousianica Sailer

Family Saldidae
Saldula (Micracantha) humilus (Say)

Family Scutellaridae
Stethaulax marmoratus (Say)

Family Tingidae
Corythuca associata Osborn and Drake
Corythuca marmorata (Uhler)

Order Homoptera

Family Achilidae
Catonia pumila Van Duzee

Family Aleyrodidae
Genus sp.

Family Aphididae
Acyrthosiphon pisum (Harris)
Brachycaudus persicae (Passerini)
Calaphis sp.
Hysteroneura setariae (Thomas)
Macrosiphum rosae (L.)
Myzus persicae (Sulzer)
Therioaphis trifolii (Monell)

Family Cercopidae
Philaenus spumarius (L.)

Family Cicadellidae
Aceratogallia sanguinolenta (Provancher)
Agallia constricta Van Duzee
Carneocephala flaviceps (Riley)
Choanthus frontalis (Van Duzee)
Coelidia olitaria (Say)
Cuerna costalis (Fabricius)
Draeculacephala antica (Walker)
Empoasca fabae (Harris)
Endria inimica (Say)
Erythroneura corona Mcatee
Erythroneura dorisae Hepner
Erythroneura lawsoniana Baker
Erythroneura plena Beamer
Erythroneura venerata Fitch
Exitianus exitiosus (Uhler)
Forcipata loca De Long and Caldwell
Graminaella nigrifrons (Forbes)
Graminaella sonora Ball
Graminella villica (Crumb)
Graphocephala coccinea (Forster)
Graphocephala versuta (Say)
Gyponana angula De Long
Menosoma cincta (Osborn and Ball)
Norvellina seminuda (Say)
Oncometopia nigricans (Walker)
Orientus ishidae (Matsumura)
Osbornellus clarus Beamer
Osbornellus rotundus Beamer
Paraphlepsius irroratus (Say)
Paraulacizes irrorata (Fabricius)
Planicephalus flavicostatus (Van Duzee)
Polyamia weedi (Van Duzee)
Scaphytopius acutus (Say)
Stirellus bicolor (Van Duzee)
Tylozygus bifida (Say)
Family Cixiidae
Olarius placitus Van Duzee
Olarius sablensis Caldwell
Family Delphacidae
Delphacodes puella (Van Duzee)
Delphacodes sp.
Liburniella ornata (Stal)
Sogatella kolophon (Kirkaldy)
Family Derbidae
Anotia bonneti Kirby
Family Diaspididae
Pseudaulacaspis pentagona (Targioni-Tozzeti)
Family Flatidae
Leptormenis relicta (Fabricius)
Metcalfa pruinosa (Say)
Ormenoides venusta (Melichar)
Family Issidae
Bruchomorpha oculata Newman
Family Membracidae
Entylia sinuata (Fabricius)
Micrutalis calva (Say)
Platycotis vittata (Fabricius)

Family Psyllidae
Trioza diospyri (Ashmead)
Trioza sp.
Genus sp.

Order Neuroptera
Family Chrysopidae
Chrysoperla carnea (Stephens)
Chrysopa nigricornis Burmeister
Chrysoperla rufilabris (Burmeister)
Chrysopa oculata Say
Family Coniopterygidae
Coniopteryx simplicior Meinander
Coniopteryx westwoodi (Fitch)
Family Hemerobiidae
Hemerobius humilinus L.
Hemerobius stigma Stephens
Micromus posticus (Walker)
Sympherobius amiculus (Fitch)

Order Coleoptera
Family Alleculidae
Hymenorus discretus Casey
Hymenorus sp.
Isomira sericea (Say)
Family Anthicidae
Macratia sp.
Notoxus monodon (Fabricius)
Notoxus murinipennis LeConte
Genera 4 spp.
Family Anthribidae
Araecerus fasciculatus (De Geer)
Family Anobiidae
Caenocara bicolor Germar
Tricorynus indistinctus (Fall)
Family Bruchidae
Bruchus brachialis Fahraeus
Family Buprestidae
Anthaxia quercata (Fabricius)
Family Cantharidae
Cantharis sp.
Chauliognathus marginatus (Fabricius)
Podabrus sp. probably *frater* LeConte
Trypherus latipennis (Germar)
Genera 3 spp.
Family Carabidae
Amara sp.
Apristus subsulcatus Dejean
Bradycellus sp.
Calathus opaculus LeConte
Calosoma scrutator Fabricius
Lebia analis Dejean
Lebia divisa LeConte
Pinacodera platicollis Say
Family Cerambycidae
Ancylocera bicolor (Oliver)
Ecyrus dasycerus (Say)
Obrium maculatum (Oliver)
Family Chrysomelidae
Acalymma vittatum (Fabricius)

Altica foliaceae LeConte
Baliosus ruber (Weber)
Bassareus sp.
Cerotoma trifurcata (Forester)
Chaetocnema sp. possibly *pulicaria* Melshor
Colaspis brunnea (Fabricius)
Cryptocephalus mutabilis Melsheimer
Cryptocephalus quadruplex Newman
Diachus auratus (Fabricius)
Dibolia sp. possibly *sinuata* Horn
Disonycha triangularis (Say)
Epitrix fuscula Crotch
Epitrix hirtipennis (Melsheimer)
Gluptina sp. possibly *spuria* LeConte
Glyptoscelis pubescens (Fabricius)
Lema sexpunctata (Oliver)
Mantura floridana Crotch
Metriona bicolor (Fabricius)
Nodonota puncticollis (Say)
Phyllotreta sp. probably *strolata* (Fabricius)
Systena corni Schaeffer
Systena elongata (Fabricius)
Systena marginalis (Illiger)

Family Cleridae
Phyllobaenus unifasciatus (Say)
Phyllobaenus verticalis (Say)
Placopterus subcostatus Schaeffer

Family Ciidae
Cis fuscipes Mellie

Family Coccinellidae
Adalia bipunctata (L.)
Anatis quindecimpunctata (Oliver)
Brachyacantha sp.
Cephaloscymnus zimmermanni Crotch
Chilocoris stigma Say
Coccinella novemnotata Herbst
Coleomegilla maculata lengi Timberlake
Cycloneda munda (Say)
Delphastis pusillus (LeConte)
Diomus terminatus (Say)
Exochomus marginipennis LeConte
Hippodamia convergens Guerin-Meneville
Hyperaspis congressis Watson
Lindorus lophanthae (Blaisdell)
Microweisea misella (LeConte)
Mulsantia picta (Randell)
Olla abdominalis sobrina Casey
Olla abdominallis (Say)
Psyllobora vigintimaculata (Say)
Scymnillus aterrimus Horn
Scymnus cervicalis Mulsant
Scymnus loiwii Mulsant
Scymnus tenebrosus Mulsant
Stethorus punctum (LeConte)

Family Curculionidae
Anthonomus rubidus LeConte
Anthonomus sp.
Apion delta Buchanan
Apion sp.
Conotrachelus anaglypticus (Say)

Conotrachelus erinaceus LeConte
Conotrachelus nenuphar (Herbst)
Ceutorhynchus erysimi (Fabricius)
Ceutorhynchus rapae (Gyllenhal)
Crytepistomus castaneus (Roelofs)
Eulechriops minutus (LeConte)
Gymnetron pascuorum (Gyllenhal)
Lixus sp.
Pantomerus cervinus (Boheman)
Sitona sp.
Sitophilus oryzae (L.)
Simcronyx sculpticollis Casey
Simcronyx griseus LeConte
Family Dermestidae
Anthrenus verbasci (L.)
Cryptarhopalum haemorrhoidale LeConte
Family Dytiscidae
Genus sp.
Family Erotylidae
Tritoma pulcher (Say)
Family Eucnemidae
Entomophthalus rufiolus LeConte
Family Euglenidae
Zonantes fasciatus (Melsheimer)
Zonantes subfasciatus (LeConte)
Family Elateridae
Aeolus ambilis (LeConte)
Conoderus lividus (De Geer)
Conoderus vespertinus (Fabricius)
Glyphonyx sp.
Melanotus decumanus (Erichson)
Family Helodidae
Cyphon sp. 1
Cyphon sp. 2
Family Histeridae
Carcinops pumilo Erichson
Family Lathridiidae
Melanophthalma distinguenda (Comolli)
Stephostethus liratus LeConte
Family Malachiidae
Attalus scincetus (Say)
Family Melyridae
Collops quandrimaculatus (Fabricius)
Pseudobaeus apicolis Say
Pseudobaeus bicolor LeConte
Family Mordellidae
Mordellistena andreae ancilla LeConte
Mordellistena guttula Helnuth
Mordellistena husseyi Liljeblad
Mordellistena sp. possibly *rufa* Liljeblad
Mordellistena testacea Blatchley
Mordellistena trifasciata Say
Family Mycetophagidae
Litargus tetraspilotus LeConte
Family Nitidulidae
Carpophilus freemani Dodson
Carpophilus lugabris Murrary
Carpophilus mutilatus Erichson
Cybocephalus nigritulus LeConte

Meligethes nigrescens Stephens
Stelidota geminata (Say)
Family Orthoperidae
Corylophodes sp.
Orthoperus sp.
Sacium sp.
Sericoderus sp.
Family Phalacridae
Stilbus sp.
Family Ptilodactylidae
Ptilodactyla serricollis (Say)
Family Rhizophagidae
Europs pallipennis LeConte
Family Scaphidiidae
Eubaocera sp.
Family Scarabaeidae
Aphodius fimetarius (L.)
Aphodius lividus (Olivier)
Aphodius stercorosus Melsheimer
Cotinis nitida L.
Euphoria spulchralis (Fabricius)
Pelidnota luteapallidipes Casey
Popillia japonica Newman
Onthophagus pennsylvanicus Harold
Onthophagus taurus Schreber
Family Scraptiidae
Allopoda lutea Haldeman
Scraptia sp.
Family Scolytidae
Hypothenimus sp.
Pseudopityophthorus pruinosus (Eichoff)
Scolytus rugulosus (Ratzeburg)
Family Staphylinidae
Stenus sp.
Genera 4 spp.
Family Tenebrionidae
Hoplocephala viridipennis (Fabricius)

Order Trichoptera
Family Leptoceridae
Oecetis inconspicua (Walker)

Order Lepidoptera
Family Arctiidae
Ecpantheria scribonia (Stoll)
Family Ctenuchidae
Lycomorpha sp.
Family Gelechiidae
Chionodes sp.
Family Geometridae
Anacamptodes sp.
Family Lasiocampidae
Malacosoma americanum (Fabricius)
Family Limacodidae
Prolimacodes scapha Harris
Family Noctuidae
Acronicta interrupta Guenee
Chamyris cerintha (Treitschke)
Lithophane antennata (Walker)
Palthis angulalis Hübner

Pyrophila pyramidoides Guenee
Family Olethreutidae
Grapholita molesta (Busck)
Family Papilionidae
Palilio glaucus L.
Family Sesiidae
Synanthedon exitiosa (Say)
Family Saturniidae
Eacles imperialis (Drury)

Order Hymenoptera
Family Aphelinidae
Aphytis sp.
Prospaltella sp.
Family Aphidiidae
Aphidius sp.
Family Braconidae
Aliolus sp.
Apanteles militaris (Walsh)
Blacus sp.
Macrocentrus delicatus Cresson
Perilitus coccinelliae Schaeffer
Phanerotoma sp.
Family Chalcididae
Hockeria sp.
Family Chrysididae
Chrysis sp.
Family Dryinidae
Aphelopus bicolor Fenton
Subfamily Gonatopodinae
Family Ecolilidae
possibly *Hexacola* sp.
Family Encyrtidae
Cheiloneurus sp.
Isodromus sp.
Litomastix sp.
Family Eulophidae
Eulophus sp.
Horismenus sp.
Tetrastichus sp.
Family Eupelmidae
Anastatus sp.
Eupelmus sp. 1
Eupelmus sp. 2
Family Formicidae
Aphaenogaster sp.
Formica schaufussi dolosa Wheeler
Formica subsericea Say
Formica sp.
Lasius sp.
Paratrechina sp.
Family Hybrizontidae
Hybrizon sp.
Family Ichneumonidae
Allophrys n. sp.
Diplazon laetatorius (Fabricius)
Eutanyacra sp.
Pristiceros lascivus (Cresson)
Pterocormus ambulatorius (Fabricius)
Syrphoctonus minimus (Cresson)

Venturia sp.
Subfamily Orthocentrinae Genus sp.
Family Pteromalidae
Asaphes sp.
Cheriopachus sp.
Halticoptera sp.
Rhaphitelus sp.
Zatropis sp.
Family Sphecidae
Liris argentata (Palisot de Beauvois)
Philanthus sp.
Tachytes sp.
Family Torymidae
Podagrion mantis Ashmead
Family Trichogrammatidae
Paracentrobia sp.
Trichogramma sp.
Family Vespidae
Polistes dorsalis (Fabricius)
Polistes fuscatus (Fabricius)
Polistes sp.
Vespula maculifrons (Buysson)
Family Xyelidae
Xyela obscura (Strobl)

Order Strepsiptera
Family Halictophagidae
Genus sp., hosts: *Endria inimica* (Say), *Draculacephala antica* (Walker)

Order Diptera
Family Calliphoridae
Lucilia illustrus (Meigen)
Family Cecidomyiidae
Clinodiplosis sp.
Lestodiplosis sp. near *grassotor* (Fyles)
Lestremia sp.
Porricondyla sp.
Stomatosema sp.
Family Chaoboridae
Chaoborus sp.
Family Chironomidae
Chironomus sp.
Procladius bellus (Loew)
Subfamily Orthocladiinae
Family Chloropidae
Apallates dissidens (Turcker)
Apallates particeps (Becker)
Hippelates pallipes (Loew)
Malloewia nigripalpus (Malloch)
Oscinella carbonaria (Loew)
Tricimba melancholia (Becker)
Family Drosophilidae
Drosophila buskii Coquillett
Leucophenga maculosa (Coquillett)
Leucophenga varia (Walker)
Lyciella sp.
Scaptomyza pallida (Zetterstedt)
Family Lauxaniidae
Homoneura sp.

Poecilominettia ordinaria (Melander)
Poecilominettia valida (Walker)
Xenochaetina muscaria (Loew)
Family Lonchopteridae
Lonchoptera furcata (Fallen)
Family Muscidae
Coenosia sp. 1
Coenosia sp. 2
Family Mycetophilidae
Acenemia sp.
Family Phoridae
Megaselia sp.
Family Pipunculidae
Tomosvaryella sp.
Family Sarcophagidae
Blaesoxipha spatulata (Aldrich)
Boettcheria cimbicis (Townsend)
Oxysarcodexia conclausa (Walker)
Ravinia derelicta (Walker)
Ravinia sp.
Sarcophaga sp.
Family Sciaridae
Bradysia sp. near *coprophilia* (Lintner)
Bradysia sp.
Lycoriella sp.
Family Sepsidae
Genus sp.
Family Spaeroceridae
Leptocera sp.
Family Stratiomyidae
Ptecticus trivittatus (Say)
Stratiomys sp.
Family Tabanidae
Tabanus atratus Fabricius
Family Syrphidae
Chrysotoxum radiosum Shannon
Metasyrphus vinelandi (Curran)
Platycheirus sp.
Syrphus vitripennis Meigen
Toxomerus marginatus (Say)
Family Tipulidae
Genus sp.

Class ARACHNIDA
Order Phalangida
Family Phalangiidae
Leiobunum ventricosum (Wood)

Order Pseudoscorpiones
Genus sp.

Order Acari
Family Bdellidae
Bdella sp.
Family Cheyletidae
Cheyletomorpha lepidopterorum (Shaw)
Family Eremaeidae
Erameus sp.

Family Erythraeidae
Leptus sp.
Family Galumnidae
Galumna sp.
Family Macrochelidae
Macrocheles muscadomesticus (Scopoli)
Family Parasitidae
Parasitus sp.
Family Phytoseiidae
Amblyseius sp.
Family Tetranychidae
Bryobia praetiosa Koch
Panoychus ulmi (Koch)
Tetranychus urticae Koch

Order Araneida
Family Anaphaenidae
Anaphaena near *fraterna* (Banks)
Aysha gracilis (Hentz)
Family Araneidae
Acacesia hamata (Hentz)
Acanthepeira stellata (Marx)
Araneus bivittatus (Walckenaer)
Araneus cingulatus (Walckenaer)
Araneus guttulatus (Walckenaer)
Araneus juniperi (Emerton)
Araneus near *pegnia* (Walckenaer)
Argiope aurantia Lucas
Argiope trifasciata (Forskal)
Cyclosa turbinata (Walckenaer)
Eustala anastera (Walckenaer)
Gea heptagon (Hentz)
Larina directa (Hentz)
Mastophora cornigera (Hentz)
aff. *Mecynogea lemniscata* (Walckenaer)
Metazygia sp.
Neoscona minima O. P.-Cambridge
Neoscona sacra (Walckenaer)
Family Clubionidae
Castianeira sp.
Clubiona sp.
Micaria sp.
Trachelas tranquillus (Hentz)
Family Gnaphosidae
Cesonia bilineata (Hentz)
Zelotes sp.
Family Linyphiidae
Florinda cocceinea (Hentz)
Frontinella pyramitela (Walckenaer)
Meioneta micaria (Emerton)
Meioneta sp.
Pityohyphantes near *phrygianus* (C. L. Koch)
Family Lycosidae
Lydosa sp.
Pardosa saxatilis (Hentz)
Pardosa sp. 1
Pardosa sp. 2
Pirata sp.

Family Lyssomanidae
Lyssomanes viridis (Walckenaer)
Family Micryphantidae
Ceraticelus formosus Banks
Eridantes near *erigonoides* (Emerton)
Erigone autumnalis Emerton
Walckenaera vugulax Blackwell
Genus sp.
Family Mimetidae
Mimetus puritanus Chamberlain
Family Oxyopidae
Oxyopes salticus Hentz
Peucetia viridans (Hentz)
Family Pisauridae
Dolomedes sp.
Pisaurina mira (Walckenaer)
Family Pholcidae
Spermophora meridonalis Hentz
Family Salticidae
Ballus sp. (not *youngi* G. and E. Peckham)
Eris aurantia (Lucas)
Eris marginata (Walchenaer)
aff. *Euophrys* sp.
Habronattus borealis (Banks)
Hentzia palmarum (Hentz)
Metaphidippus flavipedes (G. and E. Peckham)
Metaphidippus galathea (Walckenaer)
Metaphidippus sp.
Metacyrba undata (De Geer)
Myrmarachne hentzi Banks
Myrmecotypus lineatus (Emerton)
Neon near *nelli* G. and E. Peckham
Peckhamia picata (Hentz)
Phidippus audax (Hentz)
Phidippus princeps (Peckham)
Phidippus aff. *pulcherrimus* Keyserling
Sardina hentzi (Banks)
Thiodina sylvana (Hentz)
Family Tetragnathidae
Glenognatha foxi McCook
Pachygnatha sp.
Tetragnatha laboriosa (Hentz)
Family Theridiidae
Achaearanea conjuncta (Gertsch and Muliak)
Achaearanea globosus (Hentz)
Argyrodes probably *trigonum* (Hentz)
Chrysso sp.
Dipoena aff. *dorsata* Muma or n. sp.
Dipoena nigra (Emerton)
Euryopsis emertoni Bryant
Euryopsis limbata (Walckenaer)
Latrodectus mactans (Fabricius)
Spinarthus flavidus Hentz
Steatoda americana (Emerton)
Steatoda borealis (Hentz)
Steatoda grossa (C. L. Koch)
Theridion differens Emerton
Theridion frondeum Hentz
Theridion intervalatum Emerton

Theridion lyricum Walckenaer
Theridon mumarium Emerton
Theridula opulenta (Walckenaer)
Family Thomiscidae
Misumenops asperatus (Hentz)
Misumenops oblongus (Keyserling)
Synema parvula (Hentz)
Thanatus sp.
Tmarus angulatus (Walckenaer)
Xysticus bicuspis Keyserling
Xysticus funestus Keyserling
Family Philodromidae
Apollophanes sp.
Philodromus barrowsi Gertsch
Philodromus keyserlingi Marx
Philodromus rufus (Walckenaer)
Philodromus sp.
Family Uloboridae
Uloborus glomosus (Walckenear)

Order Isoptera - Winged adults were collected in the canopy during dispersal flights. Decayed trunks and large branches were infested with termites, but infestations probably occurred after the death of the wood from mechanical damage or disease.

Order Orthoptera - Most grasshoppers and crickets were winged adults, collected late in the growing season (September and October), indicating that feeding by immatures on the peach tree was minimal. One exception was the tree cricket, *Oecanthus celerinictus* Walker, the immatures of which were found during the season.

Order Thysanoptera - This group contains both phytophagous and predaceous species. Two thripids, *Frankliniella tritici* (Fitch) and *Sericothrips variabilis* (Beach), were the principal phytophagous species, *F. tritici* being an early season pest and *S. variabilis*, a mid-summer species. The western flower thrips, *Frankliniella occidentalis* (Pergande), was not collected in Anderson County, but was observed in Edgefield County reproducing on ripening fruit. This species may be of economic significance.

Aelothrips melaleucus Haliday (Aeolothripidae), a known spider mite predator, was never present in large numbers. The phlaeothripids *Haplothrips faurei* Hood and *Haplothrips mali* (Fitch) were the most common predaceous species.

Order Psocoptera - The psocids or bark lice are potential economic species in the tree canopy. They are known to feed on molds, fungi, and pollen and may act as mechanical vectors of fungal diseases such as brown rot.

Ectopsocopsis cryptomeriae (Enderlein) was the most abundant species. Its numbers reached an average of 3,3961.0 $\pm$ 405.9 per tree on 30 Aug 1978 in the sprayed block, but these numbers were exceptional and were not repeated in 1979. Other consistently abundant species were *Ectopsocus meridionalis* Ribaga and *Teliapsocus conterminus* (Walsh).

Order Hemiptera - This group is economically important since it contains the cat-facing insects, species that pierce the developing fruit, suck juices, and inject substances that stunt the growth of the surrounding tissue. The known cat-facing species collected during fruit development were *Lygus lineolaris* (Palisot de Beauvois), *Acrosternum hilare* (Say), *Euschistus servus* (Say), *Euschistus tristigmus* (Say), and

Anasa armigera (Say). *Brochymena quadripustulata* (Say) was the most abundant pentatomid and the only one that reproduced in the canopy. It has not been implicated as a cat-facing hemipteran (Rings 1957). *Leptoglossus oppositus* (Say), a coreid, was observed feeding on ripe fruit but was never collected in the early season.

Many predaceous hemipterans were collected during this study, including the spider mite predators (Lee 1981). Mirids in the genus *Phytocoris,* reduviids in the genus *Empicoris,* and *Podisus maculiventris* (Say), were consistently collected in low numbers during this study.

Order Homoptera - Aphids, scales and leafhoppers were the principal pests in this group. Leafhoppers present a special problem as vectors of several diseases of peaches.

A total of 36 species of cicadellids was collected in this study, 7 of which are known disease vectors (Neilson 1968). *Cuererna costalis* (Fabricius), *Graphocephala versuta* (Say), and *Oncometopia nigricans* (Walker) are vectors of phony peach disease bacterium. *Scaphytopius acutus* (Say), *Norvellina seminuda* (Say) and *Paraphlepsius irroratus* (Say) are vectors of eastern X-disease mycoplasma-like organisms of peaches.

Although many leafhoppers species were prevalent in the peach tree, only *Erythroneura plena* Beamer was observed to reproduce in the canopy where its numbers reached an average of 4,917.0 $\pm$ 936.1 adults per tree in the unsprayed block on 13 Sep 1978 and 4,871.0 $\pm$ 171.0 per tree on 13 Aug 1979.

The white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzeti), was a serious pest in the unsprayed block of the Anderson County orchard. Deterioration of branches and foliage from infestations of this insect was evident. Sessile adults of the white peach scale were not collected in this study.

Order Neuroptera - Of the 10 species collected, only *Chrysoperla rufilabris* (Burmeister), *Coniopteryx westwoode* (Fitch) and *Micromus posticus* (Walker) were important predators in the canopy (Lee 1981). Adult chrysopids were present in the canopy late in the season, possibly to feed on aphids.

Order Coleoptera - The beetles are a diverse group and occupy many ecological niches in the canopy. Only the economically and ecologically important families will be discussed.

Coccinellidae - Most coccinellids were general predators, but several species prefer certain arthropods. *Stethorus punctum* (LeConte) was an obligate spider mite predator. *Coleomegilla maculata lengi* Timberlake also showed a preference for spider mites (Lee 1981). The scale predators, *Microweisea misella* (LeConte) and *Scymnillus aterrimus* Horn, were important natural control agents of the white peach scale, *P. pentagona* (Targioni-Tozzeti) in the unsprayed block. The head of the *M. misella* larva was observed to be flattened horizontally, specialized for feeding on scale insects. *Scymnus loewii* Mulsant was an important predator of the black peach aphid, *Brachycaudus persicae* (Passerini). Adults and wax-covered larvae were observed feeding on aphid aggregations. Other coccinellids were either incidental or present in low numbers during the two seasons.

Curculionidae - The plum curculio, *Conotrachelus nenuphar* (Herbst), was present in large numbers in the unsprayed block (Lee 1981). The only other weevil collected in large numbers was the Fuller rose beetle, *Pantomerus cervinus* (Boheman), a leaf-feeding species as an adult. It was collected in the canopy from June to November of both years, especially in the sprayed block. Although this

weevil was numerous, no significant damage except for cylindrical holes in leaves on lower branches was observed.

Lathridiidae - A minute brown scavenger beetle, *Melanophthalama distinguenda* (Comolli), is a fungivorus species. It was present in large numbers during 1978, but was less numerous in 1979.

Nitidulidae - Most nitidulids, or sap beetles, appeared late in the growing season to feed and reproduce in decaying fruit. These beetles have been implicated as mechanical vectors of *Monolinia fructicola* (Wint.) Horey, the peach brown rot fungus. One exception was *Meligethes nigrescens* Stephens, which was collected in early spring in large numbers and was observed to inhabit the floral tube of the peach blossom. Although this beetle has never been implicated for damaging peach fruit, its activity inside the floral tube may be a source of injury to the developing fruit.

Orthoperidae - The orthoperids are closely related to the coccinellids and are predators and fungus feeders. *Orthoperus* sp., a minute beetle about 0.5 mm in length, was abundant in the unsprayed block, averaging 548.0 ± 162.0 adults per tree on 12 Oct 1978 and 720.5 ± 39.5 per tree on 31 Jul 1979.

Scarabaeidae - Two scarabs, the Japanese beetle, *Popillia japonica* Newman, and the green June beetle, *Cotinis nitida* L., were the only species of economic importance. Japanese beetles were collected in June and July. The green June beetle, collected primarily in July and August, fed on ripe fruit in large numbers and caused significant damage. These beetles are also mechanical vectors of peach brown rot fungus.

Order Lepidoptera - Although many species of Lepidoptera fed on peach foliage, sprays and natural enemies kept their numbers below an economic level. *Malacosoma americanum* (Fabricius), the eastern tent caterpillar, was an early season pest but was controlled by scheduled insecticide sprays. Most other species increased in numbers late in the season, after termination of spraying, but were suppressed by natural enemies, i.e. paper wasps.

Adults of the Oriental fruit moth, *Grapholita molesta* (Busck), were present in large numbers during both growing seasons. In the unsprayed block, extensive damage to twig terminals was observed.

The peachtree borer, *Synanthedon exitiosa* (Say), and the lesser peachtree borer, *Synanthedon pictipes* (Grote and Robinson), are serious pests of the peach tree. These diurnally active moths were seldom collected in the tree canopy. Low numbers of male peachtree borers was collected during the two year study.

Order Hymenoptera - Only the predominant parasitic hymenoptera were identified to genus and/or species due to the policies of the U.S.D.A. Systematic Entomology Laboratory, Beltsville, MD. The following is a list of parasitoids with known host data:

Aphelinidae

Aphytis sp. Host: white peach scale

Prospaltella sp. Host: white peach scale

Aphidiidae

Aphidius sp. Host: aphids

Braconidae

Aliolus sp. Host: plum curculio

Apanteles militaris (Walsh) Host: armyworms

Blacus sp. Host: probably fungus-feeding flies

Macrocentrus delicatus Cresson Host: Oriental fruit moth
Perilitus coccinelleae (Schrank) Host: *Coleomegilla maculata*
Phanerotoma sp. Host: lepidoptera larvae
Dryinidae
subfamily Gonatopodinae Host: cicadellids
Aphelopus bicolor Fenton Host: cicadellids
Encyrtidae
Cheiloneurus sp. Host: *Chrysopa rufilabris*
Litomastix sp. Host: lepidoptera larvae
Eulophidae
Eulophus sp. Host: lepidoptera larvae
Tetrastichus sp. Host: *Chrysoperla rufilabris*
Hybrizontidae
Hybrizon sp. Host: possibly ants
Ichneumonidae
Diplazon laetatorius (Fabricius) Host: Syrphidae
Pteromalidae
Asaphes sp. Host: aphids
Cheriopachus sp. Host: wood-boring beetles
Rhaphitelus sp. Host: wood-boring beetles
Torymidae
Podagrion mantis Ashmead Host: *Stigmomantis carolina* eggs.
Trichogrammatidae
Trichogramma sp. Host: lepidoptera

Order Strepsiptera - These parasitic insects were collected in two species of leafhoppers and were uncommon.

Order Diptera - Flies were abundant throughout the season in the peach tree canopy. The majority were no economic threat and were probably feeding at leaf nectaries or ripening fruit later in the season each year. Many fruit flies reproduced in rotting fruit on the ground. Ecologically, their large numbers provided a food source for predators such as spiders in the canopy. Five species of syrphid flies, aphid predators in the larval stage, were collected.

Evaluation of the Sampling Apparatus

The closed-canopy sampling apparatus was satisfactory for estimating populations of most arthropod groups in the peach tree canopy, although several extrinsic hindrances had to be overcome. A critical assessment of the apparatus components and sampling procedure follows.

The frame is instrumental in preventing significant disturbance of the branches while positioning the tree cover. Assembled from lengths of conduit, it can be readily disassembled for transportation to and from the sampling location. The light weight of the frame permits easy movement from tree to tree while assembled, thus reducing sampling time.

The polyethylene ground cover provides a smooth, low-friction surface, facilitating the recovery of fallen arthropods by allowing them to be channeled to one area. It is also impervious to ground moisture, durable and flexible. The tree cover, while efficient in preventing escape of enclosed arthropods, was rather bulky and cumbersome to use. Clamping the edges of the polyethylene secures the system

and reduces ballooning caused by wind gusts during sampling. Wind is a problem in many types of field sampling, especially when a large volume is enclosed. Flexibility in sampling data and time is necessary until calm conditions exist. Late afternoon is generally the calmest period of the day and the best time for sampling since heat and moisture factors are reduced.

Condensation inside the tree cover from transpiration and heat collection hinders recovery of specimens. Small arthropods adhere to water droplets that fall from the tree cover when it is removed, necessitating increased brushing. The problem is partially alleviated by reversing the tree cover after each sample allowing the damp side to dry. A fine-mesh, lightweight material, such as parachute cloth may be more suitable for the tree cover since it would allow the moisture to evaporate while still retaining the pyrethrin fog inside. The amount of heat inside the enclosure would also be reduced.

Evaluation of the Sampling Technique

A major advantage to this absolute technique is that the total arthropod community within the peach tree canopy, except for sessile and boring forms, are sampled. Many relative methods require the identification and quantifications of live insects before they escape. Jarring is feasible only for arthropods that tumble from vegetation when disturbed. This closed canopy sampling method is not restricted by size, activity, or behavior of mobile canopy-dwelling species. Although adult scale insects are not sampled, coccinellid predators and hymenopterous parasites of scales are well represented. Eggs and pupae also are not collected during sampling. This must be taken into consideration in quantification of predator-prey relationships. Adult and larval forms that burrow into the fruit or other parts of the tree and sessile insects are not well represented and should be sampled by more specialized techniques.

To determine the efficiency of the technique, two phytophagous arthropods that were sampled consistently during the growing season and were endemic to the peach tree canopy, the plum curculio, *Conotrachelus neuphar* (Herbst), a relatively large species, and a small cicadellid, *Erythroneura plena* Beamer were selected. The coefficient of variation (CV) of the average number per tree was used to ascertain efficiency. Where $n = 20$, the CV for the plum curculio averaged 21.02% and for *E. plena* 21.44%. Considering reduced replication and intertree variation, this amount of variation was expected and deemed acceptable.

Evaluation of the Tree as the Sampling Unit

In most forest and orchard situations, using the entire tree as the sampling unit would not be practical or possible. Peach trees are pruned to a low height and uniform shape, making closed-canopy, whole-tree sampling practical. An advantage is that the tree is kept intact and undamaged. Low densities of arthropods are detected and most microhabitats of the canopy are sampled.

Morris (1960) stated that in tree sampling, the major source of variation is often intertree rather than intratree. It was evident in this study that even though relatively uniform trees were sampled, certain trees had greater overall densities of arthropods. This may be due to varying physiological status of the trees affecting surface area, nutrient levels, and fruiting capacities.

An absolute sampling technique is the basis for a relative technique and the subsequent development of relative indices. Therefore, this closed canopy technique

not only yields information on the temporal fluctuation and densities of arthropods in peach trees, but may be an important tool towards better management practices.

ACKNOWLEDGMENTS

The authors wish to thank the many specialists who provided identification of arthropods during this study. The following specialists are associated with the Systematic Entomology Laboratory, U.S.D.A., Beltsville, MD:

Collembola - D. L. Wray
Isoptera - D. A. Nickle
Psocoptera - E. L. Mockford
Orthoptera - D. A. Nickle
Hemiptera - T. J. Henry, R. C. Froeschner
Neuroptera - O. S. Flint
Coleoptera - R. D. Gordon, T. L. Erwin, D. M. Anderson, W. F. Barr, W. A. Connell, T. J. Spilman, R. White, D. R. Whitehead
Lepidoptera - D. M. Weisman
Diptera - F. C. Thompson, R. J. Gagne, W. N. Mathis, C. W. Sabrosky, W. W. Wirth
Hymenoptera - A. S. Menke, D. R. Smith, E. E. Grissell, P. M. Marsh, R. W. Carlson, D. L. Vincent
Araneida - W. B. Peck
Acarina - R. L. Smiley

Other specialist involved were:
Ephemeroptera - J. Weaver
Plecoptera - R. Kelley
Odonata - T. White
Thysanoptera - R. Beshear
Hemiptera - W. Jones
Homoptera - L. Hepner
Trichoptera - S. Hamilton
Coleoptera - H. Dozier, Jr.

REFERENCES CITED

Bastanian, N. J., and D. H. C. Herne. 1980. A rapid method of collecting arthropods from deciduous trees. J. Econ. Entomol. 73: 832-833.

Cleveland, M. L., and D. W. Hamilton. 1958. The insect fauna of apple trees in southern Indiana, 1956 and 1957. Indiana Acad. Sci. 68: 205-207.

Collyer, E. 1951. A method for the estimation of insect populations of fruit trees. Rep. E. Malling Res. Sta. 1949-50: 148-151.

Gibbs, D. G., A. D. Pickett, and D. Leston. 1968. Seasonal population changes in cocoa capsids (Hemiptera: Miridae) in Ghana. Bull. Entomol. Res. 58: 279-293.

Ives, W. G. H. 1967. Relations between invertebrate predators and prey associated with larch sawfly eggs and larvae on tamarack. Can. Entomol. 99: 607-622.

Lee, G. T. 1981. The seasonal abundance of arthropods on peach trees in South Carolina. Ph.D. Dissertation, Clemson University, Clemson, SC. 82 pp.

Legner, E. F., and E. R. Oatman. 1962. Foliage-feeding Lepidoptera on young non-bearing apple trees in Wisconsin. J. Econ. Entomol. 55: 552-554.

Lord, F. T. 1965. Sampling predator populations on apple trees in Nova Scotia. Can. Entomol. 97: 287-298.

Lord, F. T. 1968. An appraisal of methods of sampling apple trees and results of some tests using a sampling unit common to insect predators and their prey. Can. Entomol. 100: 23-33.

McCaffrey, J. P., and R. L. Horsburgh. 1980. The spider fauna of apple trees in central Virginia. Environ. Entomol. 9: 247-252.

Morris, R. F. 1960. Sampling insect populations. Ann. Rev. Entomol. 5: 243-264.

Muir, R. C., and R. G. Gambrill. 1960. A note on the knockdown method for estimating numbers of insect predators on fruit trees. Ann. Rep. E. Malling Res. Sta. 1959: 109-111.

Neilson, M. W. 1968. The leafhopper vectors of phytopathogenic viruses (Homoptera, Cicadellidae) taxonomy, biology, and virus transmission. U.S. Dept. Agr. Tech. Bull. 1382. 386 pp.

Polles, S. G., and J. A. Payne. 1973. Pecan weevil: an improved method of sampling populations in pecan trees. J. Econ. Entomol. 66: 519-520.

Putnam, W. L. 1967. The biomechanics of *Stethorus punctillum* Weise (Coleoptera: Coccinelledae) in Ontario. Can. Entomol. 87: 9-33.

Rings, R. W. 1957. Types and incidence of stink bug injury to peaches. J. Econ. Entomol. 50: 599-603.

Southwood, T. R. E. 1978. Absolute population estimates by sampling a unit habitat - air, plants, plant products, and vertebrate hosts. pp. 130-169. In Ecological Methods. Halsted Press.