FOOD HABITS OF PHYTOSEIIDAE (ACARINA: MESOSTIGMATA) INCLUDING COMMON SPECIES ON FLORIDA CITRUS[1]

MARTIN H. MUMA
University of Florida, Citrus Experiment Station,
Lake Alfred, Florida 33850

ABSTRACT

Food habits of 11 species of phytoseiids found on or associated with Florida citrus trees were investigated with the following results. Data on *Amblyseiella setosa* Muma were inconclusive; *Amblyseius aerialis* (Muma) proved to be a general predator of tetranychids, tenuipalpids, and probably other families of mites; *Amblyseius deleoni* Muma and Denmark fed adequately and optimally on acarids, eriophyids and tetranychids, and predictably on other families; *Euseius hibisci* (Chant) fed adequately on coccid eggs and crawlers, aleurodid eggs and nymphs, and tetranychids; *Galendromus* (*Galendromus*) *floridanus* (Muma) proved to be an obligate predator of tetranychids; *Iphiseiodes quadripilis* (Banks) proved to be a general facultative predator capable of surviving on non-living organic materials; *Phytoscutus sexpilis* Muma fed optimally only on acarids but possibly survives on other hosts; data on *Proprioseiopsis dorsatus* (Muma) were inconclusive; *Typhlodromalus peregrinus* (Muma) proved to be a general facultative predator capable of surviving on fungi and non-living organic materials; data on *Typhlodromina subtropica* Muma and Denmark were inconclusive; *Typhlodromips simplicissimus* (DeLeon) fed optimally on tetranychids but other phytophagus and non-phytophagus mites are probably adequate as food.

Collation and correlation of the above findings with previously published work has indicated generic food habits for several genera of phytoseiids. *Amblydromella* spp. are probably facultative eriophyid and tetranychid predators. *Amblyseius* spp. are probably general predators. *Anthoseius* spp. seem to be pollenophagus. *Euseius* spp. are pollenophagus, facultative, general predators. *Galendromus* spp. of the typical subgenus seem to be obligate tetranychid-eriophyid predators; inadequate data are available on species of other subgenera. *Iphiseiodes* spp. are probably facultative general predators. *Macroseius* spp. are obligate nematode-anoetid predators. *Mesoseiulus* spp. seem to be obligate tetranychid predators. *Orientiseius* spp. are probably obligate predators of eriophyids and tetranychids. *Paraseiulus* spp. possibly are tydeid predators. *Phytoscutus* spp. are probably acarid predators. *Phytoseiulus* spp. are obligate predators of tetranychids that may survive on other mites and insects. *Typhlodromalus* spp. are facultative general predators. *Typhlodromips* spp. are facultative general predators. *Typhlodromus* spp. are probably facultative eriophyid or tetranychid predators. Data on 5 other cited genera are inconclusive.

Although the food habits of phytoseiids (Acarina: Mesostigmata) have been the object of much study and conjecture since the investigations of Parrott et al. (1906), much remains to be learned about them. Most early workers and some recent workers have made field observations and conducted limited laboratory experiments to determine the predatory habits of these mites. Only recently have systematic experiments demonstrated that certain species are predominately pollenophagus, others are faculta-

---

[1]Florida Agricultural Experiment Stations Journal Series No. 3689.

tive predators that can either survive or reproduce on a variety of living and non-living organic materials, and still others are obligatory predators. Survival foods, adequate foods, and optimal foods range from floral and extra-floral nectars, through fungi, pollen, and leaf hairs to insects, mites and even nematodes. In the light of this known variation in food consumed, our knowledge of phytoseiid food habits must be considered to be, at best, fragmentary.

In the present paper, results obtained over the past 20 years from studies on the food habits of phytoseiids found on or associated with Florida citrus trees are collated and correlated with previously published work. The combined data materially added to our knowledge of the food habits of these potentially important predators and permitted the development of some general concepts concerning phytoseiid feeding.

Methods

In a series of pilot studies, it was found that most phytoseiids survived for 5 to 10 days in the absence of food at room temperatures with moderate to high relative humidities. It was further noted that mite activity was greater on a familiar substrate such as a citrus leaf, and longevity was increased when water was readily available. Therefore, all experiments were conducted on whole or sectioned citrus leaves and free water was made available in saturated cotton. Offered foods were placed directly on or immediately adjacent to the leaves or leaf pieces. Feeding and rearing chambers included large cotton stoppered shell vials for individual female predators, and petri dishes, and $3.5 \times 9.0 \times 18.0$ cm plastic boxes for series of specimens. In the petri dishes and plastic boxes, the leaves or leaf pieces were floated on water-saturated cotton batting and partially covered with a second layer of water-saturated batting. Temperatures in the laboratory varied from 70° to 90° F but normally ranged from 75° to 85° F. Humidities were varied by intermittently wetting the cotton stoppers or covering and uncovering the petri dishes and plastic boxes.

Feeding experiments were conducted only as field-collected predatory mites and food materials became available from routine leaf and fruit examinations. Once female predators were exposed to candidate foods or hosts, however, they were examined daily to record survival, oviposition, development, culture establishment, and culture growth. Foods were added regularly to maintain apparent adequate food density.

If the predators did not live more than 1 to 2 weeks, the food was recorded as an inadequate food; if the predators lived longer than 2 weeks but did not oviposit beyond the first 3 to 4 days and immatures did not complete development, the food was recorded as a survival food; if the predators lived for extensive periods of time, oviposition occurred regularly and immatures completed development, the food was recorded as an adequate food; if the predators lived, oviposition was frequent, and the cultures rapidly increased in size, the food was recorded as an optimal food.

In most instances unsorted populations of prey species, including eggs, early instars, later instars, and adults, were offered as foods. When specific growth stages of prey were used, references to such are included in the text.

TABLE 1.—SUMMARY OF KNOWN FOOD REQUIREMENTS AND FOOD RANGES FOR COMMON CITRUS PHYTOSEIIDS.

Phytoseiid species tested	No. of foods tested	No. of female predators	Food or host family (Evaluation based on survival, oviposition, and development)				
			Inadequate		Survival	Adequate	Optimal
Typhlodromalus peregrinus (Muma)	27	360	Acaridae Agar + mold Aleurodidae Aschersonia Coccidae Coccidae + Aleurodidae Eriophyidae Honey Honey + citrus pollen Honeydew	Honeydew + sooty mold Misc. fungus No food Citrus pollen Tarsonemidae Tetranychidae Tydeidae Tydeidae + fungus Water	Agar + mold Aleurodidae Honey Sooty mold Tetranychidae Tydeidae + agar	Acaridae Agar + mold Aleurodidae Tetranychidae Tydeidae + agar	Aleurodidae Coccidae Tetranychidae
Iphiseiodes quadripilis (Banks)	18	330	Acaridae Aleurodidae Aleurodidae + Tydeidae Eriophyidae Honey Honey + citrus pollen Sooty mold	Sooty mold + honey Tarsonemidae Tenuipalpidae Tetranychidae Tydeidae Water	Acaridae Aleurodidae Honey Sooty mold Sooty mold + honey Tarsonemidae Tetranychidae	Aleurodidae + Tydeidae Eriophyidae Tarsonemidae	Acaridae Aleurodidae Tetranychidae
Typhlodromips simplicissimus (DeLeon)	7	40	Eriophyidae Honeydew Tetranychidae		Acaridae Aleurodidae Tetranychidae Tydeidae		Tetranychidae

Phytoseiid species tested	No. of foods tested	No. of female predators	Food or host family (Evaluation based on survival, oviposition, and development) Inadequate		Survival	Adequate	Optimal
Euseius hibisci (Chant)	11	187	Agar + mold Coccidae Honeydew Citrus pollen Tetranychidae *Malvaviscus grandiflorus* HBK pollen Tydeidae		Honeydew Tetranychidae	Coccidae Coccidae + Aleurodidae Tetranychidae	
Typhlodromina subtropica Muma & Denmark	5	32	Acaridae Coccidae Eriophyidae	Tetranychidae Tydeidae			
Galendromus (G.) *floridanus* (Muma)	9	181	Aleurodidae Aleurodidae + Coccidae Coccidae	Honey Honeydew Honey + citrus pollen		Tetranychidae	Tetranychidae
Amblyseiella setosa Muma	4	19	Tetranychidae		Tetranychidae	Tetranychidae	
Amblyseius deleoni Muma & Denmark	3	40	Acaridae Eriophyidae		Eriophyidae Tetranychidae	Acaridae Eriophyidae Tetranychidae	Acaridae Tetranychidae
Proprioseiopsis dorsatus (Muma)	5	11	Acaridae Dead Coccidae	Eriophyidae Tetranychidae	Tetranychidae		
Amblyseius aerialis (Muma)	3	27	Tetranychidae			Tetranychidae	Tenuipalpidae Tetranychidae
Phytoscutus sexpilis Muma	5	50	Acaridae Tetranychidae		Acaridae	Acaridae Tetranychidae	Acaridae

Mites exposed to inadequate or survival foods frequently escaped from feeding and rearing chambers and were lost. However, mites that died or were available at the end of the test period were mounted on permanent microscope slides for positive identification.

RESULTS

The known food requirements and food ranges of 11 common phytoseiids on Florida citrus trees (Muma 1964) are summarized in Table 1. Although these results broadly indicate the food habits of 4 species, detailed information on the species is obscured and for 7 species the data appear to be inadequate. Therefore, the following specific summary paragraphs have been prepared as a supplement to the table. Pertinent grove observations, environmental factors that limit food habits, and specific laboratory results are included.

A cryptic bias exists in the data: phytophagus mites and insects were always tested first and more frequently, and foods available on citrus trees were tested in preference to other foods.

The range in suitability of a given food for a given species of phytoseiid apparently resulted from the use of grove-collected test specimens. The previous food regimen, age, and egg deposition potential of such specimens could not be known; it is believed that these and other uninvestigated factors probably account for most of the variable results reported here.

Amblyseiella setosa Muma.—This species was described from scale-infested orange and grapefruit leaves on the west coast of Florida (Muma 1955). Recently, specimens have been taken from litter beneath citrus trees and six-spotted mite-infested citrus leaves (Muma 1964A).

Since the species has been collected from citrus trees only 8 times in 20 years, and is known from the ground surface litter of citrus and other plants, the inconclusive feeding results obtained with citrus tetranychids are not surprising.

Although Texas citrus mites, *Eutetranychus banksi* (McGregor), were an adequate food in one test, they were inadequate or only survival foods in other tests. Citrus red mites, *Panonychus citri* (McGregor), and six-spotted mites, *Eotetranychus sexmaculatus* (Riley), were inadequate or only survival foods. The adequate or optimal foods for *A. setosa* were not found.

Amblyseius aerialis (Muma).—This species was described from six-spotted mite colonies upon which it was reportedly feeding (Muma 1955). It occurs on all strata of Florida citrus trees; in unsprayed groves it is common on leaves, fruit, and litter. Muma (1964A) reported it frequently associated with infestations of *Brevipalpus* spp. It has also been observed feeding on citrus red mites and acarids.

Some tests with six-spotted mites and Texas citrus mites have indicated inadequacies of these foods, but in other tests, Texas citrus mites were both adequate and optimal food. In a single test utilizing several female predators, the red and black flat mite, *Brevipalpus phoenicis* (G.), was an opimal food.

Since survival or adequate foods must occur in ground surface litter, it is probable that this species can not only survive, but also complete development and reproduce on saprophagus or fungivorus as well as phyto-

phagus hosts. *A. aerialis* seems to be a general predator but nothing is known of its ability to live or survive on pollen or non-living organic materials.

Amblyseius deleoni Muma and Denmark (=*largoensis* Muma)—Muma, Denmark, and DeLeon (1971) recorded this species from the leaves and litter of several plants and stated that it was relatively common in spider mite and *Brevipalpus* spp. infestations.

In the present tests, six-spotted mites were either a survival, adequate, or optimal food. The two-spotted fungus mite, *Tropacarus mumai* Cunliffe, also varied from an inadequate through an adequate to an optimal food. The citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), was either an inadequate, survival, or adequate food.

A. deleoni seems to have a wide food tolerance and probably is a general feeder. Such a food habit can also be inferred from the fact that it inhabits both plants and ground surface litter. Nothing is known of its ability to survive and develop on pollen or non-living organic material.

Euseius hibisci (Chant).—Numerous food habits studies (cited under *Euseius* in discussion) have been conducted on this species in California. In Florida, Muma (1964A) noted that specimens were frequently taken in six-spotted mite colonies on citrus; and Muma, Denmark, and DeLeon (1971) stated that large populations were frequently found on *Malvaviscus grandiflorus* HBK and *Hibiscus rosa-sinensis* Linn, which produce flowers continuously throughout the year. Specimens have also been collected from populations composed of green specimens on flowering *Morus rubra* Linn.

In the tests summarized in Table 1, no food was optimal. Purple scale, *Lepidosaphes beckii* (Newm.), eggs and crawlers; a combination of Glover's scale, *Lepidosaphes gloveri* (Pack.), eggs and crawlers with whitefly eggs and larvae; six-spotted mites; and Texas citrus mites were adequate. Honeydew, citrus red mites, six-spotted mites, and Texas citrus mites were survival foods. Nine foods were inadequate. The species did feed on pollen: 20 females fed citrus pollen turned pale yellow in color and 29 females fed turk's cap pollen turned pale purple, but no specimens lived longer than two weeks.

Since survival and reproduction were obtained with different foods, *E. hibisci* should be considered a general feeder with an ability to feed, if not survive, on pollen.

Galendromus (*Galendromus*) *floridanus* (Muma).—This species was described from specimens feeding on six-spotted mites (Muma 1955). Food habits data on the species were summarized by Muma (1970) who concluded that the species was primarily a tetranychid predator and was most commonly associated with six-spotted mite colonies in citrus groves.

Of the 9 foods tested, only citrus red mite, Texas citrus mite, and six-spotted mite were adequate or optimal foods; all other tested foods were inadequate.

G. floridanus is unquestionably an obligate high-density spider mite predator.

Iphiseiodes quadripilis (Banks).—This species was described from orange leaves at Eustis, Florida by Banks (1905). Muma (1955) reported it to be most frequently found on the lower surface of unsprayed grape-

fruit leaves; he also recorded survival of the species in the laboratory on Florida red scale, *Chrysomphalus ficus* (Ashm.), purple scale, and Glover's scale eggs and crawlers. *I. quadripilis* is now known to be nocturnal, which accounts for the lack of diurnal natural feeding observations.

Food habits studies have demonstrated that two-spotted fungus mites, whitefly eggs and larvae, and citrus red mites varied as foods from inadequate to optimal; rust mites, tarsonemids, and a combination of *Tydeus* sp. and whitefly eggs and larvae varied as foods from inadequate to adequate; honey, sooty mold, *Melliola* sp., and honey plus sooty mold varied as foods from inadequate to survival; water, honey plus citrus pollen, *Tydeus* spp., and *Brevipalpus* spp. all were inadequate.

I. quadripilis seems to be a general facultative predator that can survive for an extended time on certain non-living organic materials.

Phytoscutus sexpilis Muma.—This species was described from specimens feeding on the two-spotted fungus mite on grapefruit leaves by Muma (1961) who noted that the species fed commonly on acarids on citrus.

This species, with 1 exception, consistently died on or abandoned any offered food except the two-spotted fungus mite which varied as food from inadequate to optimal. The single exception was 1 female which reproduced slowly, and the young developed slowly on *Tetranychus tumidus* Banks. Inadequate foods included two-spotted fungus mites, citrus red mites, and six-spotted mites.

P. sexpilis apparently is an acarid predator with some ability to survive and live on other species of mites; its ability to survive on pollen and non-living organic materials is unknown.

Proprioseiopsis dorsatus (Muma).—This species was described from citrus leaves with no food habits notations (Muma 1961). It has never been observed feeding under grove conditions.

The limited number of females tested have failed to survive more than a short time on any offered food except citrus red mites. One female lived longer than the required 2 weeks on this host. Six-spotted mites, two-spotted fungus mites, citrus rust mites, and dead carcasses of cottony cushion scale, *Icerya purchasi* (Mask.), were inadequate. Food habits of the species are unknown.

Typhlodromalus peregrinus (Muma).—This species was described from scale-infested orange leaves (Muma 1955) with the notation that it was by far the most common phytoseiid on Florida citrus. Additional record was made of its collection from citrus red mite infestations, six-spotted mite colonies, and from beneath purple and Florida red scale armors. Although specimens were reported to survive on purple scale and Florida red scale eggs and crawlers, the predatory nature of *T. peregrinus* was questioned since it was also found on sooty mold-covered leaves free of other mites and insects. Additional food habits notes were summarized by Muma (1964, 1964A, 1965, 1969).

Nineteen tested foods were inadequate; 8 were found to vary from a survival food to either an adequate or optimal food (Table 1).

T. peregrinus is unquestionably a general facultative predator with ability to survive and maintain populations on fungi and non-living organic materials. It is widespread in the American tropics, nocturnal, and highly tolerant of spray chemicals and spray programs.

Typhlodromina subtropica Muma and Denmark.—This species was described from citrus leaves (Muma and Denmark 1969). Although it is regularly collected from tydeid-infested, old, six-spotted mite colonies and armored scale infestations, it has never been observed feeding under grove conditions.

Although 7 tests with 5 different foods were conducted with *T. subtropica*, all tested foods were inadequate. Nothing is known concerning its food requirements.

Typhlodromips simplicissimus (DeLeon).—This species was described from *Eugenia jambos* in Mexico (DeLeon 1959). Muma (1964, 1964A) reported its common occurrence on Florida citrus trees but recorded no known food habits. *T. simplicissimus* is presently known from a number of plants and from the fruit, leaves, bark, and litter of citrus trees. It has been collected from citrus leaves infested with armored scale insects, citrus red mites, and six-spotted mites, but has not been observed feeding.

Six-spotted mites varied from an inadequate food through a survival food to an optimal food. All other tested foods, including Texas citrus mites, citrus rust mites, and the two-spotted fungus mite, were inadequate or only survival foods (Table 1).

T. simplicissimus appears to be a facultative predator of six-spotted mites but its occurrence on other plants and in other niches indicates that its food habits are not sufficiently known.

Discussion

The food habits of phytoseiid species are apparently highly variable. Some species are obligate predators, others are facultative predators that can survive on fungi, pollen, leaf hairs, or non-living organic matter, and still others are facultative or obligate pollen feeders. Since our knowledge of phytoseiid food habits is obviously fragmentary, it is also possible that some species may be scavengers.

It seems desirable, at this time, to summarize, at a generic level, the presently known food ranges. The genera utilized here are those recognized and delineated by Muma (1961), Muma and Denmark (1968), and Muma, Denmark, and DeLeon (1971). References to special studies are included where available or known. The number and ratio of studied to unstudied congeneric species are also cited. In a few instances, unpublished data at the University of Florida, Citrus Experiment Station (CES), Lake Alfred are discussed.

Amblydromella Muma, 1961.—For 2 of 15 species, eriophyids could be the optimal food with certain tetranychids adequate (Herbert 1959, Burrell and McCormick 1964). Schuster and Pritchard (1963) included walnut eriophyids and the peach silver mite as prey for 1 species. Three eastern United States species were collected from eriophyid infestations with tetranychids adequate food for 1 species (unpublished Citrus Exp. Sta. records). Nothing is known concerning survival and inadequate foods.

Amblyseiella Muma, 1961.—Food habits range cannot be deduced from the incomplete studies on 1 out of the 5 species. Since it occurs in ground surface litter as well as on the leaves of certain plants, it probably feeds on saprophagus or fungivorus forms and possibly feeds on phytophagus forms. Nothing is known about survival and inadequate food.

Amblyseius Berlese, 1914.—Two of the 60 known species have been studied. Acarids, eriophyiids, tenuipalpids, and tetranychids all are adequate or optimal foods, indicating that *Amblyseius* spp. are general predators. The common occurrence of congeners both in ground surface litter and on the leaves and fruits of trees and shrubs seems to confirm this finding. Since no studies have been made with plant or non-living organic matter, the obligate or facultative nature of the predation is not known.

Anthoseius DeLeon, 1959A.—The single species known has been collected exclusively and reported repeatedly (DeLeon 1959, 1966, 1967, Muma, Denmark, and DeLeon 1971) as feeding on pollen and colonizing within the flowers of *Heliotropium parviflorum* so it is probably pollenophagus. Nothing is known concerning other foods since the species has not been collected from other niches.

Euseius Wainstein, 1962.—Intensive studies have been conducted on 4 out of 50 species (Chant and Fleschner 1960, McMurtry and Scriven 1964A, 1965, 1966, 1966A, 1968, Swirski et al. 1967, van der Merwe 1968). All studies indicated that these species are pollen feeders that can facultatively feed on a wide range of insects and mites. In the present study, *E. hibisci* fed but did not reproduce on pollen, so other factors may limit the pollen-feeding habit. *Euseius* spp. also have a wide range of survival foods including honeydew.

Galendromus Muma 1961.—Data are available on species of 2 subgenera. Within the typical subgenus, 3 of 6 species have been studied (Fleschner and Ricker 1954, McMurtry 1963, Burrell and McCormick 1964, Lee and Davis 1968, Swirski and Dorzia 1969, Muma 1970). All studies, except those of Swirski and Dorzia (1969), show that these species are obligate predators with tetranychids as optimal foods, and with eriophyids as adequate or survival foods. Swirski and Dorzia (1969) reported survival and reproduction of *G. occidentalis* on several kinds of pollen and no survival on eriophyids. Most collection records of species in the eastern United States and West Indies verify the consensus conclusions since most specimens are collected from infestations of tetranychids. It is probable, however, that additional studies will uncover other survival and adequate hosts. Within the subgenus, *Menaseius* Wainstein 1962, only 1 of 10 species, an eriophyid feeder, has been studied (Parrott et al. 1906) but 2 other species from the eastern United States are consistently collected from eriophyid infestations on several different plants (Unpublished Citrus Exp. Sta. records). Systematic food habits studies have not been conducted on species of this subgenus so no conclusions should be drawn.

Iphiseiodes DeLeon, 1966.—One of the 3 described species is a facultative general predator capable of surviving on several different foods including fungi and honey. Its congeners probably have the same food habits.

Kampimodromus Nesbitt, 1951.—Chant (1960) reported that the type species completed development on "mildewed leaves" but other foods have not been adequately studied.

Macroseius Chant, Denmark, and Baker, 1959.—The intensive study of Muma and Denmark (1967) have delineated the food habits of the 1 known species. It is an obligate predator with nematodes as the optimal food and

anoetids as adequate food. Survival hosts are unnecessary since the species can live for 3 months without food.

Mesoseiulus Gonzalez and Schuster, 1962.—Van der Merwe (1968) demonstrated the single species to be an obligate predator with tetranychids as adequate or optimal foods. Although it fed on pollen when no living prey were available, pollen was only a survival food.

Neoseiulus Hughes, 1948.—Food habits studies on 4 of 36 known species (MacGill 1939, Dosse 1955, 1957, Herbert 1959, Chant 1960, Burrell and McCormick 1964) have demonstrated considerable intrageneric variation. This is not surprising since certain species-groups inhabit ground surface litter and stored food products, others are associated with sod and pasture land, and still others seem to prefer herbaceous or woody plants. Species similar to the generotype feed on seed infesting fungivorus or saprophagus insects and mites, whereas species similar to *N. umbraticus* may be facultative general predators.

Orientiseius Muma and Denmark, 1968.—One of the 2 known species is an obligate predator with eriophyids and tetranychids as optimal and/or adequate foods (McMurtry and Scriven 1964, unpublished Citrus Exp. Sta. data). Survival foods have not been sufficiently studied but include pollen, honeydew, and certain insects.

Paraseiulus Muma, 1961.—One of the 3 known species is an obligate predator with tydeids as the optimal food and certain other mites as survival foods (Dosse 1956). Living plants and non-living organic materials were not tested.

Phytoscutus Muma, 1961.—One of the 2 known species is an acarid predator with certain other mites as adequate or survival foods. Since *Phytoscutus* spp. are not found in ground surface litter where acarids are common, it is also possible that certain acarid species may be the optimal hosts. Plant and non-living organic materials have not been tested, so it is not known if the predation is obligate or facultative.

Phytoseiulus Evans, 1952.—Three of the 5 known species have been demonstrated to be obligate predators of tetranychids with an ability to survive and adequately reproduce on other mites and insects (Smith and Summers 1949, Herbert 1959, Bravenboer and Dosse 1962, unpublished records at the Citrus Exp. Sta.). However, plant and non-living organic materials have not been sufficiently tested.

Proprioseiopsis Muma, 1961.—The limited, inconclusive results reported for 1 of 40 species tells us nothing about the food habits of this genus. However, since most species have been described from ground surface litter, phytophagus mites or insects are eliminated as important hosts. Although the 5 species of the arboreal *dorsatus* species-group may feed on plant feeding forms, most *Proprioseiopsis* spp. must live either on saprophagus or fungivorus species or upon fungus or non-living organic material.

Typhlodromalus Muma, 1961.—Two of 12 species are facultative general predators with a wide optimal, adequate, and survival food range including pollen, fungi, and non-living organic materials (Fleschner and Ricker 1954, Chant and Fleschner 1960, McMurtry and Scriven 1965, Swirski and Dorzia 1968, Muma 1969).

Typhlodromina Muma, 1961.—Only 2 of 9 known species have been

studied (Fleschner and Ricker 1954, and the present paper). The data are conflicting so the food habits cannot be deduced at the present time.

Typhlodromips DeLeon, 1965.—Three of more than 50 known species survived and/or reproduced on a number of different foods varying from honeydew through pollen and acarids to tetranychids (Fleschner and Ricker 1954, Swirski et al. 1967, and the present study). Although studies are incomplete and do not delineate optimal and adequate foods, there is little question that they are facultative general predators that can survive on plant and non-living organic materials.

Typhlodromus Scheuten, 1857.—Although the taxonomy of this genus is still somewhat confused (Muma and Johnston 1971), there is little doubt that the food habits of at least 2 and possibly 3 out of the 5 known species have been investigated by several different workers (Herbert 1959, Chant 1960, Dosse 1956, 1961, Swirski et al. 1967A). They seem to be facultative predators that utilize either eriophyids or tetranychids or both as optimal and adequate hosts, with other foods including pollen permitting survival. Most available data indicate that *Typhlodromus* spp. feed and develop more readily on eriophyids, but conflicting results were obtained by Swirski et al. (1967A) who also found that their species reproduced on pollen.

Conclusions

Studies of individual phytoseiid species have demonstrated a wide and confusing array of food habits. However, when such species are grouped into morphologically and ecologically distinguishable genera, the confusion is reduced and generic food habits patterns become apparent. In some genera, existing data adequately define the generic food ranges; in other genera, existing data are consistent but are, perhaps, presently inadequate for definition of food ranges; in still other genera, the existing data conflict and no conclusions can be drawn concerning the food regimen.

Since our present knowledge of phytoseiid food habits indicates that generically related species occupying similar ecological niches probably have similar food habits, it is apparent that careful systematic feeding experiments should be conducted on suspected important predators. When field-collected test specimens are utilized, account should be taken of unavoidable natural mortalities predisposed by previous food regimen, stage of oviposition, condition of fertilization, and age. With laboratory reared test specimens, consideration should be given preconditioning by food regimen, temperature, humidity, and restricted gene pool. It is also possible that humidity and temperature may have an influence on the acceptibility or adequacy of food as pointed out by Mori and Chant (1966).

It is especially important that precise determination of the survival, adequate, and optimal foods for a species precede studies designed to evaluate the biological control potential of that species.

Literature Cited

Banks, N. 1905. Descriptions of some new mites. Proc. Entomol. Soc. Wash. 7: 133-142.

Berlese, A. 1914. *Acari nuovi.* Redia 10: 113-50.

Bravenboer, L., and *G. Dosse.* 1962. *Phytoseiulus riegeli* Dosse als prädator einiger shad milben aus der *Tetranychus* urticae-gruppe. Entomol. Exper. and Appl. 5: 291-304.

Burrell, R. W., and *W. J. McCormick.* 1964. *Typhlodromus* and *Amblyseius* (Acarina: Phytoseiidae) as predators on orchard mites. Ann. Entomol. Soc. Amer. 57: 483-7.

Chant, D. A. 1960. Phytoseiid mites (Acarina: Phytoseiidae). Part I. Bionomics of seven species in southeastern England. Part II. A taxonomic review of the family Phytoseiidae, with descriptions of 38 new species. Can. Entomol. 91, Suppl. 12, 166 p.

Chant, D. A., and *C. A. Fleschner.* 1960. Some observations on the ecology of phytoseiid mites (Acarina: Phytoseiidae) in California. Entomophaga 5(2): 131-9.

Chant, D. A., *E. W. Baker*, and *H. A. Denmark.* 1959. A new subfamily, Macroseiinae Nov., of the family Phytoseiidae (Acarina: Gamasina). Can. Entomol. 91: 808-11.

DeLeon, D. 1959. Seven new *Typhlodromus* from Mexico with collection notes on three other species. Fla. Entomol. 42: 113-21.

DeLeon, D. 1959A. Two new genera of phytoseiid mites with a note on *Proprioseius meridionalis* Chant (Acarina: Phytoseiidae) Entomol. News 70(10): 257-62.

DeLeon, D. 1965. A note on *Neoseiulus* Hughes 1948 and new synonymy. Proc. Entomol. Soc. Wash. 67(1): 23.

DeLeon, D. 1966. Phytoseiidae of British Guyana with keys to species (Acarina: Mesostigmata). *In* Studies on the Fauna of Suriname and other Guyanas 8: 81-102.

DeLeon, D. 1967. (posthumous) Some mites of the Caribbean area, Part I. Acarina on plants in Trinidad and West Indies. Allen Press Inc., Lawrence, Kans., USA. p. 1-66.

Dosse, G. 1955. Aus der Biologie der Raubmilbe *Typhlodromus cucumeris* Ouderman. (Acar., phytoseiidae) Zeitschrift für Pflanzenkrankheiten (Pflanzenpathologie) ünd Pflanzenschutz. 62(8/9): 593-8.

Dosse, G. 1956. Uber die Entwicklung einigea Raubmilben bei Verschiedenen Nahrungstieven (Acar., Phytoseiidae). Pflanzenschutz-Berichte. 16: 122-36.

Dosse, G. 1957. Morphologie ünd biologie von *Typhlodromus swölferi* n. sp. (Acar., Phytoseiidae) Z. Angew. Entomol. 41: 301-11.

Dosse, G. 1961. Uber die Bedeutung der Pollennahrung für *Typhlodromus* (T.) *pyri* Scheuten (=*tiliae* Oud.) (Acari, Phytoseiidae). Entomol. Exper. and Appl. 4: 191-5.

Evans, G. O. 1952. On a new predatory mite of economic importance. Bull. Entomol. Res. 43: 397-401.

Fleschner, C. A., and *D. W. Ricker.* 1954. Typhlodromid mites on citrus and avocado trees in southern California. J. Econ. Entomol. 47: 356-7.

Gonzalez, R., and *R. O. Schuster.* 1962. Species of the family Phytoseiidae in Chile I (Acarina: Mesostigmata). Univ. Chile Agr. Exp. Sta. Tech. Bull. No. 16: 1-35.

Herbert, H. J. 1959. Note on feeding ranges of six species of predaceous mites (Acarina: Phytoseiidae) in the laboratory. Can. Entomol. 37: 812.

Hughes, A. M. 1948. The mites associated with stored food products. Ministry of Agr. and Fisheries. London, H. M. Stationery Office. 168 p.

Lee, M. S., and *D. W. Davis.* 1968. Life history and behavior of the predatory mite *Typhlodromus occidentalis* in Utah. Ann. Entomol. Soc. Amer. 61: 251-5.

McGill, E. J. 1939. The gamasid mite (*Typhlodromus thripsi* n. sp.) a predator of *Thrips tabaci* Lind. Ann. Appl. Biol. 26: 309-17.

McMurtry, J. 1963. Diaspidine scale insects as prey for certain phytoseiid mites. Advances in Acarology 1: 151-4.

McMurtry, J. T., and *G. T. Scriven.* 1964. Biology of the predaceous mite *Typhlodromus rickeri* (Acarina: Phytoseiidae). Ann. Entomol. Soc. Amer. 57: 362-7.

McMurtry, J. A., and *G. T. Scriven.* 1964A. Studies on the feeding, reproduction, and development of *Amblyseius hibisci* (Acarina: Phytoseiidae) on various food substances. Ann. Entomol. Soc. Amer. 51: 649-55.

McMurtry, J. A., and *G. T. Scriven.* 1965. Life-history studies of *Amblyseius limonicus*, with comparative observations on *Amblyseius hibisci* (Acarina: Phytoseiidae). Ann. Entomol. Soc. Amer. 58: 106-11.

McMurtry, J. A., and *G. T. Scriven.* 1966. The influence of pollen and prey density on the number of prey consumed by *Amblyseius hibisci* (Acarina: Phytoseiidae). Ann. Entomol. Soc. Amer. 59: 147-9.

McMurtry, J. A., and *G. T. Scriven.* 1966A. Studies on predator-prey interactions between *Amblyseius hibisci* and *Oligonychus punicae* (Acarina: Phytoseiidae, Tetranychidae) under greenhouse conditions. Ann. Entomol. Soc. Amer. 59: 793-800.

McMurtry, J. A., and *G. T. Scriven.* 1968. Studies on predator-prey interactions between *Amblyseius hibisci* and *Oligonychus punicae*: effects of host-plant conditioning and limited quantities of an alternate food. Ann. Entomol. Soc. Amer. 61: 393-7.

Mori, H., and *D. A. Chant.* 1966. The influence of humidity on the activity of *Phytoseiulus persimilis* Athias-Henriot and its prey, *Tetranychus urticae* (C. L. Koch) (Acarina: Phytoseiidae, Tetranychidae). Can. J. Zool. 44: 863-71.

Muma, M. H. 1955. Phytoseiidae (Acarina) associated with citrus in Florida. Ann. Entomol. Soc. Amer. 48: 262-72.

Muma, M. H. 1961. Subfamilies, genera, and species of Phytoseiidae (Acarina: Mesostigmata). Fla. State. Mus. Bull. Biol. Sci. 5: 267-302.

Muma, M. H. 1964. The population of Phytoseiidae on Florida citrus. Fla. Entomol. 47: 5-11.

Muma, M. H. 1964A. Annotated list and keys to Phytoseiidae (Acarina: Mesostigmata) associated with Florida citrus. Fla. Agr. Exp. Sta. Tech. Bull. 685: 1-42.

Muma, M. H. 1965. Populations of common mites in Florida citrus groves. Fla. Entomol. 48: 35-46.

Muma, M. H. 1969. *Typhlodromalus peregrinus* (Muma) (Acarina: Phytoseiidae) on Florida citrus. Proc. 2nd Intl. Congr. Acarology: 135-48.

Muma, M. H. 1970. The natural control potential of *Galendromus floridanus* (Muma) (Acarina; Phytoseiidae) on Tetranychidae on Florida citrus trees. Fla. Entomol. 53: 79-88.

Muma, M. H., and *H. A. Denmark.* 1967. Biological studies on *Macroseius biscutatus* Chant, Denmark, and Baker (Acarina: Phytoseiidae). Fla. Entomol. 50: 249-55.

Muma, M. H., and *H. A. Denmark.* 1968. Some generic descriptions and name changes in the family Phytoseiidae (Acarina: Mesostigmata). Fla. Entomol. 51: 229-40.

Muma, M. H., and *H. A. Denmark.* 1969. The conspicua species-group of *Typhlodromina* Muma, 1961. Ann. Entomol. Soc. Amer. 62: 406-13.

Muma, M. H., H. A. Denmark, and *D. DeLeon.* 1971. Phytoseiidae (Acarina: Mesostigmata) of Florida. *In* Arthropods of Fla. and Neighboring Land Areas. (In press).

Muma, M. H., and *D. E. Johnston.* 1971. Phytoseiidae (Acarina: Mesostigmata) in Ohio. Ohio Agr. Exp. Bull. (In press).

Nesbitt, H. H. J. 1951. A taxonomic study of the Phytoseiinae (Family Laelaptidae) predaceous upon Tetranychidae of economic importance. Zoologische Verhandelingen (12): 1-96.

Parrott, P. J., H. E. Hodgkiss, and *W. J. Schoene.* 1906. The Eriophyidae Part I. The apple and pear mites. N. Y. Agr. Exp. Sta. Bull. 283: 302-3.

Scheuten, A. 1857. Einiges über Milben. Arch. für Naturges. 23: 104-112.

Schuster, R. O., and *E. A. Pritchard.* 1963. Phytoseiidae of California. Hilgardia 34: 191-285.

Smith, L. M., and *F. M. Summers.* 1949. The structure and biology of the red spider predator *"Hypoaspis" macropilis* (Banks). Proc. Entomol. Soc. Wash. 51: 209-18.

Swirski, E., S. Amitai, and *N. Dorzia.* 1967. Laboratory studies on the feeding, development, and reproduction of the predaceous mites *Amblyseius rubini* Swirski and Amitai and *Amblyseius swirskii* Athias (Acarina: Phytoseiidae) on various kinds of food substances. Israel J. Agr. Res. 17(2): 101-19.

Swirski, E., S. Amitai, and *N. Dorzia.* 1967A. Laboratory studies on the feeding, development, and oviposition of the predaceous mite *Typhlodromus athiasae* P. & S. (Acarina: Phytoseiidae) on various kinds of food substances. Israel J. Agr. Res. 17(4): 213-18.

Swirski, E., and *N. Dorzia.* 1968. Studies on the feeding, development, and oviposition of the predaceous mite *Amblyseius limonicus* Garman and McGregor (Acarina: Phytoseiidae) on various kinds of food substances. Israel J. Agr. Res. 18(2): 71-5.

Swirski, E., and *N. Dorzia.* 1969. Laboratory studies on the feeding, development, and fecundity of the predaceous mite *Typhlodromus occidentalis* (Nesbitt) (Acarina: Phytoseiidae) on various kinds of food substances. Israel J. Agr. Res. 19(3): 143-5.

van der Merwe, G. G. 1968. A taxonomic study of the family Phytoseiidae (Acari) in South Africa with contributions to the biology of two species. Repub. S. Africa, Dept. of Agr. Tech. Service, Entomol. Memoirs (18): 1-198.

Wainstein, B. A. 1962. Révision du genre *Typhlodromus* Scheuten, 1857 et systematique de la famille des Phytoseiidae (Berlese, 1916). (Acarina: Parasitiformes). Acarologia 4(1): 5-30.