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DIVERSITY AND ABUNDANCE OF MITES IN A MANDARIN CITRUS ORCHARD IN WEST SUMATRA

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ABSTRACT

Some of the most destructive pests in citrus orchards are spider mites. Monitoring prior applied pest control is a standard procedure for integrated pest management (IPM). The study aimed to survey and determine the distribution, abundance, and diversity of phytophagous, predatory, and detritivorous mites at different stages of development of arboreal plant parts, weeds and litter in the citrus orchard. A periodical sampling survey method was conducted on six growth stages of mandarin citrus, weeds and litter of the Indonesian Fruits Research Institute experimental field in Solok, West Sumatra in December 2003 to June 2004. All mites attached on each growth stage of citrus, weeds and litter were trapped and mounted on slide for identification purposes. Identification of the mites was conducted in the Acarology Laboratory, Department of Entomology, University of the Philippines at Los Banos in July-October 2004. The results showed that a very rich mite fauna of 130 species was found in the arboreal parts of citrus crops, weeds and litter below the canopy of the citrus orchard. Among the trophic groups, detritivorous mites were the most abundant, followed by the predators, phytophages, and those unknown feeding habit. Among the habitats, weeds harbored the most mite species followed by litter and arboreal parts of the citrus trees. The flush growth stage had the least diverse mite fauna with index diversity (H') of 1.27, while the most diverse (H' = 2.01) was found at fruit development phase II. Result of this research was useful in determining proper time for controlling phytophagous mites. Besides, the result also provides important information on potential predatory mites that can be used as biological control agents. Furthermore, the study implies the importance of maintaining cover crops of weeds and litter beneath the citrus trees as refuge and source of alternate prey for predators which suppressed populations of phytophagous mites.

[***Keywords*:** Acarina, biodiversity, *Citrus reticulata*, West Sumatra)

INTRODUCTION

Fruits of mandarin citrus (*Citrus reticulata* Blanco) are highly commercial and have nutritional values such as proteins, fats, carbohydrates, minerals such as calcium, phosphorus, iron, sodium, potassium, and vitamins such as vitamin A, thiamin, riboflavin, niacin, and ascorbic acid (Ray and Walheim 1980). Profit analysis of the citrus in West Sumatra showed that mandarin citrus has high feasibility with benefit/cost ratio of 3.3 (Setyobudi *et al*. 1999).

One limiting factor in citrus production is pest and disease problem. One of the most destructive pests in citrus orchards is spider mite. Spider mite at high population decreased as much as 60% of the chlorophyll from leaves and increased the transpiration rate (Corpuz-Raros 1986). As the result, they caused patchy chlorotics appearances on the leaves, and portions or entire leaves may dry up and turn brown. For instance, the citrus red mite, *Panonychus citri* (McGregor), reduced production of Tahiti lime by 29.25% (Childers and Abou-Setta 1999).

Increasing health awareness of the society on pesticide residue in agricultural products requires environmentally safe pest control methods free from pesticides. To develop control methods for phytophagous mites attacking citrus orchard, it is important to understand the critical period of mites where proper pest control must be applied. Hence, analysis of population diversity of citrus orchard mites is essential in evaluating and predicting population outbreaks of pest through monitoring relative abundance of all trophic groups' species and their relationships towards one another in the ecosystem. High diversity levels indicate ecological balance characteristic of stable communities where individual species are roughly constant through time. Diverse communities, by having many species with overlapping functions, are not only stable, but also resilient.

Researches in citrus orchard have been focusing on taxonomic studies of the acarine fauna all over the world, however, only little taxonomic information on the acarine citrus fauna of Indonesia are available. Hence, this study aimed to generate basic information on acarine species inhabiting citrus orchard in

Indonesia. Such information is needed to support future ecological works in integrated pest management (IPM) program in the country. The study were specifically pursued the following objectives: (1) conduct a survey of phytophagous, predatory, and detritivorous mites in mandarin citrus orchard; (2) determine the distribution and abundance of these mites at different stages of development of arboreal plant parts, and on weeds and litter in the citrus orchard; and (3) compare the diversity of mite fauna of the citrus orchard at different stages of crop growth.

MATERIALS AND METHODS

The research was conducted in the mandarin citrus orchard of the Indonesian Fruits Research Institute, Solok, West Sumatra, Indonesia from December 2003 to June 2004 for sampling of mites, extraction of the samples, and slide preparation. Mounted samples were sorted, identified and counted in the Acarology Laboratory, Department of Entomology, University of the Philippines at Los Baños (UPLB) from July to October 2004.

Sampling of Citrus Plants

Twenty mandarin citrus trees were used as sampling units for each of the six growth stages, namely, dormant, flush, flowering, fruit development phase I that were sampled one month after flowering stage, fruit development phase II that were sampled three months after flowering stage, and fruit development phase III that were sampled five months after flowering stage. Samples from each growth stage were only taken once at the same time, i.e. at that particular growth stage. Samples were taken from parts of citrus tree that could be reached easily by hand.

During the dormant and flush growth stages, five terminal twigs of about 15 cm in length were cut from each sample tree. The samples were immediately put in zip-lock plastic bags, properly labeled and brought to laboratory for further examinations. In the laboratory, five citrus leaf samples were randomly taken from each terminal twigs. The leaves were immediately put in the Tullgren funnel and illuminated with a 40-watt bulb for 24 hours to extract the mites. Extracted mites were trapped into a small wide-mouthed jar containing 70% ethyl alcohol placed under each funnel. The trapped mites were separated from any debris under a dissecting microscope, ready for mounting on glass slides.

For the other growth stages, i.e. flowering stage and fruit development stages I, II, and III, the flowers or fruit stalks containing reproductive parts were cut to about 15 cm long including the leaves behind them. Each sample consisting of five clusters was taken from tree branches. These samples were treated as mentioned above then put in a Tullgren funnel to trap all inhabited mites. All the mite specimens (phytophagous, predatory, detritivorous mites) were collected, labeled, and mounted on glass slides for identification, sorting and counting.

Sampling of Weeds and Litter

Weeds under the canopy of citrus trees were collected, sampled, and examined for the present of mite fauna to determine alternative hosts of phytophagous mites and the habitat range of the predators and detritivores. Ten twig samples for each weed species and five litter samples, about 0.5 kg each, were taken under canopy of citrus trees during all growth stages. All samples were put in zip-lock plastic bags, labeled, and examined as described before.

Preparation of Mite Specimens

All mites sampled were sorted and mounted in Hoyer's medium placed on glass slides according to the method of Krantz (1978) and Henderson (2001).

Sorting and Counting of Mite Specimens

All the mounted mites were examined under a compound microscope and identified to species level using appropriate taxonomic references. Some specimens were also compared with the reference standard available in the mite collections deposited in the Entomological Museum, UPLB Museum of Natural History. All species of phytophagous, predatory, and detritivorous mites from samples at all citrus growth stages were counted, as well as those on weeds and litter.

Data Gathered and Analyzed

The following data were gathered and analyzed, including species identity and total number of phytophagous, predatory, and detritivorous mites found on each arboreal plant parts collected during all growth stages of citrus, weeds, and litter under the canopy of citrus trees.

Index of diversity (H') of the mites were analyzed using the Shannon-Wiener function (Wallwork 1976) as follows:

$$H = C/N \,.\, (N \log N - \sum_{r=1}^{s} ni \log ni)$$

C = 3.321928

N = total number of individual

ni = number of individual for each species

This index has following elements: number of species (S) and equitability (E) of distribution of individuals to the various species.

Meteorological data such as precipitation, including temperature and relative humidity inside the citrus canopy were examined during the experiment.

RESULTS AND DISCUSSION

Mite Species

A total of 17,729 mites belonging to 130 species were collected during the survey, including mites inhabiting the citrus trees, weeds, and litter in the citrus orchard. Based on the generally known of the primary feeding habits, mites were categorized into three trophic groups: saprophagous or detritivorous, phytophagous, and predatory. The total number of the phytophagous, predatory, and detritivorous mites were 516; 5,998; and 11,206; respectively. The detritivores were numerical dominance (50 species in 23 families), followed by predators (71 species in 13 families) and phytophages (7 species in 2 families).

Identity of most of the mite species collected are not mentioned in published records in Indonesia before, therefore they may be new species. This means that plant mite fauna of Indonesia is little known.

Distribution and Abundance of Mites

Arboreal Citrus Mites

All trophic groups (phytophagous, predatory, and detritivorous) of mites inhabited the arboreal parts of mandarin citrus trees. Most of them were predatory mites (19 species), phytophagous mites (6 species), and detritivorous mites (5 species). Phytophagous mites were relatively abundant in the arboreal parts of the citrus trees accommodated about 60.9% population of all individual mites collected there. Number of mites found on the leaves at flush growth stage was the lowest (8 mites), whereas the highest was found at the fruit development stage II (43 mites) (Fig. 1). The most important phytophagous mites identified are *Brevipalpus californicus*, *B. obovatus*, and *B. phoenicis* known as false spider mites (family Tenuipalpidae). These species are important pests of citrus worldwide (De Leon 1961; Manson 1963; McMurtry *et al.* 1979), including those found in the Philippines (Barrion and Corpuz-Raros 1975; Corpuz-Raros 2001).

The study also identified five predatory families associated with phytophages inhabiting leaves of

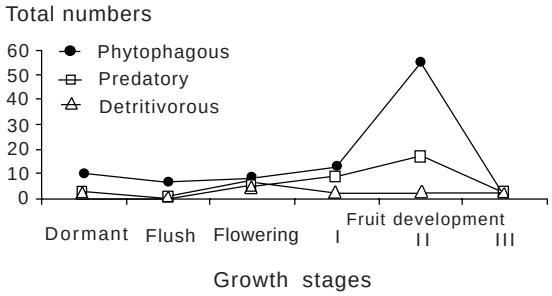

Fig. 1. Total numbers of phytophagous, predatory, and detritivorous mites found on the arboreal parts of the mandarin citrus orchard at various growth stages of the citrus.

citrus, namely Ascidae, Phytoseiidae, Ameroseiidae, Cunaxidae, and Cheyletidae with total relative abundance of 23.5%. Predatory mites identified belong to the genus *Asca (*Ascidae) such as *A. longiseta* (Fig. 2) and genus *Amblyseius* (Phytoseiidae). Four species of detritivorous mites were also found on the leaves of citrus with total relative abundance of 15.6%. These include the acarids (*Caloglyphus* sp. and *Suidasia pontifica*), which are known to be fungivorous, and the oribatids, *Scheloribates praencisus praencisus* (majority) and *Galumna flabellifera.* These predatory and detritivorous mites may be used in future pest management of citrus orchard.

Weed-Inhabiting Mites

Five weed species of the mandarin citrus orchard are *Achyranthes aspera* L.**,** *Axonopus compressus* (Sw.) Beauv., *Chromolaena odorata* (L.) R.M. King and H. Robinson, *Borreria alata* (Aubl.) DC., and *Senna occidentalis* (L.) Link**.** Numbers of mites found on the weeds, altogether, were counted for 16,168 individuals, consisting of detritivores (10,418); predators (5,348); and phytophages (402). The most abundant phytopha-

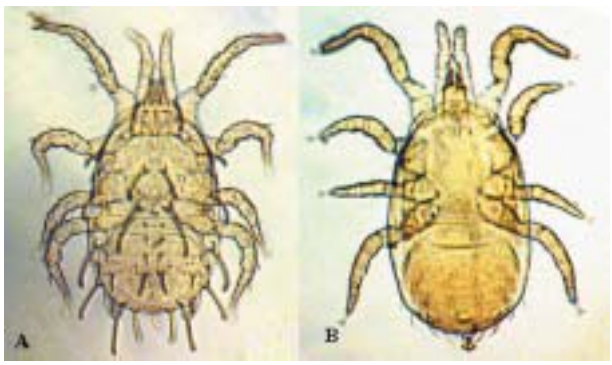

Fig. 2. The most dominant predators found in the mandarin citrus orchard in West Sumatra, Indonesia: (A) *Asca longiseta*, and (B) *Asca labrusca*.

gous mites were *B. californicus*, *Tenuipalpus* sp., and *B. obovatus*. Most of the predatory mites were found on *C. odorata* weed (59.4%), *S. occidentalis* (47.2%), *Asca longiseta* (30.0%). *A. labrusca* (6.4%), and *A. vulgaris* (11.19%) (Fig. 3). The study also found *Paraphytoseius cracentis* Corpuz and Rimando (4.1%), *Amblyseius cinctus* Corpuz and Rimando (1.7%), and *Amblyseius asiaticus* Evans (1.0%) which are known as phytoseiid predators.

Detritivores inhabiting weeds in the citrus orchard were dominated by members of the oribatid families Scheloribatidae and Trhypochthoniidae and superfamily Nothroidea. Their fluctuations paralleled those of the predatory mites (Fig. 4). Hence, it is possible that detritivorous mites also served as alternate prey of the predatory mites on the weeds.

Litter-Inhabiting Mites

All trophic groups of mites were found associated with litter below the canopy of the citrus trees. The most abundant were detritivores, totaling 1,155 individuals and belonging to 27 species. Predators followed with 234 individuals in 41 species and *Asca* spp. were the most abundance among them. A few individuals belonging to five species of phytophagous mites, mostly false spider mites (*Brevipalpus* spp.), were also extracted from litter samples. Their presence could be accidental through leaves of citrus and weeds that fell to the ground as litter. A complete fluctuation of the total numbers of mite fauna in the litter is presented at Figure 5. These fluctuations in trends of detritivores were generally followed by those of predatory mites that possibly took them as alternative prey.

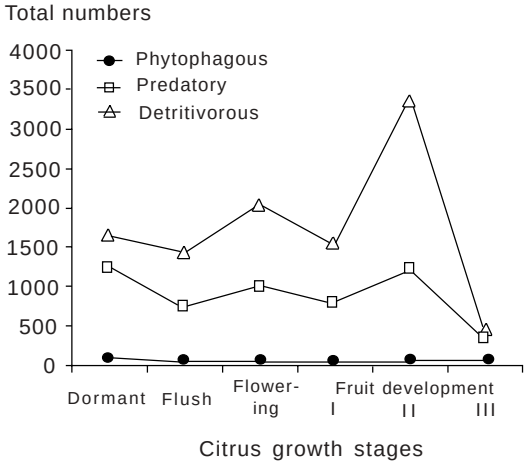

Fig. 4. Total numbers of phytophagous, predatory, and detritivorous mites found on weeds of the mandarin citrus orchard at various growth stages of the citrus.

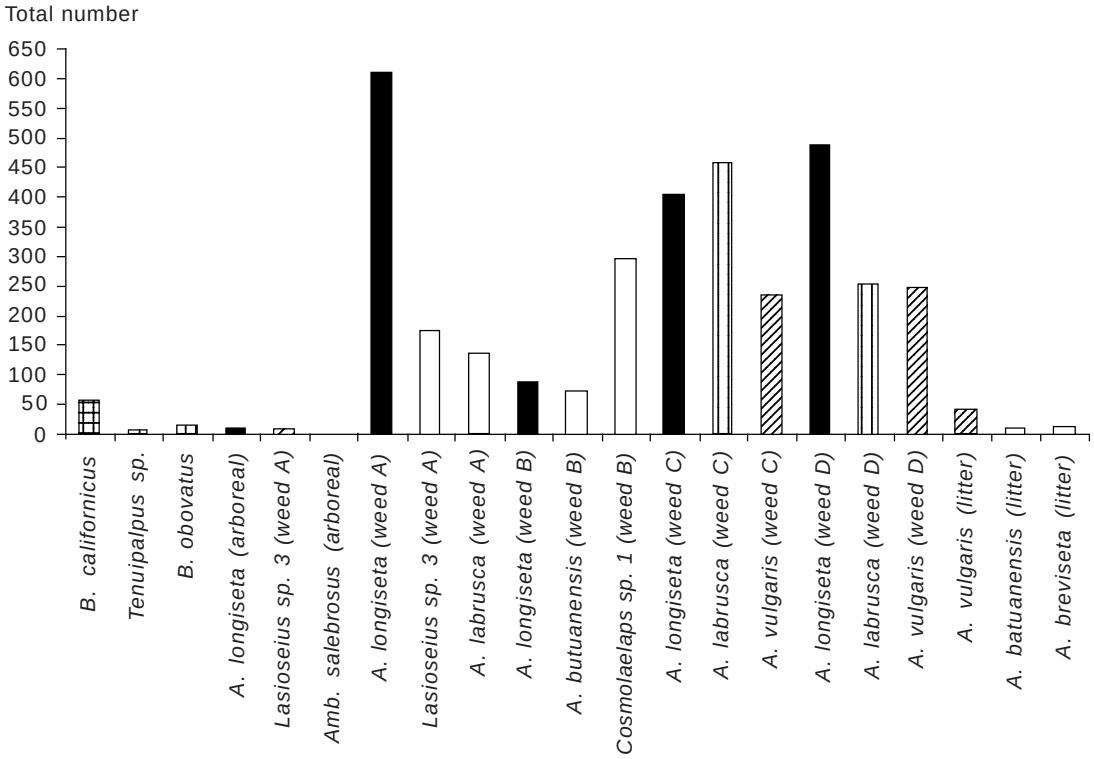

Fig. 3. Total number of phytophagous and predatory mites on various species of weeds in the mandarin citrus orchards; A = *Achyranthes aspera*, B = *Axonopus compressus*, C = *Chromolaena odorata*, D = *Borreria alata*.

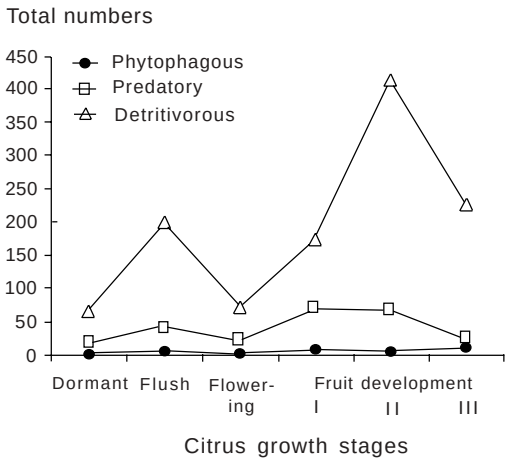

Fig. 5. Total numbers of phytophagous, predatory, and detritivorous mites found on litter of mandarin citrus orchard at various growth stages of the citrus.

Mites of the genera *Asca* spp. have not been studied as extensively as phytoseiids. Their predatory activities are limited as predators of other mites, small insects like thrips, insect eggs, and collembolans (Hurlbutt 1963), as well as nematodes (Epsky *et al.* 1988). They are commonly inhabited moss, sod, litter, nest of spiders, birds, mammals, and citrus bark and leaves of several plants (Hurlbutt 1963). In Australia, *Asca* species are considered as a factor in the natural control of phytophagous mite's family Tenuipalpidae, especially *Brevipalpus* spp. (Walter *et al.* 1993).

These generalist mite' predators like *Asca* spp. and phytoseiids are able to survive in the absence of their principal preys, i.e. by inhabiting arboreal parts of citrus trees. Occasionally, they move down to the ground and litter underneath to prey detritivores (Chuleui and Croft 2000). This type of food searching behavior is also exhibited among advanced generalist predators, therefore they have high searching capacity.

Preserving of these alternative food resources are, therefore, important factor in management of citrus pests. Weeds and litter are served as searching ground food for mites' predators, as well as their breeding ground. Therefore, there is no need to inundate the predators.

Mites Diversity

The average H' values of the three trophic guilds for arboreal parts taken together were 0.89, 1.63, and 0.63 for phytophages, predators, and detritivores respectively. Predatory mites were the most diverse among them, followed closely by detritivores, and the least were phytophages (Fig. 6).

All five kinds of weeds in the citrus orchard likely served as alternative hosts since the phytophagous mites were consistently present in weed samples. The average H' values of the three trophic guilds for all weeds taken together were 0.81 for phytophages, 2.76 for predators, and 2.15 for detritivores. Predatory mites were the most diverse among them, followed closely by detritivores, and the least were phytophages (Fig. 7).

The diversity index analysis for the litter showed average H' values of the three trophic groups as follows: 1.01 for phytophages, 3.35 for predators, and 2.84 for detritivores. Predatory mites were the most diverse among them, followed by detritivores and the least were phytophages (Fig. 8).

Predatory mites were the most diverse in all habitat observed and the fluctuations of H' values of the predatory mites at different growth stages were due

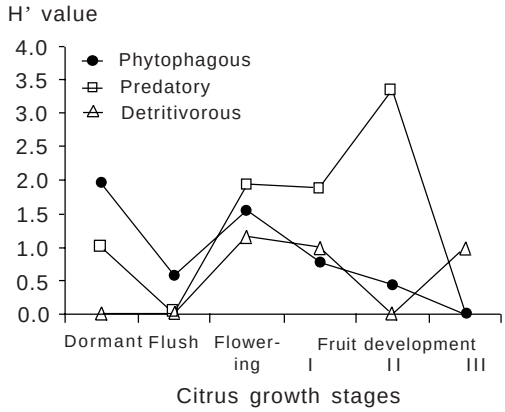

Fig. 6. Fluctuation in diversity index (H') value of phytophagous, predatory, and detritivorous mites found on the arboreal parts of the mandarin citrus orchard at various stages of the citrus trees.

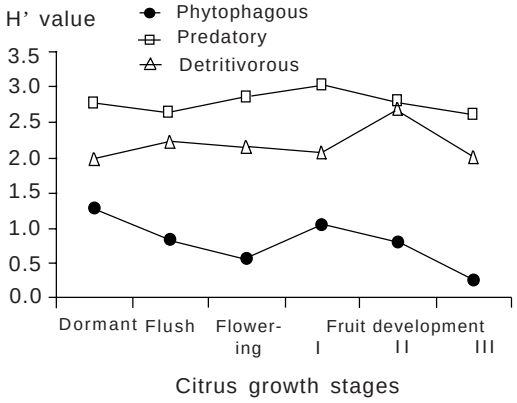

Fig. 7. Fluctuation in diversity index (H') value of phytophagous, predatory, and detritivorous mites found on the weeds in mandarin citrus orchard at various stages of the citrus trees.

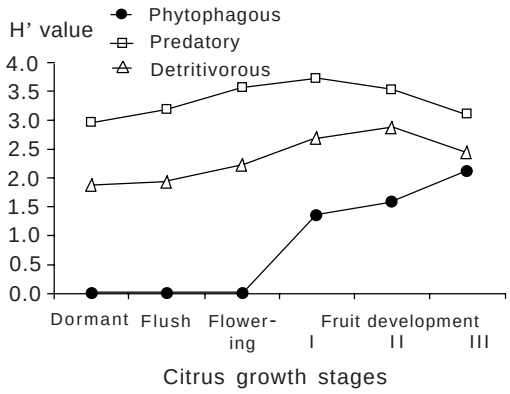

Fig. 8. Fluctuation in diversity index (H') value of phytophagous, predatory, and ditritivorous mites found on the litter in mandarin citrus orchard at various stages of the citrus trees.

to the vertical movement between the citrus leaves and the weeds and/or litter underneath. Such species like *Asca butuanensis*, *A. longiseta*, *Amblyseius cinctus*, *Am. salebrosus*, *T. transvaalensis*, *Lasioseius* sp. 1, and *Lasioseius* sp. 3 showed such movement since they were found not only in the citrus leaves but also in both weeds and litter. Other species, like *Am. fletcheri*, *Am. imbricatus*, *Am. tamatavensis*, and *P. multidentatus* were also found on citrus leaves and weeds. The genus *Asca* was the most dominant predator that existed in arboreal parts, weeds, and litter. These mites appear to be generalist predators that move upward to the citrus leaves from the weeds and litter. This abundance of alternative prey gives the predator populations a "head start" against later-developing pest populations (Settle *et al.* 1996). This process strongly suppresses pest populations and generally lends stability by decoupling predator populations from a strict dependence on phytophagous populations.

The average H' values for phytophages were always low in all habitats observed due to the dominance of *B. californicus*. The phytophagous mites found, especially *Brevipalus* spp., have high economic importance on citrus which is their preferred host (Baker and Tuttle 1987). Their occurrence on the weeds indicates that these plants are within their natural host range. However, their populations were low on the weeds as in the arboreal parts of citrus trees and also in the litter. Phytophagous mites are truly sap feeders, hence their occurrence in the litter was possibly by chance when the leaves of weeds or citrus where they previously lived, fell to the ground.

Detritivores were the second diverse on the arboreal parts, weeds, and litter of the citrus orchard. This little bit low diverse compared with predatory mites were due to the dominance of such detritivores as *Scheloribates praeincisus praeincisus*, undetermined *Nothroidea* sp. 2, and undetermined *Nothroidea* sp. 1. These mostly soil and litter inhabiting mites apparently be used as alternative prey for predators when phytophagous mites are few.

Our data indicate that there is a good species composition and relative abundance of mites occurred on the mandarin citrus trees in the orchard. The diversity and abundance of mites predators in the study area exhibited high species richness and evenness or equitability of distribution of numbers to the various species. Relative importance of these predators in relation with low number and population of the phytophages is interesting to be studied further. They may have played an important role in lowering phytophagous mites below pest levels. In addition, it is important to note that in the studied area, pesticides were not being applied and cover crops of weeds were maintained as standard practices, therefore a good IPM practices have been adopted. Monneti and Fernandez (1995) and Nohara *et al.* (2000) stated that application of pesticides increased phytophagous mites and decreased predatory mites. Furthermore, Muma (1961), Huang (1978), and Papaioannou-Souliotis *et al.* (2000) showed that weeds may serve as natural ecological refuges and potential sources of populations of phytoseiid species when conditions are favorable for them.

CONCLUSION

A total of 17,729 mites belonging to 130 species were collected during the survey. The majority of them were detritivorous mites (11,206 of 50 species), predatory mites (5,998 of 71 species), and phytophagous mites (516 of 7 species), as well as unknown feeding habits (9 of 2 species). The most important phytophagous species are *Brevipalpus californicus*, *B. obovatus*, *B. phoenicis*, *Tenuipalpus* sp., *Panonychus citri*, *Eotetranychus* sp., and *Oligonychus* sp. The most abundance preda-tors are *Asca* species, especially *A. longiseta*, *A. labrusca*, and *A. vulgaris*.

Predators were the most diverse of the three trophic groups whether on the arboreal parts of citrus trees, weeds and litter under the canopy of the citrus trees. The diversity of trophic groups of mites was the least at flush growth stage (H'=1.27), and the most (H'=2.01) at fruit development II growth stage. Among the weeds, *Axonopus compressus* had the most diverse mite fauna (average H' = 2.75), including predators and detritivores.

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