Species Diversity of Aphids (Homoptera: Aphididae) and Coccinellids in Apple Orchards of Urmia, Northwest of Iran

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Summary

Abundance and diversity of aphid and coccinellid species were monitored in apple orchards in Urmia during 2010 and 2011. In this study, eight aphid species were collected and identified in 2010 and nine were found in 2011, while only two coccinellid species were found in both years. In 2010, *Aphis pomi* (De. Geer) was the most abundant aphid (55.5%) followed by *Dysaphis plantaginea* (Passerini) (34%). However, in 2011, *Eriosoma lanigerum* (Hausmann) had the largest population (57%) in apple orchards followed by *D. plantaginea* (21.5%) and *A. pomi* (18%). Generally, more aphids were collected in June and July of 2010. However, aphid's population in 2011 was high from mid-May until early October. Shannon and Simpson diversity indices were measured. The Shannon and Simpson indices of aphids and coccinellids in 2011 were more than those in 2010. Simpson index of aphids in 2010 and 2011 were 0.573 and 0.594, respectively, indicating that the possibility of selecting two different species of aphids was 57% in 2010 and 59% for 2011.

Key words

aphids, apple, coccinellids, diversity, Urmia

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Introduction

Apple is one of the most important fruit crops and Iran is the fourth apple producer country after China, USA and Poland in the world. Urmia as a city located in West Azerbaijan Province holds half of apple fruit orchard areas and produces 50% of apple crop in Iran (Rassipour et al. n.d.). Considering the importance of apple in Iran, identifying pests and disease of the crop and their control measures seems necessary.

Aphids are secondary pests of apples, but their infestations may result in economic losses. They are apparently the sole group of animals with members that utilize plant phloem sap as their principal or sole source of food throughout their life cycle (Sattar et al. 2008). Plant viruses are also transmitted by aphids (Gray 2008). Coccinellids (common name: ladybirds) are aphidophagous predators that especially feed on aphids. *Coccinella septempunctata* (L.) is one of the major predators of aphids in gardens and both its larvae and adults feed on aphids (Atsebeha et al. 2009).

Sattar et al. (2008) reported that one adult of *C. septempunctata* consumes 77.8±5.15 of *Aphis gossypii* and 21.9, 55.9, 107.4 and 227.3 of aphids are consumed by a single larva during 1st, 2nd, 3rd and 4th instars, respectively. Therefore, they have been employed in biological control program of aphids.

Studies on the abundance of aphids and their biological control agents may be conducted in order to find flight periods and peak flights of aphids. The timing of major flights often remains the same from year to year even if the species composition changes. Information on pest and natural enemies' diversity and abundance is needed to avoid unnecessary pesticide applications and to aid the proper selection and timing of pesticide applications (Price 1997). There are several species of aphids that infest apple trees in Urmia. However, this is the first study on the aphid and coccinellids species diversity of Urmia apple orchards.

The aims of the current study were to identify aphids and coccinellids species of apple orchards in Urmia and to estimate their relative frequency and diversity.

Materials and methods

Iranian native apple is *Malus domestica* Borkh. The study was conducted on three apple orchards located in the suburbs of Urmia City in 2010 and 2011. Apple orchards were in Nazloo (37°61'95"N, 45°05'02"E), Saatloo station (Nooshin) (37°71'79"N, 45°06'29"E) and Emamzadeh village (37°53'17"N, 45°20'63"E). In order to eliminate the marginal effects, sampling was performed from depth of two to three meters in the central part of the orchards. Ten clusters per tree were selected randomly (five from lower clusters and five from top of the tree) from among the clusters on 40 trees. Then, clusters were collected and poured inside mesh covered semi-transparent plastic bag. Specification labels were installed on each bag and the bags were transferred to the laboratory, where aphids and coccinellids were identified and counted. For identifying aphids, the identification key of Blackman and Eastop (1984) was applied and coccinellids identification was done using different identification keys (Ansaripour 2010; Iablokoff-Khnzorian 1982; Perrier 1985; Vodjani 1965). Sampling was conducted every two weeks from mid-April (green tip stage) to early October (yellow apple).

The Shannon-Wiener's (Equation 1) (Magurran 1988) and Simpson's (Equation 2) (Simpson 1949) diversity indices were both used to calculate the diversity and the Pielou's (Equation 3) (Price 1997) and Simpson's (Equation 4) indices were used to calculate evenness of aphids' and coccinellids' communities.

Equation 1: Shanon's diversity indices: $H' = \sum_{i=1}^{N_s} [p_i \log p_i]$

where, p_i is the proportion of i^{th} species among all collected samples, and s is the total number of species in the community.

Equation 2: Simpson's diversity indices: $1 - D = 1 - \sum_{i=1}^{N} \frac{n_i(n_i - 1)}{N(N-1)}$

where, 1-D: Simpson's index, n_i: number of individuals in i^{th} species, N: total number of individuals in all collected species.

Equation 3: Pielou's evenness: $J = \frac{H'}{Ln(S)}$

where, s is the total number of species in the community (richness) and H' is Shanon's diversity index.

Equation 4: Simpson's equitability (evenness):

$$ED = \frac{D}{D_{\max}} = \frac{1}{\sum_{i=1}^{s} Pi^2} * \frac{1}{S}$$

Results

The samples taken in 2010 showed the presence of eight species of aphids in apple orchards. The aphid species were: 1) *Aphis pomi* (De. Geer), 2) *Dysaphis plantaginea* (Passerini), 3) *Eriosoma lanigerum* (Hausmann), 4) *Dysaphis devecta* (Walker), 5) *Pterochloroides persicae* (Cholodkovsky), 6) *Myzus persicae* (Sulzer), 7) *Dysaphis affinis* (Mordvilko, 1928), and 8) *Aphis fabae* Scopoli. However, in the 2011 sampling, one more species (*Dysaphis brancoi* (Börner, 1950)) was recorded. In this 2-year-long survey, two coccinellid species, namely *Coccinella septempunctata* L. and *Hippodamia variegata* (Goeze) were observed.

Abundance and relative frequency of aphids were assessed in Urmia apple orchards from 20 April to 3 October 2010. *Aphis pomi* (55.49%) followed by *D. plantaginea* (34.01%) had the highest frequency in 2010 and the greatest number of aphids were collected in July (Table 1). Diversity indices of aphids indicated high Shanon diversity on 20 July 2010. Subsequently, the most species diversity was recorded on 3 July 2010 (Table 2). In 2011, nine aphid species were recorded from apple orchards. In that year, *E. lanigerum* (57.11%), *D. plantaginea* (21.52%) and *A. pomi* (18.20%) were the most abundant species. Similarly to 2010, the highest number of aphids was collected in July 2011 (Table 3). The highest species diversity was observed on 1 May 2011 when Shanon's and Simpson's indices were 1.357 and 0.748, respectively (Table 4). According to the results, aphids' species diversity was higher in 2011 than in 2010.

Coccinella septempunctata was the dominant species of cocinellids in the both years. However, only two cocinellid species were recorded from apple orchards. The highest number of cocinellid species was collected in July and early September of 2010 and in 2011, the highest frequency was observed in July and early August (Table 5). Diversity indices of coccinellids in Urmia were higher in 2011 than in 2010 (Table 6).

Table 1. Frequency of occurrence of aphid species at different time intervals in apple orchards of Urmia in 2010

Species	20 Apr	3 May	20 May	3 Jun	20 Jun	3J ul	20 Jul	3 Aug	20 Aug	3 Sep	20 Sep	3 Oct	Number	Relative frequency (%)
A. pomi	6	16	26	73	138	162	180	98	110	127	74	26	1036	55.49
D. plantaginea	0	2	81	131	135	154	116	13	0	0	0	0	632	34.01
E. lanigerum	0	0	0	2	3	3	7	2	2	4	6	2	33	1.77
D. devecta	0	0	0	0	0	2	8	0	0	0	0	0	10	0.53
P. persicae	0	0	0	0	4	6	10	0	0	0	0	0	20	1.07
M. persicae	0	0	0	0	0	0	0	0	0	10	24	0	34	1.82
D. affinis	0	0	0	0	0	0	0	2	7	0	2	7	9	0.48
A. fabae	20	0	0	0	0	0	0	0	0	0	0	0	90	4.82
Total	26	18	107	206	280	327	321	115	119	141	106	35	1864	100

Table 2. Diversity indices of aphids at different time intervals in Urmia in 2010

Diversity indices	20 Apr	3 May	20 May	3 Jun	20 Jun	3 Jul	20 Jul	3 Aug	20 Aug	3 Sep	20 Sep	3 Oct	Total
H	0.540	0.348	0.554	0.700	0.809	0.850	0.975	0.523	0.308	0.382	0.824	0.706	1.086
EH	0.245	0.158	0.252	0.318	0.368	0.386	0.444	0.238	0.140	0.174	0.375	0.321	0.494
1-D	0.369	0.209	0.371	0.472	0.526	0.533	0.554	0.262	0.143	0.184	0.462	0.416	0.573
ED	0.172	0.138	0.175	0.209	0.233	0.237	0.248	0.114	0.129	0.135	0.204	0.186	0.260

H: Shanon's index, EH: Shannon's equitability, 1-D: Simpson's index, ED: Simpson's equitability.

Table 3. Frequency of occurrence of aphid species at different time intervals in apple orchards of Urmia in 2011

Species	16 Apr	1 May	16 May	1 Jun	16 Jun	1 July	16 Jul	1 Aug	16 Aug	1 Sep	16 Sep	1 Oct	16 Oct	Number	Relative frequency (%)
A. pomi	0	10	48	86	152	162	150	96	57	55	55	39	0	910	18.20
D. plantaginea	0	14	110	162	189	316	149	63	50	18	5	0	0	1076	21.52
E. lanigerum	0	12	40	95	125	239	335	350	325	320	339	360	225	2855	57.11
D. devecta	0	0	0	0	0	2	10	0	0	0	0	0	0	12	0.24
P. persicae	0	0	0	0	0	2	6	7	0	0	0	0	0	15	0.30
M. persicae	0	0	0	0	0	0	0	0	0	2	7	16	0	25	0.50
D. affinis	0	0	0	0	0	0	0	0	3	6	5	0	0	14	0.28
D. brancoi	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0.06
A. fabae	8	19	24	38	0	0	0	0	0	0	0	0	0	89	1.78
Total	8	55	222	381	466	721	650	516	435	404	411	415	225	4999	100

Table 4. Diversity indices of aphids at different time intervals in Urmia in 2011

Diversity indices	16 Apr	1 May	16 May	1 Jun	16 Jun	1 Jul	16 Jul	1 Aug	16 Aug	1 Sep	16 Sep	1 Oct	16Oct	Total
H	0	1.357	1.228	1.275	1.084	1.095	1.125	0.891	0.767	0.719	0.604	0.471	0	1.111
EH	0	0.617	0.559	0.580	0.493	0.498	0.512	0.405	0.349	0.327	0.275	0.214	0	0.505
1-D	0	0.748	0.666	0.697	0.658	0.648	0.629	0.491	0.412	0.352	0.301	0.237	0	0.594
ED	0.111	0.419	0.330	0.365	0.324	0.315	0.298	0.135	0.188	0.171	0.158	0.145	0.111	0.273

H: Shanon's index, EH: Shannon's equitability, 1-D: Simpson's index, ED: Simpson's equitability.

Table 5. Frequency of occurrence of ladybird's community in apple orchards of Urmia during 2010 and 2011

Year	Species	3 May	20 May	3 Jun	20 Jun	3 Jul	20 Jul	3 Aug	20 Aug	3 Sep	20 Sep	3 Oct	Number	Relative frequency (%)
2010	*C. septempunctata*	2	3	7	6	12	8	2	0	13	1	7	61	83.56
	H. varigata	0	0	2	4	2	4	0	0	0	0	0	12	16.43
	Total	2	3	9	10	14	12	2	0	13	1	7	73	100
2011	*C. septempunctata*	1	3	4	3	8	8	4	3	1	3	4	42	75
	H. varigata	0	0	0	1	0	5	6	0	2	0	0	14	25
	Total	1	3	4	4	8	13	10	3	3	3	4	56	100

Table 6. Diversity indices of ladybird's community in apple orchards of Urmia during 2010 and 2011

Year	Diversity indices	3 May	20 May	3 Jun	20 Jun	3 Jul	20 Jul	3 Aug	20 Aug	3 Sep	20 Sep	3 Oct	Total
2010	*H*	-	-	0.529	0.673	0.410	0.636	-	-	-	-	-	0.446
	EH	-	-	0.295	0.375	0.228	0.355	-	-	-	-	-	0.249
	1-D	0	0	0.388	0.533	0.263	0.484	0	-	0	-	0	0.278
	ED	0.50	0.50	0.764	0.961	0.662	0.90	0.50	-	0.50	0.50	0.50	0.689
2011	*H*	-	-	-	0.562	-	0.666	0.366	-	0.366	-	-	0.562
	EH	-	-	-	0.313	-	0.371	0.204	-	0.204	-	-	0.313
	1-D	-	0	0	0.50	0	0.512	0.533	0	0.666	0	0	0.381
	ED	0.50	0.50	0.50	0.80	0.50	0.949	0.961	0.50	0.90	0.50	0.50	0.80

H: Shannon's index, EH: Shannon's equitability, 1-D: Simpson's index, ED: Simpson's equitability

Discussion

In our study, 89.5 percent of the aphids captured in 2010 belonged to only two species that were identified as *A. pomi* and *D. plantaginea*, while more than 96 percent of the identified aphid species in 2011 were *E. lanigerum*, *D. plantaginea* and *A. pomi*. Weather conditions (temperature, humidity and rainfall) are known to influence insect population dynamics (Aneni et al. 2013). Temperature threshold for development of *D. plantaginea* is 4.5°C. Our conclusion that the population of this species is rapidly increased in the spring and significantly reduced with warm weather in the summer is in agreement with Wyss et al. (1999). In addition to weather, bio-control agents such as aphidophagous ladybirds may also reduce aphid's population. However, Dixon et al. (1997) indicated that coccinellid predators grew much slower than their prey and cannot be used as an effective biological control agent. Hemptinne and Dixon (1997) stated that ladybirds tend to oviposit only over a very short period of time when aphid population has reached the peak of abundance. This may be one of the reasons for ineffective biological control of aphids.

In Urmia, *C. septempunctata* species was the dominant species of apple orchards. Akhavan et al. (2013) stated that *C. septempunctata* was more abundant species in Hamedan district, Iran.

Results indicated that the abundance and species diversity of coccinellids was too low in apple orchards. Low predator populations may be due to the periodic spraying of insecticides over three generations of *Carpocasa pomonella* L, codling moth. Spraying begins in mid-July and reduces the frequency of aphids and consequently reduces food resources and frequency of coccinellids. Caballero-López et al. (2012) reported that simple landscapes shown to be beneficial to aphidophagous insects, including *C. septempunctata*. This suggests that abundance and frequency of coccinellid predators is reduced with increasing complexity at landscape. Therefore, reduction of predator populations in apple orchards could be due to the great complexity of the orchards rather than the fields. In Switzerland, Wyss (1995) applied different strategies in order to enhance the number of aphid predators in apple orchards. Planting resistant apple varieties and the sowing of strips of flowering plants were among the strategies. However, in the tested orchards in Urmia, no indirect strategy has been applied previously.

Diversity indices depend not only on species richness but also on the evenness, or equitability, with which individuals are distributed among the different species (Okpiliya 2012). In our study, the maximum value of Simpson's index for aphid's community was 0.748 and 0.697 on 1 May and 1 June 2011. This suggests that the possibility of selecting two different species of aphids randomly were 74 and 69%, while; the minimum value of Simpson's index for aphids was 0.143 on 20 August 2010. For coccinellids, Simpson's index was 0.278 and 0.381 in 2010 and 2011, respectively. The low species diversity index (Simpson) could be due to the uniform distribution of individuals among species.

Conclusion

It could be concluded that aphid populations may show year-to-year fluctuations but the dominant species usually do not vary. Therefore, identifying aphid species, their abundance, role of environmental factors affecting these species and applying an alternative pest control technique seems essential. However, further studies are required to adjust an extended area-wide study, sampling procedures and extensive taxonomic identification of pest-predators in West Azerbaijan Province.

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