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Research Article

Fauna and species diversity of thrips (Insecta: Thysanoptera) on Montpellier maple trees *Acer monspessulanum* in Zagros forests of Ilam province, Iran

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Abstract: Montpellier maple *Acer monspessulanum* L. is one of the trees in Zagros forests (Iran) which is host to several economically important thrips species. The purpose of this study was to find the fauna of thrips on Montpellier maple trees in Ilam province, western Iran, during 2015-2016. The abundance and species diversity of thrips were examined twice a month via standard sweep net and shaking flowers and leaves to white plastic tray at two location sites including Gachan and Manesht Mountains. Out of the 7062 thrips specimens that were collected, 16 thrips species were identified, which belonged to 10 genera and four families. The estimated domination coefficient showed that in both sites *Taeniothrips inconsequens* Uzel was eudominant and onion thrips, *Thrips tabaci* Lindeman was dominant species. There were 5 and 4 species classified as subdominant for Gachan and Manasht, respectively. Four predatory thrips were found on Montpellier maple trees including *Aeolothrips intermedius* Bagnall, *Scolothrips longicornis* Priesner, *Haplothrips flavitibia* Williams and *H. globiceps*. Of these, *A. intermedius* was the most abundant predator in both collection sites, whereas others showed a low population density. According to diversity index calculations, the Shannon diversity, Pielou's evenness and Margalef's species richness indices were 1.83, 0.68 and 1.67 for Gachan, and 1.48, 0.62 and 1.26 for Manesht, respectively.

Keywords: Thrips, diversity, population

Introduction

The Zagros forests with a semi-Mediterranean climate located in western Iran represent more than 40% of the country's forests. There are different kinds of trees in Zagros with the dominant species of Oak trees *Quercus brantti* Lindl. (Purhashemi *et al.*, 2004). The other species, Montpellier maple tree *Acer monspessulanum* L. is a deciduous shrub with leathery and three-lobed dark green leaves (van Gelderen and van Gelderen, 1999). In Zagros forests, several insects and mites are feeding on maple trees including mites (especially eriophyid and spider mites), aphids, caterpillars, and gall-forming cynipid wasps (Mirzaei and Mirab-balou, 2015).

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Of the 6000 species of thrips (Order Thysanoptera) described worldwide, over 200 species have been recorded in Iran (Mirab-balou, 2013), and this number continues to increase as new thrips species are collected. In Iran, only a few thrips species are recorded as serious pests (Minaei *et al.*, 2007; Mirab-balou and Chen, 2011). Most thrips including *Thrips tabaci* Lindemann feed on plants, attacking flowers, leaves, buds and fruits. Several species of thrips feed on fungus spores, and a few are beneficial predators (Pobożniak *et al.*, 2007).

Measuring species diversity is an important aspect of environment to achieve the information on the extent to which humans alter the natural habitats (Sisk *et al.*, 1994; Humphries *et al.*, 1995). In addition, species diversity may be used to evaluate the occurrence of new species in a habitat (Mirab-balou *et al.*, 2017). Species diversity takes into account both species richness and species evenness (Brown *et al.*, 2007). Perhaps the simplest and most frequently used measure of biological diversity is species richness. Species richness is simply a count of species, and it does not take into account the abundances of the species or their relative abundance distributions (Brown *et al.*, 2007).

Some studies have been done on thrips species composition and diversity (Childers and Nakahara, 2006; Ganaha-Kikumura *et al.*, 2012; Wang *et al.*, 2014). Childers and Nakahara (2006) studied on thrips species within citrus orchards in Florida. They found 21 plant feeding species among which only *Frankliniella bispinosa* Morgan, *Chaetanaphothrips orchidii* Moulton, *Danothrips trifasciatus* Sakimura, and *Heliothrips haemorrhoidalis* Bouche have been considered economic pests on Florida citrus trees. Ganaha-Kikumura *et al.* (2012) studied the species composition of thrips on chrysanthemum in Okinawa. Their results were unexpected as *Thrips nigropilosus* Uzel was an important pest species of chrysanthemum while the frequency of *T. tabaci* was low, and *F. occidentalis* was not found. Wang *et al.* (2014) showed that based on comparisons of Shannon-Wiener diversity index, Pielou evenness index, and Simpson dominance index, the diversity of Chinese litter-dwelling thrips in the tropics was higher than that in the temperate areas.

Early detection of thrips is critically important because symptoms of their feedings often remain hidden until serious damage is done (Fueutes and Salazar, 2003). Thus, knowing the important thrips species for each region and their population densities on plants is important for their management. It is known that natural enemies such as thrips predators have crucial importance on the population density of thrips pest species (Fathi *et al.*, 2008).

At present, there is no information on thrips associated with maple trees in Iran (Mirab-balou, 2016). Therefore, this study was conducted to determine the species composition of thrips fauna on Montpellier maple trees in two location sites of Zagros forests (Gachan and Manesht Mountains), and to check which thrips species are the most dominant on these trees.

Materials and Methods

Thrips collection

Thrips specimens were collected on Montpellier maple trees (*A. monspessulanum*) of Manesht Mountain (N 33° 41' 33.36", E 46° 27' 28.08") and Gachan Mt. (N 33° 38' 43.08", E 46° 29' 9.96") located in Zagros forests, Ilam province (west of Iran) (Fig. 1). The survey was made twice a month from April to July during 2015-2016. Specimens of thrips were collected for 60 min on 10 trees from each location site by using standard sweep net (38 cm in diameter) and extracted from maple trees by beating the branches, flowers and leaves over a white plastic tray (500 × 400 mm). The thrips that fell onto the tray were then individually collected using a fine paint brush and transferred into vials with 75% ethanol alcohol and total numbers recorded.

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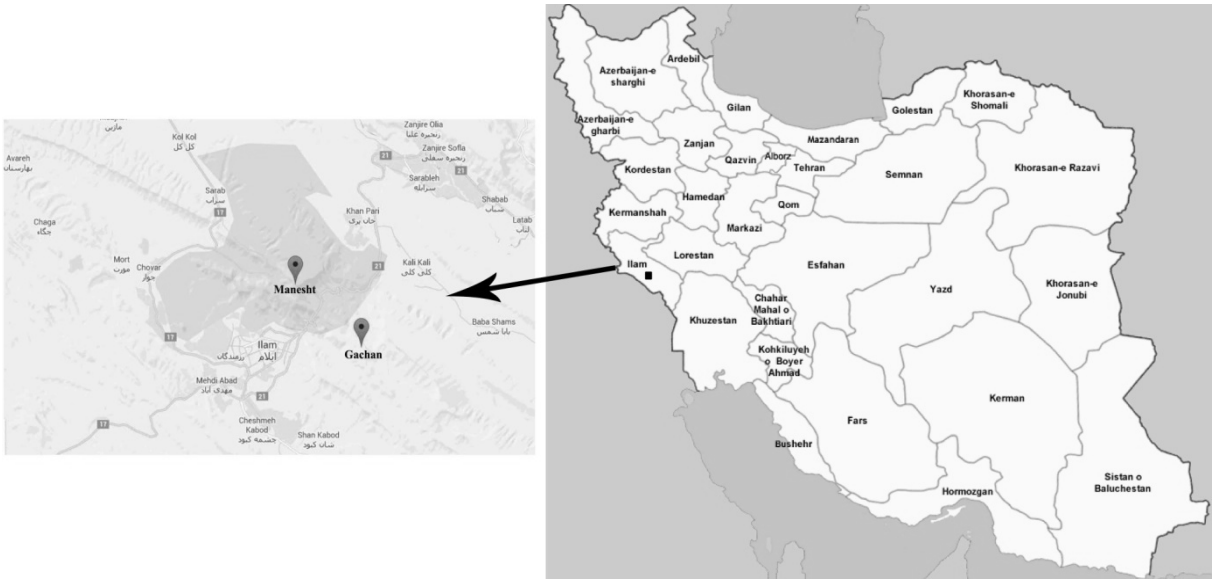

Figure 1 Map of Iran (right), showing two location sites of study in Ilam province (left).

Thrips identification

The method for preparing and mounting thrips on slides for microscopic identification follows Mirab-balou and Chen (2010). Only adult thrips were identified to species and the larvae were not, because their identification is not possible.

Data analysis

Diversity was calculated by Shannon-Wiener's Index. This is the most commonly used index in ecology of communities (Ludwig and Reynolds, 1988) and allows comparisons between communities:

$$H' = -\sum_{i=1}^{s} \frac{n_i}{N} \ln \frac{n_i}{N}$$

In which, H'-Shannon-Wiener's Index, n_i - number of specimens of i-species per sample, N- total number of individuals of all the species, and s- number of species in community.

Evenness was calculated by Pielou's evenness index which has two contributing components including the number of species and the distribution of individuals among those species (equitability):

$$J = \frac{H'}{\ln S}$$

In which, J - Pielou's evenness index, H' - Shannon-Wiener's Index and S - total number of species collected in the sample (Pielou, 1975).

Species richness was estimated using the Margalef's richness index. Species richness is the number of species recorded and does not take into account relative abundances, instead includes the sum of individuals recorded for all the species in a specific sample plot:

$$D_{mg} = \frac{(S-1)}{\ln N}$$

In which, D_{mg}- Margalef's richness index, S - the number of species recorded and N - the total number of individuals in the sample (Margalef, 1958).

Domination coefficient informs what percentage out of the total amount of the collected specimens for a given area is constituted by specimens of a particular species. It was calculated by Kasprzak and Niedbala (1981) formula:

$$D_i = \frac{n_i}{N} 100\%$$

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In which, n_i- number of specimens of a given species in a given area and *N*-number of all the specimens collected from a given area.

Results

Both terebrantian and tubuliferan thrips were found on trees collected at two collection sites. From the 7062 thrips specimens that were collected, 16 species were identified which belonged to 10 genera and four families (Table 1). A total of 921 terebrantian thrips were mounted onto glass slides for identification. Thirteen terebrantian species were identified, all belonging to the family Thripidae (except *Aeolothrips intermedius* Bagnall and *Melanthrips fuscus* Sulzer *that* belong to Aeolothripidae and Melanthripidae, respectively).

Total number of thrips specimens collected from Gachan and Manasht were 4360 and 2702, respectively. In both sites, the number of females was approximately 3.7 times more than males. The number of species found in Gachan (15) was more than Manasht (11). Overall, *Taeniothrips inconsequens* Uzel was the most abundant species at both collection sites, followed by onion thrips, *T. tabaci* (Table 1).

Four predatory thrips were found on Montpellier maple trees: *A. intermedius*, *Scolothrips longicornis* Priesner, *Haplothrips flavitibia* Williams and *H. globiceps*. Of these, *A. intermedius* was the most abundant predator in both collection sites, whereas *S. longicornis*, *H. flavitibia* and *H. globiceps* showed a low population density (less than 30) during all sampling dates (Table 1).

According to diversity index calculations, the Shannon diversity, Pielou's evenness and Margalef's species richness indices were 1.83, 0.68 and 1.67 for Gachan, and 1.48, 0.62 and 1.26 for Manesht, respectively (Table 1). The estimated domination coefficient showed that in both sites *T. inconsequens* was eudominant and *T. tabaci* was dominant. There were 5 and 4 species classified as subdominant for Gachan and Manasht, respectively (Table 2).

Table 1 Total number of adult thrips species collected on Montpellier maple trees, Shannon diversity Index, Pielou's evenness index and Margalef's species richness index at Gachan Mt. and Manesht Mt. in Ilam province, Iran.

Family	Species name	Gachan Mt.			Manesht Mt.		
		Total	♀	♂	Total	♀	♂
Aeolothripidae	*Aeolothrips intermedius*	260	183	77	81	65	16
Melanthripidae	*Melanthrips fuscus*	44	30	14	44	24	20
Thripidae	*Anaphothrips obscurus*	11	11	0	-	-	-
	Chirothrips manicatus	24	20	4	-	-	-
	Frankliniella intonsa	386	246	140	111	77	34
	Frankliniella occidentalis	193	136	57	99	65	34
	Frankliniella tenuicornis	47	40	7	-	-	-
	Scolothrips longicornis	25	19	6	15	10	5
	Taeniothrips inconsequens	1805	1418	387	1253	871	382
	Tenothrips frici	11	8	3	-	-	-
	Thrips meridionalis	150	111	39	80	50	30
	Thrips tabaci	897	897	0	864	864	0
	Thrips vulgatissimus	371	213	158	113	73	40
Phlaeothripidae	*Haplothrips flavitibia*	-	-	-	11	8	3
	Haplothrips globiceps	7	5	2	-	-	-
	Haplothrips reuteri	129	87	42	31	20	11
Total		4360	3424	936	2702	2127	575
Total number of observed species		15	-	-	11	-	-
Shannon diversity index		1.83	-	-	1.48	-	-
Pielou's evenness index		0.68	-	-	0.62	-	-
Margalef's species richness index		1.67	-	-	1.26	-	-

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Table 2 Domination coefficient and sex ratio of thrips species collected on Montpellier maple trees at Gachan Mt. and Manesht Mt. in Ilam province, Iran.

Family	Species name	Gachan Mt.			Manesht Mt.		
		Total	♀	♂	Total	♀	♂
Aeolothripidae	*Aeolothrips intermedius*	5.96	70.38	29.62	3.00	80.25	19.75
Melanthripidae	*Melanthrips fuscus*	1.01	68.18	31.82	1.63	54.55	45.45
Thripidae	*Anaphothrips obscurus*	0.25	100.00	0.00	-	-	-
	Chirothrips manicatus	0.55	83.33	16.67	-	-	-
	Frankliniella intonsa	8.85	63.73	36.27	4.11	69.37	30.63
	Frankliniella occidentalis	4.43	70.47	29.53	3.66	65.66	34.34
	Frankliniella tenuicornis	1.08	85.11	14.89	-	-	-
	Scolothrips longicornis	0.57	76.00	24.00	0.56	66.67	33.33
	Taeniothrips inconsequens	41.40	78.56	21.44	46.37	69.51	30.49
	Tenothrips frici	0.25	72.73	27.27	-	-	-
	Thrips meridionalis	3.44	74.00	26.00	2.96	62.50	37.50
	Thrips tabaci	20.57	100.00	0.00	31.98	100.00	0.00
	Thrips vulgatissimus	8.51	57.41	42.59	4.18	64.60	35.40
Phlaeothripidae	*Haplothrips flavitibia*	-	-	-	0.41	72.73	27.27
	Haplothrips globiceps	0.16	71.43	28.57	-	-	-
	Haplothrips reuteri	2.97	67.44	32.56	1.14	64.52	35.48

Domination coefficients of thrips species collected from Gachan and Manasht at four months are shown in Tables 3 and 4, respectively. At both collection sites, results showed that in April *T. tabaci* was eudominant and *T. inconsequens* was dominant. This trend was inverse in remaining months (May, June and July). At both collection sites, *Frankliniella* species had 10 or less dominant coefficient throughout the April to July. Other thrips species had low dominant coefficient. Tubuliferan species (i.e. *H. flavitibia*, *H. globiceps* and *H. reuteri*) had low dominant coefficient (less than 4). Despite the fact that the dominant coefficient of *A. intermedius* was very low during first month of study, it increased sharply in the last month (July) to reach 13.64 at Gachan and 6.3 at Manasht (Tables 3 and 4). Two species, *Anaphothrips obscurus* Muller and *Tenothrips frici* Uzel were found accidentally on maple trees at Gachan, and resulted probably from the migration of the insects from the weeds and other trees.

No male thrips were found for *T. tabaci* and *A. obscures* (Table 1). In this study, all the thrips species collected had wings, nevertheless a wingless form of male of *Chirothrips manicatus* was found at Gachan Mountain

Table 3 Domination coefficient of adult thrips species collected on maple trees in four different months, Gachan Mt. in Ilam province, Iran.

Thrips species	April	May	June	July
Aeolothrips intermedius	0.57	3.42	5.38	13.64
Melanthrips fuscus	0.57	1.07	0.92	1.42
Anaphothrips obscurus	0.98	0	0.35	0
Chirothrips manicatus	1.26	0.39	0	0.85
Frankliniella intonsa	10.00	8.42	9.49	7.39
Frankliniella occidentalis	9.40	4.40	3.82	1.13
Frankliniella tenuicornis	3.31	0.35	0.12	1.04
Scolothrips longicornis	0.57	0.35	0.56	0.75
Taeniothrips inconsequens	24.31	46.62	49.39	39.97
Tenothrips frici	0	0	0.35	0.56
Thrips meridionalis	7.33	3.03	2.4	1.99
Thrips tabaci	31.40	19.9	15.58	19.14
Thrips vulgatissimus	6.55	9.71	8.24	9.19
Haplothrips globiceps	0.11	0.29	0	0.28
Haplothrips reuteri	3.64	2.05	3.40	2.65

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Table 4 Domination coefficient of adult thrips species collected on maple treesin four different months, Manesht Mt.in Ilam province, Iran.

Thrips species	April	May	June	July
Aeolothrips intermedius	0.58	1.86	2.49	6.30
Melanthrips fuscus	0.96	1.86	1.47	2.10
Frankliniella intonsa	6.78	7.27	1.36	2.94
Frankliniella occidentalis	2.32	1.35	5.33	4.48
Scolothrips longicornis	0.38	0.67	0.45	0.70
Taeniothrips inconsequens	15.17	50.46	60.29	48.47
Thrips meridionalis	4.06	1.86	3.51	2.38
Thrips tabaci	60.46	29.61	21.26	26.61
Thrips vulgatissimus	6.58	3.89	2.83	4.34
Haplothrips flavitibia	0.58	0.50	0.22	0.42
Haplothrips reuteri	2.13	0.67	0.79	1.26

Discussion

Sampling maple trees of two sites located in Ilam county resulted in identification of 16 thrips species which most of them were phytophagous and a few were predators. There are a number of studies on thrips fauna in different ecosystems. In the study by Hurej *et al*. (2014) 17 thrips species were identified on lupin plants. Pobożniak and Anna (2011) reported 22 species from the flowers and inflorescences of 37 species of herbs. Mirab-balou *et al.* (2017) collected 27 species belonging to 13 genera of thrips species in fruit orchards in Qazvin province, northwest of Iran. This difference in results of different studies could be related to differences in plant species, climate conditions, sampling methods and the duration of studies. Here we report one more thrips family (Melanthripidae) compared to the study by Pobożniak and Anna (2011).

Among phytophagous thrips, *T. inconsequens* and *T. tabaci* were the most dominant species. Several studies have shown that *T. tabaci* is the most dominant among the species of Thysanoptera. In the studies by Pobożniak (2005) and Mirab-balou *et al.* (2017), *T. tabaci* was classified as eudominant species. In the case of *T. inconsequens*, there are fewer studies showing this species as eudominant (Teulon *et al.*, 1998). *T. inconsequens* is widely distributed in most countries (Mirab-balou *et al.*, 2015). Adults of this species have been recorded from over 200 plant species including species of *Acer* (Sapindaceae), *Fagus* and *Quercus* (Fagaceae), *Fraxinus* (Oleaceae), *Prunus* and *Pyrus* (Rosaceae). This species seriously damages young leaves and causes premature leaf fall of sugar maple in north east of USA (Teulon *et al.*, 1994).

T. inconsequens has been identified for the first time on Montpellier maple trees of Iran through this study. The larvae and adults of this species can cause significant damage by feeding on the flowers and leaves. During the months of April till the first week of July, this kind of damage is seen in the nature. Severe foliage damage could result in early spring defoliation followed by refoliation in May or June. According to Teulon *et al.* (1998), this species has only one generation per year and populations do not increase over the summer.

Among the predators, *A. intermedius* was the most dominant species. *A. intermedius* specimens have been found in Europe on 30 different host plants, always in mixed populations with phytophagous insects including 18 thrips species (Trdan *et al.*, 2005). Adults and larvae of *A. intermedius*, were found as predator of 44 species of thrips (Riudavets, 1995). The main pest genera for which *A. intermedius* has been reported as predator are: *Haplothrips* (Dyadechko *et al.*, 1971) and *Thrips* **(**Franco *et al.*, 1999**)**.

Conclusion

In the present study, it was found that *T. inconsequens* and *T. tabaci* are respectively eudominant and dominant thrips species on *A. monspessulanum*. At both collection sites, *A. intermedius* was the dominant predator thrips species on Montpellier maple trees. There is a need for more investigations on the role of *A. intermedius* as a biological control agent of phytophagous thrips.

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فون و تنوع گونه‌ای تریپس‌ها (Insecta: Thysanoptera) روی درختان افرا (*Acer monspessulanum*) در جنگل‌های استان ایلام، ایران

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چکیده: درخت افرا *Acer monspessulanum* L. یکی از گونه‌های درختی جنگل‌های زاگرس است که میزبان چندین گونه تریپس با اهمیت اقتصادی می‌باشد. هدف از این مطالعه بررسی فون و تنوع گونه‌ایی تریپس‌ها روی درختان افرا بود که در استان ایلام طی سال‌های ۱۳۹۴ و ۱۳۹۵ انجام شد. نمونه‌برداری از تریپس‌ها دو بار در ماه و در دو منطقه کوهستانی گچان و مانشت و با استفاده از تور حشره‌گیری و تکان دادن گل‌ها و برگ‌ها روی سینی انجام شد. از ۷۰۶۲ نمونه جمع‌آوری شده، ۱۶ گونه تریپس شناسایی شد که متعلق به ۱۰ جنس و چهار خانواده بودند. ضریب غالبیت برآورد شده نشان داد در هر دو منطقه گونه *Taeniothrips inconsequens* Uzel به‌عنوان فوق‌غالب و تریپس پیاز، *Thrips tabaci* Lindeman، به‌عنوان گونه غالب است. در منطقه مانشت ۴ گونه و در منطقه گچان ۵ گونه به‌عنوان نیمه‌غالب تعیین شد. چهار گونه تریپس شکارگر با نام‌های علمی *Aeolothrips intermedius* Bagnall، *Scolothrips longicornis* Priesner، *Haplothrips flavitibia* Williams و *H. globiceps* از روی درختان افرا جمع‌آوری شد. از بین این گونه‌های شکارگر، گونه *A. intermedius* بیش‌ترین فراوانی در هر دو منطقه را داشت درحالی‌که بقیه گونه‌های شکارگر تراکم پایینی نشان دادند. شاخص تنوع شانون، شاخص یکنواختی پیلو و شاخص غنای گونه‌ایی مارگالف به‌ترتیب ۱/۸۳، ۰/۶۸ و ۱/۶۷ برای منطقه گچان، و ۱/۴۸، ۰/۶۲ و ۱/۲۶ برای مانشت برآورد شد.

واژگان کلیدی: تریپس، تنوع، جمعیت

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