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The temporal effects of forest fires on abundance and diversity of oak gall wasps (Hymenoptera: Cynipidae)

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Abstract. The galls are induced by gall inducing insects and can be considered as abnormal plant growth triggered by the gall inducer. The population of gall-forming organisms is influenced by many ecological factors such as fire, which may change their richness and diversity. Thus, in present study, six locations including three burned areas and three control areas (in the years 2012, 2013 and 2014) were selected to determine the relationship between the frequency and diversity of gall wasps and a time interval after forest fires. Then, 30 individuals of *Quercus brantii*, were selected at the suitable distance from each other. The results showed that as the time interval between forest fires increase, the frequency and diversity of gall wasps increase as well. Moreover, it was revealed that *Andricus grossulariae* and *Synophrus politus,* as the most sensitive types to forest fires, returned to the locations with a longer delay.

Key words: diversity, fire, frequency, gall wasps, West Azerbaijan.

Introduction

Forests are mature ecosystems, and it takes millions of years to incorporate their four main elements including plant communities, animal communities, microorganisms and abiotic factors. The rate of survival of each factor depends on the other factors (Colgan & Erbilgin 2011). Regarding the type of forest, different herbaceous and tree species, species of insects, arthropods and vertebrates appear in forests. Investigating the relationship between these organisms in food chains and networks clarifies the importance of biodiversity for the stability of natural balance. There is a complex nutritional relationship between plants and animals, which has not been considered seriously (Colgan & Erbilgin 2011). Environmental condition is the most effective factor which determines the suitability of a host for an herbivore. The altitude, soil texture, slope, growth direction, climate, micronutrients of soil and vegetative condition of an ecosystem can affect the rate and quantity of vegetative growth in a given region. These factors can increase or decrease plant growth and favourability of plant for an herbivore which consequently lead to a change in the diversity of plants and animals (especially, diversity of insects), accordingly (Eyles et al. 2009, Wallin & Raffa 2001).

West Azerbaijan province is located in Northern Zagros Mountains in Iran. Forest of region is covered by *Q. brantii* (Lindl 1840), *Quercus libani* (Oliver 1801) and *Quercus infectoria* (Oliver 1801) as dominant tree species. *Q. brantii* and *Q. libani* belong to section Cerris and *Q. infectoria* belongs to section Quercus within the genus Quercus. These species are found in pure and mixed community (Sabeti 1994, Sagheb Talebi et al. 2004). Oak gall wasps (Cynipidae) are highly dependent on oak species and a rich fauna of them has been reported on oak species around the world (Csóka et al. 2005). Each gall wasp induces a particular gall which is unique in terms of shape and structure. Shape of galls is representative for gall forming specie. The galls can be developed on different parts of a plant tissue such as leaves, stems, inflorescence and roots (Nylander 2004, Csóka et al. 2005, Raper 2009). Formation of galls in plants is due to a gall forming activity and it is associated with a kind of deformation in plant tissue and gall location. This activity is considered as a defensive posture of plants that plants may mount defensive responses to prevent gall initiation (Stone et al. 2002). The difference between the fauna of oak gall wasps and their distribution are associated with their specialized functions on the host (Stone et al. 2002). According to Price (2005), there is a significant positive relationship between dominant plant species and richness of gall wasps. Studies showed that the size of a tree is mentioned as another effective factor of the richness of gall wasps (Cornell 1986). Quality of host plant, including availability of nutrients, the height and crown of the oak tree as well as abiotic factors including stress from dehydration or severe temperature changes, can affect the richness and diversity of gall forming insects (Prior & Hellmann 2010). Studies show that there is a direct relationship between the richness of these insects and the dominant vegetation of the region (Stone et al. 2002). Blanche (2000) found that environmental temperature and precipitation rate have a limited role in distribution of gall insects. She believes that the role of climate was negligible. Zargaran et al. (2011) investigated oak gall wasps (Hymenoptera: Cynipidae) species richness using Rarefaction and Jackknife indices in West Azerbaijan. They indicated that wasps' diversity and distribution depends on oak species and subspecies. Zardoeie Heidary et al. (2012) investigated the diversity of oak gall wasps in Kermanshah province and found that the species of *Cerroneuroterus lanuginosus* (Melika 2010), *Dryocosmus israeli* (Sternlicht 1968) and *Pseudoneuroterus saliens* (Melika 2010) have the highest frequency. Moreover, species such as *Andricus coriariformis* (Melika et al. 2008), *Andricus megalucidus* (Melika et al. 2003), *Andricus istvani* (Melika 2008), *Pseudoneuroterus macropterus* (Hartig 1843) and *Synophrus olivieri* (Kieffer 1898) had the lowest frequency. Furthermore, it was found that the species of *C. lanuginosus, P. saliens* and *Aphelonyx persica* (Melika et al. 2004) had the widest distribution in the province and they were considered as dominant gall-forming species in Kermanshah province.

Assessment of paths in biodiversity is important in confronting the reduction of species. This means that reduction of biodiversity endangers species and loss of one species will affect other species in all food chains and networks (Magurran 1988). Reduction of diversity of gall wasps (due to their direct dependence on host plant (oak species)) points to the presence of a stressful factor or a destroying factor such as fire and reduced species of host plants in the region. Despite the frequent occurrence of fire in the forests and rangelands of Iran, few studies have addressed this issue. The latter fact may imply that the impact of fire, as an ecological factor, on forest ecosystems (especially in West and North-West of Iran), is not clearly understood. Regarding this issue, present study aims to find the relationship between density and diversity of gall wasps and forest fire.

Materials and methods

Three regions were determined as the research areas (1: 45°29′44″ E; 36°10′16″ N, 2: 45°28′30″ E; 36°12′30″ N and 3: 45°29′38″ E; 36°10′07″ N). These areas belonged to Sardasht forests located in West Azerbaijan province. These regions suffered from surface fires in 2012, 2013 and 2014, respectively. Regarding the lack of data before fires and in order to comparison and eliminating the marginal effect, similar regions near the burned areas as control (unburned) regions with the similar area, habitat condition and topographical properties were selected. A distance of 200 to 300 meters was considered between the control areas and the burned areas.

<u>Investigation on gall insects</u>

<u>*Calculating the number of required samples:*</u> To determine proper number of samples a primary sampling was done before the main sampling. The relative error was determined by RV = (SE/m) ×100 equation and by using the data obtained from primary sampling. Where (m) is the mean of data and (SE) is the standard error of the primary data. The relative error factor indicates the accuracy of the primary sampling which is acceptable up to 25 percent. If the relative error was higher than 25 percent, the number of prime samples must be increased. Since the number of samples can affect species diversity and consequently alter the indices, therefore sample size is determined as equal as possible for all sampling areas (Magurran 2004). Regarding the aforementioned facts, maximum number of 30 samples was considered for each site.

<u>*Sampling of trees in order to count gall insects:*</u> Sampling was done along with two transects. A distance of 25 meters was considered between transects. Regarding the area of the region, individuals of *Q. brantii* (with similar diameter and height) were selected at a suitable distance from each other on each transect (10 to 15 meters). Then, total number of galls on the individual trees was counted and recorded. To investigate the gall wasps of oak, sampling was conducted in each site in May and October of 2015 for spring and summer-autumn galls, respectively.

Given that, each gall is related to only one gall wasp, the collected samples were identified based on their appearance and by applying the book of "Gall Wasps of Ukraine" (Melika 2006) as well as with the collaboration of the entomology lab technician of Urmia University.

<u>Statistics</u>

Indices of Simpson and Shannon Heterogeneity and Evenness were calculated by using Ecological Methodology Software (Version 6.0).

SPSS Statistical Software (Version 21) was used to analyse the data. Box Plot command was used to identify and eliminate outlier data. Then, the normality of data distribution was examined by using Kolmogorov-Smirnov Test. Having confirmed the normality of data, ANOVA and Duncan tests to compare the means for continuous data were used. The discrete data and frequency were analysed using Chi-square test.

Table 1. Life cycles and host plant of the oak galls. (*Q.*= *Quercus*)

Gall Wasps Species	Gall location	Larval cells	Gene-ration	Gall developed	Adult emerge	Host
Andricus cecconii (Kieffer, 1901)	inflorescence	1-2	Sexual	May - June	July - August	*Q. brantii*, *Q. libanii*, *Q. castaneifoliae*
Andricus istvani (Melika, 2008)	Leaf &Young branches	Several	Sexual	May	June	*Q. brantii*
Andricus grossulariae (Giraud, 1859)	Inflorescence/ Lateral buds & fruit	One/ Several	Sexual/ Asexual	May – June/ August-October	August/ January-April	Q. *brantii, Q. libanii, Q. macranthera, Q. castaneifoliae / Q. infectoria, Q. macranthera*
Andricus multiplicatus (Giraud, 1859)	Terminal buds	Several	Sexual	May – June	June	*Quercus brantii*,*Q. libanii, Q. castaneifoliae*
Cerroneuroterus lanuginosus (Giraud, 1859)	Leaf	One	Asexual	August	February - next Spring	*Q. brantii*, *Q. libanii*, *Q. castaneifoliae*
Pseudoneuroterus saliens (Kollar, 1857)	Fruit buds/ Leaf	Several/ One	Sexual/ Asexual	Spring/ July- November	May/ October-February	*Q. brantii*, *Q. libanii*, *Q. castaneifoliae*
Aphelonyx persica (Melika et al. 2004)	Lateral buds	One	Asexual	June	September	*Q. brantii*, *Q. libanii*, *Q. castaneifoliae*
Synophrus politus (Hartig, 1843)	buds	One	Asexual	July	February	*Q. brantii*, *Q. libanii*
Aphelonyx cerricola (Giraud, 1859)	Thin branches	1-2	Asexual	Summer	Autumn-Winter	*Q. brantii*
Chilapis nitida ssp *israeli* (Sternlicht, 1968)	Leaf	One	Asexual	Summer-Autumn	Autumn-Winter	*Q. brantii*, *Q. libanii*

Table 2. List of spring gall wasps species in different study areas.

Burned 2012	Unburned 2012	Burned 2013	Unburned 2013	Burned 2014	Unburned 2014
A. cecconii	*A. cecconii*	*A. cecconii*	*A. cecconii*	*A. cecconii*	*A. cecconii*
A. istvani	*A. istvani*	*A. istvani*	--	*A. istvani*	*A. istvani*
A. grossulariae	*A. grossulariae*	--	*A. grossulariae*	--	*A. grossulariae*
A. multiplicatus	*A. multiplicatus*	*A. multiplicatus*	*A. multiplicatus*	--	*A. multiplicatus*

Results

Based on samplings conducted in spring and autumn, a total number of 10 species of oak gall wasps was identified in the research areas. Among all the species, *Andricus cecconii* (Kieffer 1901) (sexual generation), *A. istvani* (Melika 2008) (sexual generation), *A. grossulariae* (Giraud 1859) (sexual generation) and *A. multiplicatus* (Giraud 1859) (sexual generation) were observed in spring and *Cerroneuroterus lanuginosus* (Giraud 1859) (asexual generation), *Pseudoneuroterus saliens* (Kollar 1857) (asexual generation), *Aphelonyx persica* (Melika et al. 2004) (asexual generation), *Synophrus politus* (Hartig 1843) (sexual generation), *Aphelonyx cerricola* (Giraud 1859) (asexual generation) and *Chilaspis nitida* (Sternlicht 1968) (asexual generation) were observed in autumn (Table 1).

All identified spring galls were detected in both burned and control areas in 2012 and in control areas in 2014, only two species including *A. cecconii* and *A. multiplicatus* occurred in burned and control areas in 2013. Species *A. istvani* only detected in the burned area while the *A. grossulariae* was observed in the control area in 2013. The burned area in 2014 had the least presence of galls comprising of *A. cecconii* and *A. istvani*. Among all the studied galls in the spring, only *A. cecconii* was observed in all the sites (Table 2).

Table 3 illustrates that some species including *C. lanuginosus*, *P. saliens* and *A. persica*, collected in the autumn, were observed in all the sites. However, the species *C. nitida* was observed only in the control area in 2013 and *A. cerricola* was found only in research areas in 2013.

The highest and the lowest mean values of Simpson's heterogeneity and evenness indices of spring galls were attributed to the control areas in 2014 and 2012, respectively (m=0.87, 0.32). The highest mean value of Shannon's heterogeneity and evenness indices was observed in the burned area in 2013 and in the control area in 2014 (m=0.93, 0.88) and the lowest mean value was related to the control and burned areas in 2012, re-

Table 3. List of autumn gall wasps species in different study areas.

Burned 2012	Unburned 2012	Burned 2013	Unburned 2013	Burned 2014	Unburned 2014
C. lanuginosus	*C. lanuginosus*	*C. lanuginosus*	*C. lanuginosus*	*C. lanuginosus*	*C. lanuginosus*
P. saliens	*P. saliens*	*P. saliens*	*P. saliens*	*P. saliens*	*P. saliens*
A. persica	*A. persica*	*A. persica*	*A. persica*	*A. persica*	*A. persica*
	S. politus	*S. politus*	*S. politus*		
		A. cerricola	*A. cerricola*		
			C. nitida		

Table 4. Mean (± standard error) of Heterogeneity and Evenness indicators of spring galls in the study areas.

Shannon E	Shannon H'	Simpson's index (1/D)	Simpson's E (1-D)	Study areas
0.340±0.66	0.340±0.66	0.170±0.82	0.215±0.33	Burned area in 2012
0.071±0.61	0.093±0.69	0.041±0.69	0.052±0.32	Unburned area in 2012
0.084±0.73	0.143±0.93	0.074±0.73	0.069±0.43	Burned area in 2013
0.076±0.72	0.071±0.72	0.056±0.75	0.067±0.41	Unburned area in 2013
0.000±0.00*	0.000±0.00*	0.000±0.00*	0.000±0.00*	Burned area in 2014
0.072±0.88	0.072±0.88	0.115±0.87	0.053±0.45	Unburned area in 2014

Table 5. Mean (± standard error) of Heterogeneity and Evenness indicators of autumn gall species in the study areas.

Shannon E	Shannon H'	Simpson's index (1/D)	Simpson's E (1-D)	Study areas
0.062±0.95	0.362±1.14	0.068±0.94	0.167±0.58	Burned area in 2012
0.304±0.61	0.421±0.74	0.219±0.65	0.248±0.38	Unburned area in 2012
0.030±0.95	0.031±0.95	0.036±0.94	0.067±0.60	Burned area in 2013
0.189±0.74	0.224±0.85	0.182±0.74	0.147±0.46	Unburned area in 2013
0.254±0.73	0.460±1.06	0.211±0.71	0.238±0.50	Burned area in 2014
0.325±0.72	0.325±0.72	0.192±0.80	0.230±0.41	Unburned area in 2014

spectively (m=0.66, 0.61). Since the burned area in 2014 did not have any repetition (a gall was seen only on one tree), means and standard errors considered to be zero. The results of ANOVA (regardless of the burned area in 2014) showed that there was no significant difference among the mean value of the indices in the study areas (α=0.05) (Table 4).

The highest mean values of Simpson and Shannon's evenness indices were determined for autumn galls of the burned area in 2012 and 2013 (m=0.95, 0.60). Burned areas in 2012 and 2014 had the highest mean values for Shannon's heterogeneity index (m=1.14, 1.06). However, the highest mean value of Simpson's heterogeneity index was found in the burned area in 2012 and 2013 (m= 0.94). Regardless of the control area in 2014 (having the lowest mean value for Shannon's heterogeneity index (m=0.72)), the lowest value for all indexes was found in the control area in 2012 (m=0.74). The results of ANOVA indicated that there is no significant difference among the mean value of the indices in the study areas (α=0.05) (Table 5).

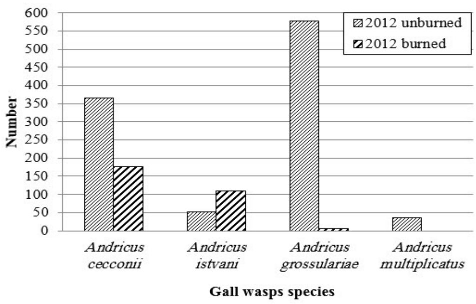

Figure 1. Frequency of spring gall species in the study areas of 2012.

As shown in Figure 1, the most frequent spring galls were *A. grossulariae* (96%) and *A. cecconii* (96%, 61%), respectively, which were detected in the control area of 2012.While *A. multiplicatus* and *A. istvani* had the least frequency among all the species (8.8%, 0%), respectively. Regarding the Figure 1, species *A. grossulariae*, in burned areas has the least value (1%) among all the species in the study areas while it has highest value (96%) in control. Furthermore, *A. cecconii* species is the most frequent gall (29%) in the burned area in 2012, and the species *A. multiplicatus* was not observed in the burned area.

There were three types of spring galls in both burned and unburned areas in 2013 (Fig. 2). The species *A. istvani* was specific to the burned area and *A. grossulariae* was specific to the control area and both gall species had almost equal frequency (5.2%, 4.6%). The species *A. cecconii* and *A. multiplicatus* were more frequent than other gall species in the burned and control area (25.7%, 22.8%), respectively. Moreover, the species *A. cecconi* has the highest frequency (25.7%) in the burned area in comparison to the other gall species.

According to Figure 3, *A. cecconii* is the most frequent spring gall in both burned (30.7%) and control areas (3.5%) in 2014. After that, *A. grossulariae* occupied the second place in the unburned area (15.3%) and the species *A. istvani* and *A. multiplicatus* with an equal abundance (4.3%, 3.8%) were the least frequent galls. The burned area had only two gall species in which *A. istvani* with 0.3 % was the least frequent one.

A. persica, *C. lanuginosus*, *S. politus* and *P. saliens* were the most frequent autumn galls in the both control and burned areas in 2012. Regarding the burned area, it was revealed that after *A. persica* with 43% frequency, the species *C. lanuginosus* (22%) was the second most frequent gall, and *P. saliens* (14%) was the least frequent gall species (Fig. 4).

As indicated in Figure 5, *S. politus* (34%) was the most frequent autumn gall in the control area in 2013. Then, *C. nitida* (30%), *P. saliens* (26%), *C. lanuginosus* (21%), *A. persica* (21%) and *A. cerricola* (2%) were the next galls in terms of frequency. Regarding the burned area, *A. persica* (24%), *P. saliens* (17%) and *C. lanuginosus* (8%) were the most fre-

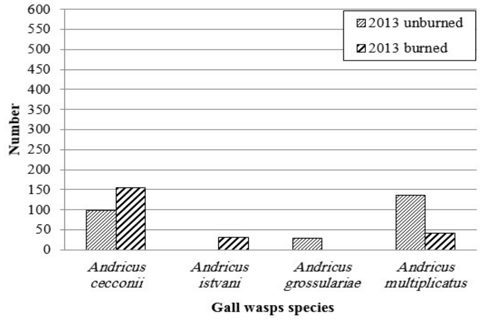

Figure 2. Frequency of spring gall species in the study areas of 2013.

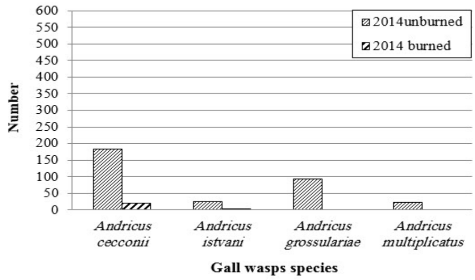

Figure 3. Frequency of spring gall species in the study areas of 2014.

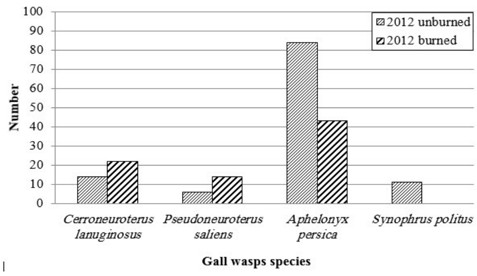

Figure 4. Frequency of autumn gall species in the study areas of 2012.

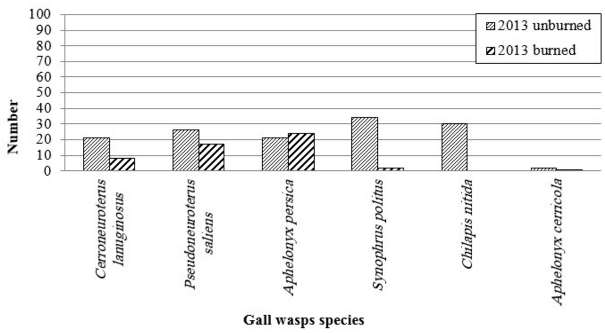

Figure 5.Frequency of autumn gall species in the study areas of 2013.

quent gall species, respectively. In contrast, *S. politus* (2%) and *A. cerricola* (1%) had the lowest frequency at the burned area. Finally, the species *C. nitida* was observed only in the control area.

As seen in Figure 6, the species *P. saliens* (100%) and *A. persica* (78%) are the most frequent autumn galls in the control area in 2014. The frequency order of gall species in the burned area was different from that of in the control area so that the species *A. persica* (62%) and *P. saliens* (37%) were the most frequent galls in the control and the burned area, respectively. Finally, the species *C. lanuginosus* (7%) was the lowest frequent gall in both burned and control areas.

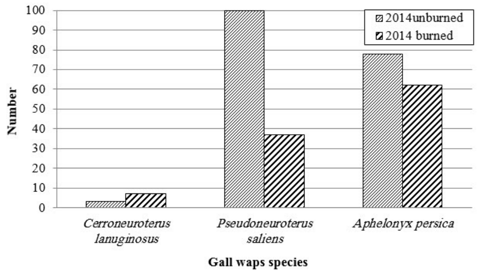

Figure 6. Frequency of autumn gall species in the study areas of 2014.

Discussion

The results of the spring gall sampling indicate that forest fires have affected the oak gall wasps and have decreased numbers of gall wasps in the region. Conversely, the species number and density of wasps increased after fires. According to Figures 1, 2 and 3, it can be inferred that the frequency of *A. cecconii, A. istvani* and *A. grossulariae* increases with time after fire occurrences. However, this trend has proportionally occurred with delay in case of *A. grossulariae*. The main reason of this trend is due to occurrence of these gall insects. These insects have occurred even in small numbers in the burned area in 2012, after three years of occurrence of fire. Besides the *Q. brantii*, there is *Q. infectoria* near transects in the study areas, but their flowering or fruiting as well as their distance from transects have not been investigated because it was not the purpose of this study. It should be noted that these gall insects have been the most frequent insects among all the gall insects in the control area in 2012 and in other study areas as well. The latter point proves the sensitivity of this species of wasps to the forest fire. Accordingly, it can be concluded that fire has more effect on *A. grossulariae* than on other species of wasps. The increased number of *A. multiplicatus* species in the second year after the fire (2013) and its absence in 2012 and 2014 imply that the fire had not been able to, positively or negatively, affect these gall-forming wasps. It is noteworthy that two years after the occurrence of fire, the diversity of these gall-forming wasps has been increased which is suggestive of the positive effect of fire. The main cause could have been the suppression of growth of new shoots after the fire.

Based on results of autumn sampling, the fire has positively affected the frequency of *C. lanuginosus*. It is must be noted that, not only in the first year after fire, the frequency of these wasps was greater than in adjacent control areas, but also their frequency has increased over time. In the burned area in 2012, three years after the occurrence of fire, the numbers of these wasps were not only greater than throughout preceding years, but also they were more frequent than within their adjacent control area. Given the impact of forest fires on the frequency of *P. saliens*, it seems that their population has decreased in the first year after the fire. As for the sensitivity of the species to fire, it turned out that the population has recovered three years after the fire and has even outnumbered the population in the control area. The species *A. persica* is also influenced by the forest fire. As seen, the numbers of these species have decreased one year after the fire. However, the frequency increased after the next year. Nevertheless, they faced another reduction in the third year after the fire. According to some field observations, it is argued that because these galls are formed on young shoots (Sadeghi et al. 2009), the suppression of the latter happening mainly due to human interventions such as pruning. Among all the species of gall wasps that have been sampled in autumn, *S. politus* was the most sensitive to fire because it has not succeeded to recover in the burned area even 2 years after the forest fire. *S. politus* is a gall wasps but it belongs to *Synophrus politu* which is an inquiline. Inquilines are sponger insects that live in oak galls caused by gall wasps. They are able to create gall of their own.

Generally, it could be argued that the abundance of these gall wasps could increase after the fire in correlation with their diversity. Tavakoli & Piroozi (2011) have found that the population and diversity of gall insects have considerably decreased due to forest fires and their faunistic composition has been changed completely. Even surface fires have resulted in scarcity of some common species. These findings justify the results of the present study. Since few investigations have been undertaken on the impacts of fire on gall insects, it has been decided to resort to some similar studies discussing the influence of fire on the other insects. Changes of butterfly communities after forest fire were studied by Kwon et al. (2013). They argue that specialized species of grasslands decrease in the first year of the fire, but generalist species do not increase significantly. The richness of butterflies does not change, but their diversity gets reduced because of sharp increase in the frequency of a species named *Polygonia c-aureum*. Community of butterflies in year of fire and after fire was different which indicates a temporary change of the population in that year. Furthermore, the species richness was significantly different in burned and unburned areas. However, this cannot be attributed to the impacts of forest fire because the species composition of local butterfly collection was highly diverse and there were some non-repetitive sampling at their local habitats. Gongalsky & Persson (2013) found that the burned area was occupied by flying insects (mostly from order Diptera) within a few months after the fire. When the vegetation was grown within one or two years after the fire, plant-feeding groups such as aphids, cicadellids and thripses were more abundant than in the unburned forest. Elia et al. (2012) found that, given the temporal variation, there was a significant difference between frequency of Coleoptera in two years at both burned and unburned areas. Actually, the greatest abundance was observed in the second year after the fire. Then, the temporal variations were significant in terms of Lepidoptera species. Finally, they concluded that frequency of Coleoptera and Lepidoptera increased and decreased during the study period, respectively. Kulakowski & Jarvis (2013) argued that Diameter at Breast Height (DBH) was the most important factor in determining sensitivity to mountain pine beetle. Accordingly, they believed that tree diameter (dbh) was indicated as the most important factor in determining susceptibility to mountain pine beetle such that larger trees are more susceptible to mountain pine beetle. Furthermore, they stated that low-intensity fire was a factor to intensify sensitivity of trees to mountain pine beetle. Six & Skov (2009) stated that the population of all bark beetle was low during the study period and after the treatment in the thin-only and control units, the mortality rate of trees was at the lowest level. However, the aforementioned rate was more frequently detected in burned units.

So, it can be stated that forest fire can increase frequency and diversity of galls and that these gall wasps not only can recover themselves and return to their original ecological environment within two to three years after the fire, but also their return is accompanied with the arrival of new species and as a result with more diversity and frequency. Plant stress probably affects gall forming organisms negatively. It is because of this fact that they usually prefer large, vigorously growing shoots, leaves or buds, and abiotic stress result is re-education of plant growth (price 1991, Kozlowski et al. 1991). At different development stages from seed to mature, levels of herbivory in plants are varying. Therefore, plant's defences can change during development (Santos & Fernandes 2010). Since galls are considered as abnormal structures on plants and given this fact that gall formation is a kind of defensive posture of plant (Stone et al. 2002) and regarding this issue that there is a competition between gall-inducing factors and host species to gain food (Thompson & Cunningham 2002), therefore this increased level of diversity and frequency of these gall wasps may be a serious alarm to host plant. Arthropods, especially insects are the most important factors that may outbreak their population locally, relatively or for a fairly long time in unfavourable conditions ecosystem and this along with abiotic factors an human interventions can affect the oak forest regeneration, negatively. Oak gall wasps (Cynipidae) are one of the major pests of oak forests and undoubtedly, cynipids can harm or kill their hosts (Crawley & Long 1995, Fay & Hartnett 1991, Maisuradze 1961, Kato & Hijii 1997). Most of the references have pointed out that gall wasps are not pests since they have some specific economic benefits, while these insects in case of infestation may cause a destructive damage to the trees' organs (including leaves, buds and rods) (Salamatnia et al. 2014). Although the occurrence of gall is a sign of the adaptability between gall-inducing insect and host plant, gall-inducing insects cause damage to the host plant, so in this situation, that gall-inducing insect benefits while host plant get damaged. On the other side, gall-inducing insect can increase the concentration of nutrients and metabolites in plant tissue. This can occur in two ways: by increasing the transportation of these materials from adjacent tissues or by increasing the rate of photosynthesis in the damaged sections. Therefore, most of the gall-inducing insects cause damage to the sections in which gall emerges (such as flowers and seeds). Beside the direct damage, they compete with the plant organs for absorption of the nutrients and photosynthesis. The rates of damage are varying, based on the population of gall-inducing insects. Therefore, measuring these damages is difficult (Stone & Schonrogge 2003). According to current ecological conditions of western oak forests of Iran, high levels of vulnerability of these forests and results of this study; it may be possible to claim that forest fire is considered a serious threat to these areas due to the increasing population of insects.

Fire should be considered as a key factor in succession of natural forests in terms of decision making and forest management plans. Fire influences the abundance and diversity of galls as a short-terms reaction. This leads to significant effects on such sensitive ecosystems as west forests. Also, further investigations should be undertaken on spatial and temporal dynamic of insects and fire regime to protect forest diversity on the long-term scale. As such, relevant organizations are expected to support and protect these forests as basic resources for sustainable development considering their significant role in balancing human environment, soil and water conservation, reduction of air and dust pollution and drought prevention.

References

Blanche, K.R. (2000): Diversity of insect-induced galls along a temperature-rainfall gradient in the tropical savannah of the Northern Territory. Australian Ecology 25(4): 311-318.

Colgan, L.J., Erbilgin, N. (2011): Tree-mediated interactions between the jack pine budworm and a mountain pine beetle fungal associated. Ecological Entomology 36(4): 425-434.

Cornell, H.V. (1986): Oak species attributes and host size influence Cynipine wasp species richness. Ecology 67(6): 1582-1592.

Crawley, M.J., Long, C.R. (1995): Alternate bearing, predator satiation and seedling recruitment in *Quercus robur*. Ecology 83: 683–96.

Csóka, G.y., Stone, G.N., Melika, G. (2005): Biology, Ecology and Evolution of Gall-inducing Cynipidae: in: Raman, A., Schaefer, C.W., Withers, T.M. (eds.), Biology, Ecology and Evolution of Gall-Inducing Arthropods. Science Publishers, USA.

Elia, M., Lafortezza, R., Tarasco, E., Colangelo, G., Sanesi, G. (2012): The spatial and temporal effects of fire on insect abundance in Mediterranean forest ecosystems. Forest Ecology and Management 263: 262–267.

Eyles, A., Bonello, P., Ganley, R., Mohammed, C. (2009): Cross-induction of systemic induced resistance between an insect and a fungal pathogen in Austrian pine over a fertility gradient. Oecologia 153: 365-374.

Fay, PA., Hartnett, D.C. (1991): Constraints on growth and allocation patterns of *Silphium integrifolium* (Asteraceae) caused by a cynipid gall wasp. Oecologia 88:243–50.

Gongalsky, K.B., Persson, T. (2013): Recovery of soil macrofauna after wildfires in boreal forests. Soil Biology & Biochemistry 57: 182-191.

Kato, K., Hijii, N. (1997): Effects of gall formation by *Dryocosmus kuriphilus* Yasumatsu (Hym: Cynipidae) on the growth of chestnut trees. Journal of Applied Entomology-Zeitschrift Fur Angewandte Entomologie 121: 9-15.

Kozlowski, T.T., Kramer, P.J., Pallardy, S.G. (1991): The Physiological Ecology of Woody Plants. Academic Press, San Diego, USA.

Kulakowski, D., Jarvis, D. (2013): Low-severity fires increase susceptibility of lodgepole pine to mountain pine beetle outbreaks in Colorado. School of Geography, Clark University, Worcester, MA, United States.

Kwon, T.S., Kim, S.S., Lee, C.M., Jung, S.J. (2013): Changes of butterfly communities after forest fire. Journal of Asia-Pacific Entomology 16: 361–367.

Magurran, A.E. (1988): Ecological Diversity and Its Measurement. 1stEdition. Croom Helm Ltd. Publishing, London. pp. 179.

Magurran, A.E. (2004): Measuring Biological Diversity. Blackwell Publishing. Oxford, UK.

Maisuradze, L. (1961): Notes on the gall flies (family Cynipidae) which are harmful to oak in the Lenkoran zone. Scientific Papers of the Azerbaidzhan State University. Series on Biological Sciences 1: 21–30.

Melika, G. (2006): Gall Wasps of Ukraine Cynipidae. Vestnik Zoologii. Published by The Schmalhausen Institute of Zoology National Academy of Sciences of Ukraine. p. 644.

Nylander, J.A.A. (2004): Bayesian phylogenetics and the evolution of gall wasps. Summaries of Uppsals Dissertations from the Faculty of Science and Technology 937: pp. 43.

Price, P.W. (2005): Adaptive radiation of gall-inducing insects. Basic and Applied Ecology 6: 413-421.

Price, P.W. (1991): The plant vigor hypothesis and herbivore attack. Oikos 62: 244-251.

Prior, K.M., Hellmann, J.J. (2010): Impact of an invasive oak gall wasp on a native butterfly: A test of plant-mediated competition. Ecology 91: 3284-329.

Raper, C.M.T. (2009): Parasitic wasps. <www. Parasitic wasps>. pp.13

Sabeti, H. (1994): Forests, Trees and Shrubs of Iran. 2nd Edition. Yazd University Press. [in Persian]

Sadeghi, S. E., Assareh, M.H., Tavkoli, M. (2009): Oak gall wasps of Iran. Vol. 1. p. 286. Agricultural Research, Education and Extension Organization, Research Institute of Forest and Rangelands. Institute of Forests and Rangelands Press, Tehran. [in Persian]

Sagheb Talebi, K.h., Sajedi, T., Yazdian, F. (2004): Forests of Iran. Institute of Forests and Rangelands Press, Tehran. [in Persian]

Salamatnia, A., Gani B., Hoshmand, M. (2014): The status of oak forests in Iran. pp.57-61. In: 1st National Conference of Oak Forest. Yasouj University, Iran, 3-4 Sep. 2014.

Santos, J.C., Fernandes, G.W. (2010): Mediation of herbivore attack and induced resistance by plant vigor and ontogeny. Acta Oecologica 36: 617-625.

Six, D.L., Skov, K. (2009): Response of bark beetles and their natural enemies to fire and fire surrogate treatments in mixed-conifer forests in western Montana. Forest Ecology and Management 258: 761–772.

Stone, G.N., Schönrogge, K. (2003): The adaptive significance of insect gall morphology. Trends in Ecology and Evolution 18 (10): 512–522.

Stone, G.N., Schonrogge, K., Atkinson, R., Bellido, D., Pujade-Villar, J. (2002): The population biology oak gall wasps (Hymenoptera: Cynipidae). Annual Review of Entomology 47: 633-668.

Thompson, J.N., Cunningham, B.M. (2002): Geographic structure and dynamics of coevolutionary selection. Nature 417: 735-738.

Tavakoli, M., Piroozi, F. (2011): The First Conference on Wildfire in Natural Resources Lands.Gorgan, Iran. p. 96, 26-27. Oct. 2011. [in Persian]

Wallin, K.F., Raffa, K.F. (2001): Effects of folivory on subcortical plant defences: Can defence theories predict interguild processes? Ecology 82: 1387-1400.

Zardoeie Heidary, M., Zamani, A.A., Salari, H., Talebi, A.A. (2012): Diversity of oak gall wasps in Kermanshah province. MSc Thesis. Faculty of Agriculture and Natural Resources, University of Razi, Kermanshah, Iran. p.98. [in Persian]

Zargaran, M. R., Safaralizadeh, M.H., Pourmirza, A.A. (2011): A study on the abundance and species diversity of cynipid wasps (Hym: Cynipidae) in West Azerbaijan province, Iran. Journal of Entomological Society of Iran 31(2): 63-77. [in Persian]