Biology of Apricot Bud Gall Mite, *Acalitus phloeocoptes* Determining the Emergence Time of the First Generation Using the Degree Day Model and Its Control

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Abstract

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The plum bud gall mite, *Acalitus phloeocopte* Nalepa (Acari: Trombidiformes) is one of the important pests of plum trees. The biology and control of this mite during the 2021-2022 period was investigated. The results obtained showed that this mite had four generations a year and spends the winter as adult female mite. The estimated degree days (DD) for the emergence of 50% of wintering mites with two temperature thresholds of 6.2 and 5.8°C degrees were calculated as 68.50 and 88.00 DD in 2021 and 72.00 and 90.50 DD in 2022, respectively. The number of new galls formed by this mite following different treatments such as volck oil (as winter oil), liquid sulfur, propargit, phenpyroxymit, abamectin, tetradifon and sunmite along with water as a control treatment was determined. The results showed that in 2021, the sulfur treatment led to the least number of new galls 14.22±0.53, whereas in 2022 abamectin gave the least number of new galls 17.70±1.32. The integrated pest/crop management including pruning and removing infested branches in winter, a foliar spray with 80% liquid sulfur at the end of winter before budding or spraying with abamectin using degree-days following 50% overwintering mite emergence from galls, gave the best results and is recommended for adoption by farmers.

Keywords: Biology, degree day, plum bud mite, control, acaricides.

Introduction

The mites of the superfamily Eriophyoidea (Acari: Trombidiformes) are known as gall mites, bud mites, rust mites and eriophyoids and have high economic importance and host specialization (Jin *et al*., 2014; Krantz & Walter, 2009; Shijuan *et al*., 2021). This mite is widely spread on a large number of plant species in cold, warm and temperate regions around the world, and due to its small size, it is spread by wind, rain, insects and birds and easily transferred from infested to healthy hosts and from one location to another (Bu-Mei *et al*., 2011; Kapaxidi, 2013; Lindquist, 1996; Skoracka & Kucynski, 2003; Skoracka *et al*., 2010). Eriophyoid mites penetrate into the cuticle of plants by means of their stylet and feed on the cells of the plant, causing the release of nutrients, reducing gas exchange and photosynthesis and ultimately causing damage (Skoracka & Kuczyński, 2003; Zhang *et al*., 2014).

The plum bud gall mite, *A. phloeocoptes* (Nalepa) is one of the serious eriophyoid mites on plum tree in West Azarbaijan province. This mite belongs to the Eriophyidae family, which was first identified from Austria on plum trees by forming scabs next to the host buds (Jeppson *et al*., 1975; Li *et al*., 2021). The first signs of damage caused by the gall mite in Iran were reported on almond trees in the almond-growing areas of Kashmar in Khorasan-Razavi Province (Kamali *et al*., 2016). This species is mainly spread in Europe and the Mediterranean region on stone fruits (Li *et al*., 2021). Most of the plant hosts with signs of gall mite damage are reported on almond, plum and apricot trees, with no accurate information on yield loss (quantitative and qualitative) (Weibelzahl & Liburd, 2009). At present, this mite is becoming a serious pest in most orchards of plum trees (Kamali *et al*., 2016). It has a simple life cycle which includes eggs, larvae, nymphs and adults (Krantz & Ehrensing, 1990; Michalska *et al*., 2010). This pest spends the winter in the gall and in the spring, it comes out of the galls when the temperature rises and moves towards the buds of the branches and through feeding it causes scabs around the buds of stone fruit trees. The affected buds do not grow normally, and the resulting branches have fewer leaves and do not produce flowers (Houshyari *et al*., 2018). This mite also causes malformation of fruits, and all plant organs except the roots may be attacked by this pest (Jeppson *et al*., 1975). The control of this mite is possible by applying preventive measures and agricultural practices such as the use of resistant cultivars and spraying with acaricides when the overwintering mites leave the galls in the spring, when the weather warms up, and they attack the new buds (Vacante, 2016).

Population increase can be predicted by understanding the biological mite characteristics (Gastagnoli & Oldfield, 1996; Li *et al*., 2021). One of the most important methods for predicting the emergence of overwintering mites is to use the degree day (DD) model in addition to continuous monitoring (Houshyari *et al*., 2018). Many studies on various pests have shown that there is a direct relationship between degree day and the growth rate of insects and mite (Kowalsick & Clark, 2006). Degree day is a good and reliable measure to predict the response of different species of plants, insects and mites to climate change (Beasley & Adams, 1996; Fand *et al*., 2014; Peddu *et al*., 2020). Accurate degree day calculation can be used to predict the emergence of a specific stage of

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the pest to develop the appropriate integrated management strategy (Fand *et al*., 2015; Trnka *et al*., 2007).

Due to the scarce studies done on biology and control of this mite, the present research was conducted to investigate the biology and determining the time of emergence of the overwintering generation from galls by degree day model and evaluating several acaricides for their ability to control *A. phloeocoptes*.

Materials and Methods

This study was carried out in a plum orchard with an area of 4500 m^2 with latitude of 46.187269 and longitude of 36.927313 in two consecutive years 2021 and 2022 near Miandoab city in West Azarbaijan province (Figure 1).

Figure 1. Geographical location of the contaminated orchard where experiments were conducted near Miandoab city in West Azarbaijan province, Iran.

Biology and life cycle

The biology and life cycle of plum bud mite were investigated under laboratory conditions. In early March, samples of infested branches were collected from different plum tree orchards previously described (Bergh, 1992; Kamali *et al*., 2016), and transported to the laboratory in a portable refrigerator. In order to keep the buds fresh, the surface of the branches with a length of 50 cm was disinfected with 75% ethyl alcohol and placed in a 3% agar solution. In order to prevent contamination with saprophytic fungi, glassware and accessories were sterilized in an autoclave at 120°C under a 15 pounds per square inch pressure for 20 min. 60 Petri dishes with a diameter of 9 cm were used for studying each growth stage. The mature females were removed and transferred from the galls on leaf disk by a brush under temperature of 25±2°C, 65±5% RH, 16:8 h light/dark photoperiod conditions and monitored under a stereo microscope with 60x magnification and individuals from the egg stage to adult were counted.

Mite emergence prediction based on the degree-day model

In order to determine the emergence of 50% of the mite overwintering generation based on the degree-day model, the minimum and maximum temperatures were recorded from March 15 using data logger model (BENETECH GM1365), and the degree day values were based on the Berg and Chad model with a low threshold temperature of 6.2°C (Bergh & Judd, 1993) and based on the model of Houshyari *et al*., 2018, this value was considered 5.8°C, and using the Modified Average Method the temperature required for the emergence of 50% of the overwintering generation was calculated by equation 1 (Mcmaster & Wilhelm, 1997). At the same time, sticky tape traps were used to catch and estimate the emergence population of *A. phloeocoptes* from galls and count them every three days, and the tapes were changed every week (Bergh, 1992).

$$\text{Growth degree days (GDD)} = \frac{\text{Maximum Temp.} - \text{Minimum Temp.}}{2} - \text{base temperature at the start of metabolic activity}$$

Chemical bioassay

The acaricides used in this study included volck oil (EC formulation 80% produced by Sam Sazan Company), liquid sulfur (EC formulation 80% produced by GolChemi), propargite (Omite, EC formulation 57% produced by Elixir Agricultural Company of Yazd), fenpyroxymate acaricides (Ortus®, 5% SC formulation) produced by Paksam Company, abamectin (1.8% EC formulation produced by Golsam Company), tetradifon (Tedione®, 7.52% EC formulation) non-systemic acaricide produced by Be Rowish and sunmite (Pyridabene®, 20% WP formulation), contact and non-systemic acaricide and an insecticide produced by Kimia Gohar Khak Company), along with the control treatment of each of the compounds in the recommended concentration and tested in five replicates. Volck oil was used as a winter control on March 15 and other compounds were applied at the bud stage, before flowering, on trees that had the same infestation. Trees infested with gall mite were marked with a colored band. Three months after spraying, when new galls appeared, which are different from the old galls in color, the number of new galls in 10 branches 30 cm long were counted in the laboratory with a stereo microscope.

Data analysis

In order to calculate the length of growth period of the bud gall mite, the mean and standard deviation (Mean±SD) were obtained from the descriptive analysis and to evaluate the efficiency of different treatments, one way ANOVA was performed in SPSS Ver. 22 software and significance of the treatments was determined using the Tukey test at the probability level of 95%.

Results

The growth period of the biological stages of the bud gall mite, *A. phloeocoptes* are presented in Table 1. This mite started feeding on one-year buds of the host and the most damage was observed on two-year buds. Female individuals gradually start their migration outside the gall from mid-March and spread on the branches. Males were smaller than females in size. The eggs were transparent, colorless and spherical, and before hatching, they gradually turn white. The nymphs of the first age were transparent and less mobile, but they start feeding immediately and their body color changes to bright. The color of the nymphs of the second age was dark pink, the nymphs become active, and they were able to get out of the galls. This pest also had two resting stages. Examining the branches infested with gall in December, February and March showed that this mite hibernates as an adult female mite.

In both 2021 and 2022 investigations, it was found that the first nymphs emerged from the galls during the second half of March, the first oviposition took place in the spring of 2021 in the middle of May and in 2022 slightly later towards the end of May. The oviposition of the next generations in 2021 took place in late June, early August and mid-September and in 2022 in early July, mid-August and late September, respectively. This investigation showed that this mite produced four generations per year (Figure 2).

Table 1. The developmental period of the biological stages, life cycle duration, fertility and fecundity of the bud gall mite, *Acalitus phloeocoptes.*

Stage	Number of galls	Sex	Duration (Days) Range	Mean±SD
Developmental stage				
Egg	20	-	2.80-4.11	3.07±0.25
Protonymph	20	-	2.90-3.85	3.16±0.23
Quiescent I	20	-	1.10-2.22	1.38±0.18
Deutonymph	20	Male	3.50-5.20	4.47±0.13
		Female	4.50-5.55	5.00±0.59
Quiescent II	20	Male	1.10-1.45	1.21±0.20
		Female	1.00-1.50	1.38±0.13
Adult	20	Male	1.20-1.40	13.54±1.34
		Female	1.22-1.80	14.95±1.43
Stages of the mature mite				
Preoviposition period	30	-	2.20-3.30	2.57±0.12
Oviposition period	30	-	4.55-8.20	7.00±0.37
Postoviposition period	30	-	1.22-2.30	1.77±0.24
Longevity	30	Male	8.12-11.34	9.44±1.36
		Female	11.50-14.50	13.75±1.32
Fecundity	30	-	28.00-33.50	30.05±1.98

Estimating mite emergence based on the degree day model

In this study, the estimated degree days for the emergence of 50% of wintering mites with two temperature thresholds of 6.2 and 5.8°C in two consecutive years 2021 and 2022 were obtained and summarized in Table 2. The estimated degree-days for the emergence of 50% wintering mites with two temperature thresholds of 6.2 and 5.8°C in 2021 and 2022 were calculated 68.50, 88.00 and 72.00, 90.50, respectively. The results obtained with both methods by counting mites with sticky tapes showed that the degree-day calculated by the method of Houshyari *et al*. (2018) is closer to the value calculated in this study.

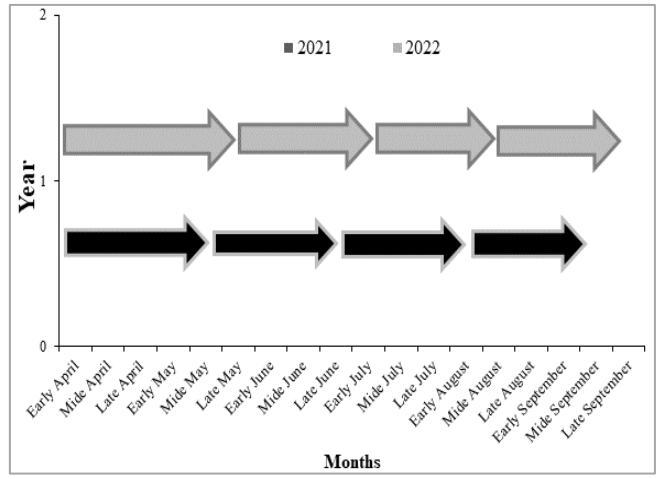

Figure 2. Oviposition period of plum bud gall mite, *Acalitus phloeocoptes* during two consecutive years 2021 and 2022.

Table 2. Estimated degree days for the emergence of 50% of overwintering stage mites of *Acalitus phloeocoptes* with two temperature thresholds.

Year	Estimated degree-days for the emergence of 50% of overwintering mites: Bergh & Judd method (temp. threshold 6.2°C)	Houshyari *et al*. method (temp. threshold 5.8°C)
2021	68.50	88.00
2022	72.00	90.50

Chemical control

Analysis of variance resulting from impact volck oil, liquid sulfur, propargite, fenpyroximate, abamectin, tetradifon and sunmite at recommended concentrations along with control treatment in two consecutive years 2021 and 2022 showed that significant difference between the treatments were observed (Table 3).

Effect of different treatments (volck oil, liquid sulfur, propargit, phenpyroxymit, abamectin, tetradifon and sunmite along with the control treatment) on plum gall mite showed that the sulfur treatment in 2021 and abamectin treatment in 2022 gave the best control and/or the least damage.

Table 3. Effect of different treatments on the development of new galls caused by plum gall mite, *Acalitus phloeocoptes* on plums in two consecutive years 2021 and 2022.

Treatment	Recommended con.	Number of new galls 2021	Number of new galls 2022	Time of control
Volck oil	4%	21.04±3.10 cd	24.24±2.20 cd	Second half of March
Sulfur	5.0 L/1000	14.22±0.53 d	19.32±0.50 ef	After opening the petals and fruit formation
Propargite	1.2 L/1000	21.20±2.11 cd	22.00±1.11 de	The same
Fenpiroxymit	1.0 L/1000	22.13±2.23 c	20.23±1.20 ef	The same
Abamectin	0.7 L/1000	16.50±1.04 cd	17.70±1.32 f	The same
Tetradifen	2.0 L/1000	22.12±2.22 c	27.22±2.13 c	The same
Sunmite	0.5 L/1000	33.00±3.32 b	31.05±2.60 b	The same
Control	water	71.90±3.11 a	70.21±3.22 a	The same

Values followed by the same letters in the same column are not significantly different at P=0.05.

Discussion

Eriophyoid mites are economic and dangerous pests on fruit and forest trees (Van Leeuwen *et al*., 2009). Many workers in different countries reported the effectiveness of chemical pesticides for the control of almond and plum bud gall mite (Di Stefano, 1971; Duran *et al*., 2006; Dzhadaibaev & Dyagilev, 1977; Gushina, 1976; Temreshev *et al*., 2018; Lacasa *et al*., 1990; Laffi & Ermini, 1998; Mezei, 1995; Talhouk, 1971).

In the study of using degree-days to determine 50% emergence of overwintering mites, the low threshold temperature for pear rust mite was about 6.2°C and its value was 61.7 degree-days (dd) (Bergh & Judd, 1993). Based on the data of Houshyari *et al.* (2018), the low threshold temperature for this mite was estimated 5.8°C and total degree-days for the emergence of 50% of overwintering mites was 86.95 dd. In this study, the estimated degree-days for the emergence of 50% of wintering mites with two base temperature thresholds of 6.2 and 5.8°C were 68.50 and 88.00 dd in 2021 and 72.00 and 90.50 dd in 2022, respectively. The results obtained by both methods and after counting mites trapped by sticky tapes showed that the degree-day calculated by method of Houshyari *et al.* (86.95 dd) is closer to the values obtained in this study (88.00 and 90.50 dd), and the slight difference with our results can be the result of different localities.

In the investigation of the number of generations of *A. phloeocoptes* on almonds in Khorasan- Razavi province by Kamali *et al*. 2016, four generations were reported which is consistent with the results obtained in this study, which can be due to climate similarity. Duran *et al*. (2006) reported in Spain that the release of this mite from galls occurred from early March to late April. In this study, however, it was found that females were first observed leaving the galls during the second half of March and continued doing that until the end of April, in both years.

It can be concluded from this study that *A. phloeocoptes* mite starts feeding on one-year buds of the host and the most damage is observed on two-year buds, and the mite had four generations a year on plum trees and overwinters as an adult female mite. The first spawning took place in the spring of 2021 in the middle of May and in 2022 at the end of May. The results showed that in 2021, sulfur treatment gave the best effect, and in 2022, abamectin gave the best mite control. It is suggested to manage this pest by carrying out appropriate agricultural practices such as pruning and removing infested branches in winter. In addition, a foliar spray with 80% liquid sulfur at the end of winter before budding or an abamectin spray at the time when 50% of overwintering mites leave the galls, estimated by the degree-day method, are recommended.

الملخص

نوربور، ف.، س. أرميده، س. ميرفخرائي و ح. كمالي. 2024. حياتية حَلَم براعم الخوخ/البرقوق (*Acalitus phloeocoptes*) المحددة لتوقيت ظهور الجيل الأول باستخدام نموذج درجات الحرارة اليومية ومكافحته. مجلة وقاية النبات العربية، 42(3): 275−280.

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يعد حَلَم براعم الخوخ/البرقوق (*Acalitus phloeocopte* Nalepa) (Acari: Trombidiformes) من أهم آفات أشجار الخوخ/البرقوق. تم التقصي عن حياتية ومكافحة هذا الحَلَم خلال الفترة 2021−2022. أظهرت النتائج أن لهذا الحَلَم أربعة أجيال في العام ويقضي فترة التشتية بطور أنثى بالغة. تم تقدير درجات الحرارة اليومية لظهور 50% من طور التشتية عند عتبتين لدرجات الحرارة وهما 6.2 و 5.8°س حيث كانت درجات الحرارة اليومية 68.50 و 88.00°س في عام 2021؛ 72.00 و 90.50°س في عام 2022، على التوالي. كذلك تم احصاء عدد ثآليل البراعم المتكونة بعد تطبيق عدة معاملات للمكافحة مثل: زيت فولك (زيت شتوي)، الكبريت السائل، propargit، phenpyroxymit، abamectin، tetradifon و sunmite مقارنة مع معاملة الماء كشاهد. بينت النتائج أن المعاملة بالكبريت السائل أدت إلى ظهور أقل عدد من ثآليل البراعم 14.22±0.53 خلال عام 2021، بينما في عام 2022 أدت المعاملة بمبيد abamectin إلى ظهور أقل عدد من ثآليل البراعم

1.32±17.70. إن الإدارة المتكاملة للآفة بما في ذلك التقليم وإزالة الفروع المصابة في الشتاء والرش الورقي بالكبريت السائل 80% في نهاية الشتاء قبل التبرعم أو رش مبيد abamectin باستخدام نموذج درجات الحرارة اليومية بعد ظهور 50% من الحَلَم بطور التشتية أعطت أفضل النتائج ويوصى باعتمادها من قبل المزارعين.

كلمات مفتاحية: حياتية، درجات الحرارة اليومية، حَلَم براعم الخوخ/البرقوق، مكافحة، مبيدات حَلَم.

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