CUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES

MSc. THESIS

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SEASONAL CYCLE OF *Aphis gossypii* Glover (HEMIPTERA: APHIDIDAE) IN THE EASTERN MEDITERRANEAN REGION OF TURKEY

DEPARTMENT OF PLANT PROTECTION

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ABSTRACT

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Aphis gossypii Glover (Hemiptera Aphididae) seasonal cycle in the Eastern Mediterranian region of Turkey was evaluated in this study and the result shows that *A. gossypii* nymph and adult population fluctuation in the autumn season was 5.267 nymph and adult per leaf, 1.400 nymphs, and adult per leaf in the squash plant and 0.056 nymphs and adult per leaf in the citrus plant. This result shows that the Citrus *A. gossypii* population was lower compared to the Cucumber and Squash plants. *Aphis gossypii* nymph and adult population fluctuation in the Spring season was 0.01 nymph and adult per leaf in the cucumber plant, 0.03 nymph, and adult per leaf in the Eggplant, and 0.01 nymph and adult per leaf in the squash plant, 0.24 nymph, and adult per leaf in the Pepper plant, and 2.833 nymphs and adult per leaf in the citrus plant. This result shows that citrus *A. gossypii* population was higher in spring compared to the Cucumber, Eggplant, Pepper, and Squash plants. *Aphis gossypii* nymph and adult population fluctuation in the Summer season 5.5 nymph and adult per leaf in the cucumber plant, 2.0 nymph, and adult per leaf in the Eggplant 2.5 nymph and adult per leaf in the Pepper plant and 0.02 nymph and adult per leaf in the citrus plant. This result shows that citrus A. Gossypii population was lower in summer compared to the Cucumber, Eggplant, and Pepper plants.

Keywords: Anholocylic, Cotton-cucumber aphis, *Capsella bursa-pastoris,* overwinter, Seasonal cycle

ÖZ

YÜKSEK LİSANS TEZİ

Aphis gossypii Glover (HEMIPTERA: APHIDIDAE)'nin Doğu AKDENİZ BÖLGESİNDE MEVSİMSEL DÖNGÜSÜ

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Bu çalışmada Türkiye'nin Doğu Akdeniz bölgesinde *Aphis gossypii* Glover (Hemiptera Aphididae) mevsimsel döngüsü değerlendirilmiş ve sonuç *A. gossypii* nimf ve ergin popülasyonunun sonbahar mevsimindeki dalgalanmasının yaprak başına 5.267 nimf ve ergin, 1.400 nimf ve ergin olduğunu göstermektedir. kabak bitkisinde yaprak başına ve narenciye bitkisinde yaprak başına 0.056 peri ve ergin. Bu sonuç Citrus *A. gossypii* popülasyonunun Salatalık ve Kabak bitkilerine göre daha düşük olduğunu göstermektedir. Bahar mevsiminde *A. gossypii* nimf ve ergin popülasyon dalgalanması, salatalık bitkisinde yaprak başına 0,01 nimf ve ergin, Patlıcan bitkisinde yaprak başına 0,03 nimf ve ergin, kabak bitkisinde yaprak başına 0,01 nimf ve ergin, 0,24 nimf ve ergin olmuştur. Biber bitkisinde yaprak başına ergin ve narenciye bitkisinde yaprak başına 2.833 nimf ve ergin. Bu sonuç, ilkbaharda narenciye *A. gossypii* popülasyonunun Salatalık, Patlıcan, Biber ve Kabak bitkilerine göre daha yüksek olduğunu göstermektedir. Yaz mevsiminde *A. gossypii* nimf ve ergin popülasyon dalgalanması Salatalık bitkisinde yaprak başına 5,5 nimf ve ergin, Patlıcanda yaprak başına 2,0 nimf ve ergin Biber bitkisinde yaprak başına 2,5 nimf ve ergin ve yaprak başına 0,02 nimf ve ergin narenciye bitkisi. Bu sonuç, turunçgil *A. gossypii* popülasyonunun Yaz aylarında Salatalık, Patlıcan ve Biber bitkilerine göre daha düşük olduğunu göstermektedir.

Anahtar Kelimeler: Anholosiklik, *Capsella bursa-pastoris*, kışlama, Mevsimsel döngü, pamuk yaprakbiti

EXTENDED SUMMARY

There are several insect pests and diseases that are threatening the plant diversity of Turkey. Aphids are among the most dominant and economically important hemipteran insect pests in the country and around the world. A total of 5100 species of aphids are known to exist globally which are classified within 510 accepted genera, and these species are observed to colonize about 300 plant families. About 258 species of aphids were found in the 1980's in Turkey, after which 33 more species were recorded.

Aphids feed directly on plants, carry and transmit disease-causing plant viruses. Primarily, they cause direct damage to the crop through directly feeding or sucking the phloem of the plant which can stimulate foliar alterations, delay of the plant growth, few amounts of fruit set, lower fruit retention, reduced cotton lint weight, and ultimately results in the death of the plant.

In addition, aphids form abundant balmy substances. Nitrogen and high carbohydrate compounds are found in the plant juice. Aphids absorb a large amount of plant sap from the phloem of plants to meet their nutritional needs while taking more carbohydrates than they need. They produce a honey-like substance which creates a sticky surface on leaves, fruits, branches and stems and makes the plant surface suitable for the development of mold fungi. This fungal growth covers the fruit, leaves and stem and affects photosynthesis by reducing light absorption which directly can result in crop yield loss.

Aphids are important pests of citrus and vegetables in eastern Mediterranean region of Turkey, and these include *Aphis gossypii* Glover, *Aphis spiraecola* Patch, *Aphis craccivora* Koch, *Myzus persicae* (Sulzer) and *Toxoptera aurantii* (Boyer de Fonscolombe) (Hemiptera: Aphididae) species belonging to Aphididae family. *A. gossypii* are the most important of all aphid species. In the spring, after the aphids pass the harsh winter conditions in the egg stage, the eggs hatch to produce wingless females, and they grow parthenogenetically. Afterwards, winged parthenogenetic females emerge after one or more generations, and they migrate to other plants to form new colonies. They reproduce in primary hosts and females lay eggs for wintering.

The cotton aphid (*A. gossypii*), in particular, has 6 different developmental periods a year and reproduce both sexually and asexually by giving large number of

offspring. This species prefers moist, warm and humid conditions. Cotton aphid is a polyphagous insect which feeds on many crops of agricultural importance such as cotton, tobacco, rice, cereals, eggplant, pepper, Squash, cucumber, bean, watermelon, melon, potato.

Aphis gossypii occurs in temperate, sub-tropic and tropic regions around the world having a wide range of hosts of different food, fiber, and ornamental crops belonging to 88 plant families. For all these reasons, intensive application of chemicals is used for controlling these insects. Acetamprid, imidacloprid and thiamethoxam belonging to the neonicotinoid group are the most commonly used for the control.

However, over-dependency on chemical applications had resulted in the development of resistance in aphid populations in Turkey and around the world. An increasing number of studies have demonstrated the presence of neonicotinoid resistance in *A. gossypii*.

Biological control, which is an important component within integrated pest management (IPM) programs, has increasingly become a great insect control option in conditions where chemical control is not desired or inadequate. Acquiring adequate amount of information on the seasonal cycle of *A. gossypii* or any other insect pest has a vital importance for IPM that targets effective suppression of pest populations. In addition, it serves as a useful tool for understanding the periodic flactuation of local aphid populations which in turn provides an input for designing appropriate pest management strategies. Winter is an important season for aphids, and hence, overwintering is a key element for sustainance of the population in upcoming seasons. *Capsella bursa-pastoris* (L.) is the overwintering host plant for *A. gossypii*.

In addition, it serves as a useful tool for understanding the periodic flactuation of local aphid populations which in turn provides an input for designing appropriate pest management strategies. Therefore, the general aim of this study was to understand the seasonal life cycle of *A. gossypii* on the summer plants, on spring plants, on autumn plants, and to determine the seasonal cycle of the *A. gossypii* on winter plants.

Aphis gossypii alatae population fluctuation in the autumn season was 0.244 alatae per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* alatae population fluctuation in the autumn season was 0.222 alatae per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* alatae population fluctuation in

the autumn season was 0.111 alatae per leaf for a total average of 9 weeks in the citrus plant. There is a significant difference in the alatae population in the autumn season between plants but not between the weeks.

Aphis gossypii alatae population fluctuation in the autumn season was 5.267 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* nymph and adult population fluctuation in the autumn season was 1.400 nymph and adult per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* nymph and adult population fluctuation in the autumn season was 0.056 nymph and adult per leaf for a total average of 9 weeks in the citrus plant. There is a significant difference in the nymph and adult population in the autumn season between plants but not between the weeks.

Aphis gossypii alatae population fluctuation in the Spring season was 0.222 alatae per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.8 alatae per leaf for a total average of 9 weeks in the Eggplant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.111 alatae per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0 alatae per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.233 alatae per leaf for a total average of 9 weeks in the citrus plant. There is a significant difference in the alatae population in the autumn season between plants but not between the weeks.

Aphis gossypii nymph and adult population fluctuation in the Spring season was 0.01 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* nymph and adult population fluctuation in the Spring season was 0.03 nymph and adult per leaf for a total average of 9 weeks in the Eggplant. *Aphis gossypii* nymph and adult population fluctuation in the Spring season was 0.01 nymph and adult per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.24 nymph and adult per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* nymph and adult population fluctuation in the Spring season was 2.833 nymph and adult per leaf for a total average of 9 weeks in the citrus plant. There is a significant difference in the nymph and adult population in the Spring season between plants but not between the

weeks.

Aphis gossypii alatae population fluctuation in the Summer season was 0.3 alatae per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* alatae population fluctuation in the Summer season was 0.2 alatae per leaf for a total average of 9 weeks in the Eggplant. *Aphis gossypii* alatae population fluctuation in the Summer season was 0 alatae per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* alatae population fluctuation in the Summer season was 0 alatae per leaf for a total average of 9 weeks in the citrus plant. There is a significant difference in the alatae population in the Summer season between plants but not between the weeks.

Aphis gossypii nymph and adult population fluctuation in the Summer season was 5.5 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* nymph and adult population fluctuation in the Summer season was 2.0 nymph and adult per leaf for a total average of 9 weeks in the Eggplant. *Aphis gossypii* nymph and adult population fluctuation in the Summer season was 2.5 nymph and adult per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* nymph and adult population fluctuation in the Summer season was 0.02 nymph and adult per leaf for a total average of 9 weeks in the citrus plant. There is a significant difference in the nymph and adult population in the Summer season between plants but not between the weeks.

The aphid collected from *C. bursa-pastoris* was 7 different aphid species which are *A.gossypii*, *A. craccivora*, *A. fabae*, *Rhopalosiphum maidis* (Fitch), *Brevicoryne brassicae* (Linaeus), *Lipaphis erysimi* (Kaltenbach)and *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae).

The resul shows that the a gossypii found on the Citrus in spring more than any other vegetables in this study after the number of aphids overwintering *C. bursa-pastoris* ended in abril the number of *A. go*ssypii in citrus increases in spring season while the other two seasons the number of *A. gossypii* in vegetables was more than those in Citrus.

GENİŞLETİLMİŞ ÖZET

Türkiye'de bitki çeşitliliğini tehdit eden birçok zararlı ve hastalık bulunmaktadır. Yaprak bitleri, ülkemizde ve dünyada en baskın ve ekonomik açıdan önemli Hemiptera içerisinde yer alan zararlılardır. Dünyada kabul edilen 510 cins içinde sınıflandırılan toplam 5100 yaprak biti türü bilinmektedir ve bu türlerin yaklaşık 300 bitki familyasında kolonize olduğu gözlemlenmiştir. Türkiye'de 1980'lerde yaklaşık 258 yaprak biti türü bulunmuştur, ardından 33 tür daha kaydedilmiştir.

Yaprak bitleri doğrudan bitkilerle beslenir, hastalığa neden olan bitki virüslerini taşır ve iletir. Öncelikle, yaprak değişikliklerini uyarabilen, bitki büyümesini geciktirebilen, meyve tutumunu azaltabilen, pamuk tiftiği ağırlığını azaltan ve nihayetinde bitkinin ölümüyle sonuçlanan bitkinin floemini doğrudan besleyerek veya emerek ürüne doğrudan zarar verirler.

Ek olarak, yaprak bitleri bol miktarda ballımsı maddeler oluşturur. Bitki suyunda azot ve yüksek karbonhidrat bileşikleri bulunur. Yaprak bitleri, ihtiyaçlarından daha fazla karbonhidrat alırken besin ihtiyaçlarını karşılamak için bitkilerin floeminden büyük miktarda bitki özsuyu emer. Yapraklarda, meyvelerde, dallarda ve gövdelerde yapışkan bir yüzey oluşturan ve bitki yüzeyini küf mantarlarının gelişimine uygun hale getiren bal benzeri bir madde üretirler. Bu mantar büyümesi meyveyi, yaprakları ve gövdeyi kaplar ve doğrudan ürün verimi kaybına neden olabilecek ışık emilimini azaltarak fotosentezi etkiler.

Yaprak bitleri, Türkiye'nin Doğu Akdeniz bölgesindeki önemli narenciye ve sebze zararlılarıdır. Bunlar arasında *Aphis gossypii* Glover, *Aphis spiraecola* Patch, *Aphis craccivora* Koch, *Myzus persicae* (Sulzer) ve *Toxoptera aurantii* (Boyer de Fonscolombe) (Hemiptera: Aphididae) bulunur. *Aphis gossypii*, tüm yaprak biti türlerinin en önemlisidir. İlkbaharda yaprak bitleri yumurta evresindeki sert kış koşullarını geçtikten sonra yumurtalardan kanatsız dişiler meydana gelir ve bunlar partenogenetik olarak ürerler. Daha sonra bir veya daha fazla nesil sonra kanatlı partenogenetik dişiler ortaya çıkar ve yeni koloniler oluşturmak için diğer bitkilere göç ederler. Birincil konukçuda ürerler ve dişiler kışlama için yumurta bırakırlar.

Özellikle pamuk yaprak biti (*A. gossypii*) yılda 6 farklı gelişim dönemine

sahiptir ve çok sayıda yavru vererek hem eşeyli hem de eşeysiz olarak çoğalır. Bu tür ılık ve nemli koşulları tercih eder. Pamuk yaprak biti pamuk, tütün, pirinç, hububat, patlıcan, bamya, biber, kabak, salatalık, fasulye, karpuz, kavun, patates gibi tarımsal önemi olan birçok ürünle beslenen polifag bir böcektir.

Aphis gossypii 88 bitki familyasına ait çok çeşitli farklı gıda, lif ve süs bitkileri barındıran dünya çapında ılıman, subtropik ve tropik bölgelerde bulunur. Tüm bu nedenlerle, bu böcekleri kontrol etmek için yoğun kimyasal uygulaması kullanılmaktadır. Neonikotinoid grubuna ait acetamiprid, imidacloprid ve thiamethoxam en sık kullanılanlardır. Ancak kimyasal uygulamaların aşırı yapılması sonucunda, Türkiye'de ve dünyadaki yaprak biti popülasyonlarında direncin gelişmesine neden olmuştur. Artan sayıda çalışma, *A. gossypii*'de neonikotinoid direncinin varlığını göstermiştir.

Entegre zararlı yönetimi (IPM) programlarının önemli bir bileşeni olan biyolojik mücadele, kimyasal kontrolün istenmediği veya yetersiz olduğu durumlarda giderek daha büyük bir böcek kontrol seçeneği haline gelmiştir. *A. gossypii* veya diğer herhangi bir zararlı zararlının mevsimsel döngüsü hakkında yeterli miktarda bilgi edinmek, zararlı popülasyonlarının etkili bir şekilde bastırılmasını hedefleyen IPM için hayati öneme sahiptir. Buna ek olarak, yerel yaprak biti popülasyonlarının periyodik dalgalanmasını anlamak için yararlı bir araç olarak hizmet eder ve bu da uygun zararlı yönetimi stratejilerinin tasarlanması için girdi sağlar. Kış, yaprak bitleri için önemli bir mevsimdir ve bu nedenle kışlama, gelecek mevsimlerde nüfusun geçimi için kilit bir unsurdur. *Capsella bursa-pastoris*, *A. gossypii*'nin kışı geçirdiği önemli bir bitkidir.

Buna ek olarak, yerel yaprak biti popülasyonlarının periyodik dalgalanmasını anlamak için yararlı bir araç olarak hizmet eder ve bu da uygun zararlı yönetimi stratejilerinin tasarlanması için girdi sağlar. Bu nedenle, bu çalışmanın genel amacı doğrultusunda , *A. gossypii*'nin mevsimsel yaşam döngüsünü anlamak ve ayrıca *A. gossypii*'nin yaz, sonbahar ve ilkbahar bitkileri üzerindeki mevsimsel yaşam döngüsünü üzerinde mevsimsel yaşam döngüsünü belirlenmiştir.

Aphis gossypii kanatlı bireylerin popülasyon dalgalanması sonbahar mevsiminde hıyar bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.244 alatae olmuştur. *Aphis gossypii* alatae populasyon dalgalanması sonbahar

mevsiminde kabak bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.222 alata olmuştur. *Aphis gossypii* alatae populasyon dalgalanması sonbahar mevsiminde narenciye bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.111 alata olmuştur. Sonbahar mevsiminde alatae populasyonunda haftalar arasında değil de bitkiler arasında önemli bir fark var olduğu belirlenmiştir.

Aphis gossypii alatae populasyon dalgalanması sonbahar mevsiminde hıyar bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 5.267 nimf ve ergin olmuştur. Sonbahar mevsiminde *A. gossypii* nimf ve ergin popülasyon dalgalanması kabak bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 1.400 nimf ve ergin olmuştur. *Aphis gossypii* nimf ve ergin popülasyonunun sonbahar mevsimindeki dalgalanması narenciye bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.056 nimf ve ergin olmuştur. Bitkiler arasında sonbahar mevsiminde nimf ve ergin popülasyonunda önemli bir fark vardır, ancak haftalar arasında bir fark belirlenmemiştir.

Aphis gossypii alatae popülasyon dalgalanması ilkbahar mevsiminde hıyar bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.222 alata olmuştur. *Aphis gossypii* alatae populasyon dalgalanması Bahar mevsiminde toplam 9 hafta boyunca kabak bitkisi yaprak başına 0,8 alatae olmuştur. Bahar mevsiminde *A. gossypii* alatae populasyon dalgalanması, biber bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.0 alatae olmuştur. Bahar mevsiminde *A. gossypii* alatae popülasyon dalgalanması, turunçgil bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.233 alatae olmuştur. Sonbahar mevsiminde alatae populasyonunda haftalar arasında fark olmadığı, bitkiler arasında önemli bir farklılığın varlığı belirlenmiştir.

Aphis gossypii nimf ve ergin populasyonu ilkbahar mevsiminde, hıyar bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.01 nimf ve ergin olmuştur. *Aphis gossypii* nimf ve ergin populasyonu ilkbahar mevsiminde toplamda 9 hafta boyunca yaprak başına 0.03 nimf ve ergin olmuştur. İlkbahar mevsiminde *A.gossypii* nimf ve ergin popülasyon dalgalanması kabak bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.01 nimf ve ergin olmuştur. Bahar mevsiminde *A. gossypii* alatae populasyon dalgalanması biber bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.24 nimf ve ergin olmuştur. Bahar mevsiminde *A. gossypii* nimf ve ergin popülasyon dalgalanması, turunçgil

bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 2.833 nimf ve ergin olmuştur. Bahar mevsiminde nimf ve ergin popülasyonunda bitkiler arasında önemli bir farklılık vardır, ancak haftalar arasında fak tespit edilmemiştir.

Aphis gossypii alatae populasyon dalgalanması yaz mevsiminde hıyar bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0,3 alata olmuştur. Yaz mevsiminde *A. gossypii* alatae populasyon dalgalanması, patlıcan bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0,2 alata olmuştur. Biber bitkisinde *A. gossypii* alatae populasyon dalgalanması yaz mevsiminde toplam ortalama 9 hafta boyunca yaprak başına 0,00 alatae olmuştur. *Aphis gossypii* alatae populasyon dalgalanması yaz mevsiminde turunçgil bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0,00 alata olmuştur. Yaz mevsiminde alatae popülasyonunda haftalar arasında fark bulunamazken, bitkiler arasında önemli bir fark vardır.

Aphis gossypii nimf ve ergin popülasyonunun yaz sezonundaki dalgalanması hıyar bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 5.5 nimf ve ergin olmuştur. Yaz mevsiminde *A. gossypii* nimf ve ergin popülasyon dalgalanması, patlıcan bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 2.0 nimf ve ergin olmuştur. Biber bitkisinde *A. gossypii* nimf ve ergin popülasyonu yaz mevsiminde yaprak başına 2.5 nimf ve ergin olmak üzere toplam ortalama 9 hafta olmuştur. Yaz mevsiminde *A.gossypii* nimf ve ergin popülasyon dalgalanması, turunçgil bitkisinde toplam ortalama 9 hafta boyunca yaprak başına 0.02 nimf ve ergin olmuştur. Yaz mevsiminde nimf ve ergin populasyonunda bitkiler arasında önemli bir farklılık vardır, ancak haftalar arasında belirlenmemiştir.

Capsella bursa-pastoris toplanan yaprak bitlerinde toplamda 7 farklı tür belirlenmiştir. Bunlar; *A.gossypii*, *A. craccivora*, *A. fabae*, *Rhopalosiphum maidis* (Fitch), *Brevicoryne brassicae* (Linaeus), *Lipaphis erysimi* (Kaltenbach) ve *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae) teşhisleri yapılmıştır.

Sonuç olarak, *C. bursa-pastoris*'de kışı geçiren yaprak biti sayısının nisan ayında sona ermesinden sonra bu çalışmada turunçgillerde ilkbaharda bulunan *A. gossypii*'nin diğer sebzelerden daha fazla olduğu gözlemlenmiştir. Diğer iki mevsimde ise sebzelerde bulunan *A. gossypii* sayısının turunçgillere göre daha fazla olduğu belirlenmiştir.

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LISTE OF ABBREVIATIONS

ANOVA	: Analysis of Variance
FAO	: Foad and Agricultural organisation
G	: gram
GLM	: General Linear Model
IPM	: Integrated Pest Management
Kg	: Kilogram
Nbr	: Number
Ro	: Net reproduction
r =	: Intrinsic Rate of Increase,
SPSS	: Statistical Package for the Social Sciences
TDT	: Total Developmental Time
T/ha	: Ton per hectare
To	: Number of generation
Var	: variety
x =	: Age in days

1. INTRODUCTION

Turkey is a crossroad between Europe, Asia and Near East, and it is one of the largest countries in Europe with unique geographical features, various types of climates, and remarkable richness in animal and plant diversity (Görür et al., 2019). Approximately 12,000 of 391,000 global plant species are recorded in Turkey which makes the country 22nd among the list of countries with highest plant diversity in the world (Eminağaoğlu, 2015; Güner et al., 2012).

There are several insect pests and diseases that are threatening this plant diversity in Turkey. Aphids are among the most dominant and economically important hemipteran insect pests in the country and around the world (Blackman & Eastop, 2006). These insects have oval or round body shapes, and their body length generally varies between 0.5–3.5 mm (Lodos, 1986). They are polymorphic species and their bodies have colors ranging from light green to black; their wings are highly developed and individuals with/without wings can be found in the populations (Lodos, 1986).

A total of 5100 species of aphids are known to exist globally which are classified within 510 accepted genera, and these species are observed to colonize about 300 plant families (Blackman and Eastop, 2019; Favret, 2019). About 258 species of aphids were found in 1980's in Turkey (Çanakçıoğlu 1975) after which 33 more species were recorded by Tuatay (1991, 1993) and Düzgüneş et al. (1982). The last decades have seen a growing number of aphid studies which resulted in around 40 new records. In 2017, Turkey's aphid fauna has comprised of over 550 species (Görür et al. 2017; Şenol et al. 2017), and 20 new species were added in 2018 which increased the number to 570 species (Read et al, 2018).

In addition to expanding their spreading areas in recent years, aphids have become important due to damage to plants, and the development of resistance to seed consumption is possible in some rural parts of Turkey. Chemicals is used for their control in a short amount of time (Görür, 2008). Aphids produce dense

populations by giving a large number of offspring in one year under suitable conditions, and they often prefer young leaves, shoots, buds and flowers of plants (Blackman & Eastop, 2006).

They are an economically important group of insects because they feed directly on plants, carry and transmit disease-causing plant viruses (Perring et al. 2018). Primarily, they cause direct damage on the crop through directly feeding or sucking the phloem of the plant which can stimulate of foliar alterations, delay of the plant growth, fewer fruit setting, lower fruit retention, reduced cotton lint weight, and ultimately results in the death of the plant (Raboudi et al. 2002; Perring et al. 2018). In addition, aphids form abundant balmy substances. Nitrogen and high carbohydrate compounds are found in the plant juice. Aphids absorb a large amount of plant sap from the phloem of plants to meet their nutritional needs, while taking more carbohydrates than they need. They produce honey-like substance which creates a sticky surface on leaves, fruits, branches and stems, and makes the plant surface suitable for the development of mold fungi. This fungal growth covers the fruit, leaves and stem, and affects photosynthesis by reducing light absorption which directly can result in crop yield loss. In addition, these sticky and black appearances also affect the aesthetic value of the plant (Blackman & Eastop, 2006; Perring et al. 2018).

For all these reasons, intensive application of chemicals is used control these insects. Acetamprid, imidacloprid and thiamethoxam belonging to the neonicotinoid group are the most commonly used insecticides (Herron et al., 2011; Satar et al., 2017). However, over-dependency on chemical applications had resulted in the development of resistance in aphid populations in Turkey and around the world (Wang et al. 2007; Ulusoy et al. 2018). An increasing number of studies have demonstrated the presence of neonicotinoid resistance in *A. gossypii* (Herron et al., 2011; Bass et al., 2015; Ulusoy et al., 2018). Biological control, which is an important component within integrated pest management (IPM) programs, has increasingly become a great insect control option in conditions where chemical

control is not desired or inadequate (van Lenteren 2000).

Aphids are important pests of citrus and vegetables in eastern Mediterranean region of Turkey, and these include *Aphis gossypii* Glover, *A. spiraecola* Patch, *A. craccivora* Koch, *Myzus persicae* (Sulzer) and *Toxoptera aurantii* (Boyer de Fonscolombe) (Hemiptera: Aphididae) species belonging to Aphididae family (Uygun et al. 2001). *A. gossypii* are the most important of all aphid species. In the spring, after the aphids pass the harsh winter conditions in the egg stage, the eggs hatch to produce wingless females, and they grow parthenogenetically (Ebeling, 1951). Afterwards, winged parthenogenetic females emerge after one or more generations, and they migrate to other plants to form new colonies. They reproduce in primary hosts and females lay eggs for wintering (Ebeling, 1951).

The cotton aphid (*A. gossypii*), in particular, has 6 different developmental periods a year and reproduce both sexually and asexually by giving large number of offspring. This species prefers moist, warm and humid conditions (Ebert and Cartwright 1997). It survives as an egg in harsh winter weather and reproduces asexually on weeds and cultivated plants in places where winter is not extreme (Ebeling, 1951). Cotton aphid is a polyphagous insect which feeds on many crops of agricultural importance such as cotton, tobacco, rice, cereals, eggplant, okra, pepper, pumpkin, cucumber, bean, watermelon, melon, potato (Fuller et al., 1999). *A. gossypii* occurs in temperate, sub-tropic and tropic regions around the world having a wide range of hosts of different food, fiber, and ornamental crops belonging to 88 plant families (Ebert and Cartwright 1997).

Acquiring adequate amount of information on the seasonal cycle of *A. gossypii* or any other insect pest has a vital importance for IPM that targets effective suppression of pest populations.

In addition, it serves as a useful tool for understanding the periodic flactuation of local aphid populations which in turn provides an input for designing appropriate pest management strategies. Therefore, the general aim of this study

was to understand the seasonal life cycle of *A. gossypii*, its ecological range, and associated natural enemies on different host plants in all seasons of the year.

Specific objectives of the study

To determine the seasonal cycle of the *Aphis gossypii:*

A: on different plant in summer season

B: on different plant in spring season

C: on different plant in autumn season

D: on different plant in winter season

2. LITERATURE REVIEW

Kersting, et al., (1999) conducted a study on the developmental time, survival, and reproduction of the cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae), evaluated on detached cotton leaves at five constant and two alternating temperatures (15, 20, 25, 30, 35, 25/30, and 30/35°C).

Blackman and Eastop, (2000) reported that *Aphis fabae* (Scopoli) (Hemiptera: Aphididae) is a polyphagous cosmopolitan pest and one of the best-known pests of agricultural eco-systems, causing damage to horticultural plants.

Oljaca et al., (2000) conducted field study on an experimental field, and, the objective of this study was to find the optimal spatial arrangement of maize–beans intercrop in irrigated and rained farming systems. Plant arrangement patterns in an intercropping system did not significantly affect Leaf Area Index evaluated developmental periods and fertility. Longevity and mortality rates of aphids on *Eriobotrya japonica* Rosaceae: Eryoptra *Pyracantha coccinea* (Roemer var. lalandi), and *Citrus sinensis* (Washington navel) at four constant temperatures (15, 17.5, 20, and 25 ± 1 ° C) were studied in laboratory conditions. According to the results, *Aphid spiraecola* (Hemiptera: Aphididae) has 11 host plants and overwinters on *E. japonica* as anholocyclic in the Eastern Mediterranean Region of Turkey. *E. japonica*, *P. coccinea*, *Viburnum tinus*, and all varieties from genus citrus were found as important hosts of *A. spiraecola*. The growth time of *A. spiraecola* ranges from 14.4 days for 15 ° C to 6.5 days for 25 ° C in *E.japanica*, 13.3 days for 15 ° C to 25 ° C in P. It ranged from 6.7 days and 12.1 days for 15 ° C to 25 ° C in Washington core to 5.8 days. In the heart of Washington, mortality was not observed at lower temperatures (15, 17.5, and 20 ° C) and 6.8% mortality at 25 ° C, while the mortality rate in *E.japonica* varied between 9.1% and 15.7% at 15 ° C. % at 25 ° C. Intrinsic increase rates (rm) at 15°C, 0.1029, 0.1078 and 0.1551 y / y / day-1 in *E. japonica, P. coccinea* and, Washington belly, respectively. On the other hand, the highest rm was calculated at 25 ° C (0.2891 / ♀ / day-1) in the

Washington core. *A. spiraecola's* lower developmental thresholds were 7.4, 5.8, and 7.2 ° C, and in *E.japanica, P.*…

Satar et al., (2005) conducted a study of the developmental time, survivorship, and reproduction of *A. gossypii* which was evaluated on detached cucumber leaves at nine constant temperatures ranging from 15±1°C to 35±1°C in 2.5°C increments in the laboratory. Developmental periods of immature stages ranged from 10.8 days at 15°C to 4.1 days at 30°C and 32.5°C. Constant 35°C was lethal to immature stages of *A. gossypii*.

Satar et al., (2008) conducted a study which was evaluated developmental times, survival rates, and reproduction of the cotton aphid, *A. gossypii* and the green peach aphid, *Myzus persicae* (Sulzer) was separately evaluated on detached pepper leaves at eight constant temperatures (15.0,17.5, 20.0, 22.5, 25.0, 27.5, 30.0, and 32.5°C) in temperature cabinets.

Satar et al., (2008) carried out a study about the host plants of *A. spiraecola* in the Eastern Mediterranean Region of Turkey, and the life cycle of the host plants was examined. The developmental periods and fertility, longevity and mortality rates of aphids on *E. japonica*, *P. coccinea*, and *C.sinensis* (Washington navel) at four constant temperatures (15, 17.5, 20, and 25 ± 1 ° C) under laboratory conditions were also evaluated in this study.

Satar et al. (2010), carried out a study of *A. gossypii* to determine some biological parameters on eggplant and okra plants, the net reproductive power of aphids in the eggplant was 29.225 (female/female/day), and 25.621 (female/female/day) in gumbo and emphasized that hereditary reproductive ability (Ro), reproductive power (rm) and short mating time (DT) were higher in eggplant than okra.

Sangün and Satar (2012), conducted survey studies to identify lettuce aphid species and also monitored their populations and flight activities during the 2009-2010 growing season. Seven aphid species, *Aphis gossypii* Glover, *Aulacorthum solani* (Kaltenbach), *Hyperomyzus lactucae* (L.), *Myzus (Nectarosiphon) persicae*

(Sulzer), *Nasonovia ribisnigri* (Mosley), *Rhopalosiphum nymphaeaipe* (L.), and *Pemphigus bursidi*)are determined in the region. *Nasonovia ribisnigri* emerged as the most common of these aphid species. In the study aiming to determine the fluctuations in the aphid population in lettuce fields, an increase in the population was detected in the first planting lettuce area in November (2009), while another peak was observed in the second lettuce planting period in March (2010). In addition, in the third sowing period of lettuce, no aphid was detected in which milk formation (bitter) occurred and the temperature increased. A total of twelve aphid species identified during the study were collected with a water pan trap to determine the flight activity of aphids, while six aphids were also observed in the field. *Hyperomyzus lactucae* (41%), *N. ribisnigri* (16%), and *M. (N.) persicae* (24%) constituted 81% of the individuals caught in the traps. The flight activity patterns of *N. ribisnigri* in the traps were quite similar to those observed in the field.

Satar et al. (2012) showed that *Capsella bursa-pastorisis* is the key host for overwintering of Aphididae such as *A. fabae*, *A. craccivora*, *A.gossypii*, *Brevicoryne brassicae* (L.*), Lipaphis erysimi* (Kaltenbach), *Rhopalosiphum padi*(L.), and *Rhopalosiphum maidis*(Fitch). Moreover, these aphid colonies on the *Capsella bursa-pastoris* also become sources for parasitoids and hyperparasitoids.

Serdar, et al. (2012) carried out a study aimed to investigate the regional distribution, seasonal fluctuation, host and host-age preferences within citrus species of *A. gossypii*, *A. spiraecola*, *A. craccivora*, *Aphis (Toxoptera) aurantii* (Boyer de Fanscolombe), and *M. (N.) persicae* (Hemiptera: Aphididae) in 15 sub-regions from Adana, Hatay, Osmaniye, and Mersin were conducted between 2007 and 2009. While mandarin was more preferred than other citrus species, grapefruit was the least preferred citrus species among three provinces.

Mota et al. (2013) examined the biological parameters of *A. gossypii* in different periods of two different cotton plants under 25 ºC, 70% humidity and 12 h illumination conditions. female life is 13.08; 45.95; 18.66, 11.81; 42.77; 15.16, 10.42; 33.77; 14.16, 10.27; 29.39 and 13.03; Delta Opal cultivars were 12.8; 39.84;

15.4, 10.69; 35.73; 13.83, 10.16; 33.45; 12:33; 9.85; 32.28 and 16 respectively.

Patil and Patel (2013), in their studies on the biology of *A. gossypii* in *Plantago ovata*, stated that *A. gossypii* changed color from oval-shaped, greenish coffee to yellowish coffee during the first nymph period, and emerald green, 2nd, 3rd and 4th periods. They stated that aphids turned dark green in the adult period. The mean duration of transition was 2.04 ± 0.16 days, 1.68 ± 0.16 days, 2.00 ± 0.17 days, and 1.64 ± 0.13 days, respectively. Total nymph period was found to be 8.64 ± 0.20 days. The average life expectancy was 16.36 ± 0.54 days; reproductive and post-reproductive periods were 0.68 ± 0.48 days, 15.50 ± 0.56 days, and 1.40 ± 0.12 days, respectively. They found that they completed the total life cycle on average in 23.76 ± 0.65 days, gave 46.50 ± 0.65 nymphs per female and gave 6.5 ± 0.52 nymphs in one day.

Satar et al., (2014) carried out a two-year study which was presented aphids, aphid parasitoids, and hyperparasitoids found in citrus orchards, the parasitoids' and hyperparasitoids' seasonal abundance, and the plant–aphid–parasitoid relationships in Hatay, Osmaniye, Adana, and Mersin provinces of the eastern Mediterranean region of Turkey. *Aphidius colemani* Viereck, *Binodoxys angelicae* (Haliday) and *Lysiphlebus confusus* Tremblay and Eady (Hymenoptera: Braconidae: Aphidiinae) have emerged as the most common parasitoids among 10 aphidine and aphelinide taxa detected in different citrus species. Hyperparasitoids belonging to the genus *Alloxysta*, *Phaenoglyphis*, for the first time emerging from aphids that feed on citrus Asaphes in Turkey, the *Pachyneuro*, *Syrphophagus* and, *Dendrocerus* been reported. Among them *Asaphes spp*., *Pachyneuron spp*. And *Syrphophagus spp*. was recorded as the most common. *Citrus reticulata* (Blanco) and *Citrus lemon* (L.) was recorded as the main host for aphid parasitoids and hyperparasitoids

Karacaoğlu et al., (2017) worked to suppress the aphid populations in citrus trees, natural enemies are provided with winter quarters to increase their effectiveness. The study was conducted between November 2006-May 2007 and

November 2007-May 2008 in two different 1 ha young citrus groves (Alata-Mersin and Kayarlı-Adana). For this purpose, the trials were carried out in 7 plots as 6 different types of grass and leguminous plants and unplanted control plots. Seeded plant species in this work were broad bean, broad bean+common vetch, broadbean+common vetch+triticale, triticale+common vetch, triticale+clover, and triticale+trifolium. The experiment was established in a randomized complete block design with four replications. After the seeds of the seeded plant varieties germinated, the gardens were checked every week to count aphids and beneficial insects. Although *A. craccivora*, *A. spiraecola*, and *A. gossypii* are very common aphids in citrus, *A. craccivora*, *A. fabae*, and wheat aphids have been identified as common aphids in different grass or leguminous plants. Although *A. craccivora* is not a common aphid for citrus trees in the Erdemli-Mersin region, it was the highest population of aphids in these citrus orchards. While *Coccinella septempunctata* was the most common predator species on leguminous and triticale plants, *Scymnus spp*. was one of the most common species on citrus.

Satar et al., (2020) conducted a study aimed to investigate the regional distribution, seasonal fluctuation, host and host-age preferences of some aphid species such as *A. gossypii*, *A. spiraecola*, *A. craccivora*, *A. (T.) aurantii*, and *M. persicae* in citrus species which were conducted in 15 sub-regions from Adana, Hatay, Osmaniye and Mersin, between 2007-2009. In this study the mandarin was preferred more than other citrus types while grapefruit was the least preferred citrus fruit in all three provinces. Among the citrus species in the Mersin region, *A. spiraecola* was the most common in lemons, while *A. (T.) aurantii* preferred mandarin compared to the others. The most preferred citrus fruit in Adana and Hatay regions was mandarin. Age-related aphid preferences differed in the citrus age scale by region. *A. (T.) aurantii* was most prevalent in Hatay between the ages of 11-20 and in Mersin between the ages of 21-40. The prevalence of citrus varieties in Adana and Hatay had a parallel effect on the aphid distribution. However, *A. spiraecola* is the predominant type of aphid on the lemon. Adana, which has a richer

flora compared to Mersin and Hatay regions, has been determined as the highest density of aphids in different species and the fact that *A. gossypii* and *A. spiraecola* create an infection rate of 30-40% in citrus orchards not only in spring but also in July, and they are again intense in autumn, making these pests harmful in four seasons.

3. MATERIALS AND METHODS

3.1. *Aphis gossypii* population fluctuation in some vegetables

In this study, some vegetables such as cucumber, melon, pepper, and eggplant were planted in the spring and autumn seasons in the experimental site of the Department of Plant Protection, Cukurova University. The fluctuation of *A. gossypii* populations was studied by taking ten leaves from each plant and counting the number of aphids and their predators and parasitoids on the leaves. Sampling was carried out by walking from one end to the other in the middle of the vegetable field.

The plants of that vegetable field were visually inspected and the aphid infestation counted. Five different vegetables, cucumber, eggplant, pepper, and Squash were planted three times (August 22, 2020, 11 June 2020 and, 23 March 2021) (Figure 3.1) to determine the population fluctuations of aphids in vegetable crops to determine aphid population fluctuations and flight activities in vegetable fields. Çukurova University Faculty of Agriculture Plant Protection Department in the field of Research and Application Farm.

Figure 3.1. Vegetables in the field

Vegetable crops were planted in the soil in double rows on each ridge and 50 of each plant were planted in the field (Figure 3.2). Weed control in vegetable fields was performed mechanically during growth trials. Before planting, care was taken that the seedlings and seeds do not contain pesticides.

Figure 3.2. Vegetable crops planted in the soil in rows using drip irrigation system

3.1.1. Sampling the Aphids of the vegetables

In this study, four vegetables were planted and sampling was done as follows:

i. Sampling was done by taking ten leaves randomly.
ii. The leaves were wrapped with papers and took to the lab.
iii. Aphids and other beneficial insects were checked and counted under binocular.
iv. This procedure was repeated in all seasons of this work.

3.2. *Aphis gossypii* population fluctuation on a citrus orchard

In this study, the population fluctuation of *A. gossypii* was determined in the young citrus leaves (shoots) in the citrus orchard (Figure 3.3) in the experimental site of the Department of Plant Protection, Cukurova University. In each week, a total of 100 shoots were collected from randomly selected 25 trees. Subsequently, the number of aphids and associated natural enemies was counted on each shoot.

Figure 3.3. aphid invested a citrus leaves (shoots) in citrus orchard

3.3. *Aphis gossypii* population fluctuation on *Capsella bursa-pastoris*

Winter is an important season for aphids, and hence, overwintering is a key element for the sustenance of the population in upcoming seasons. *Capsella bursa-pastoris* is the overwintering host plant for *A. gossypii* in the area (Figure 3.4). Ten shepherd's purs, *C. bursa-pastoris*, plants were collected wrapping journal every week from fields surrounding the citrus and vegetable plots starting from November to April and brought to Citrus pest Lab. All aphid species were identified and counted on a weekly basis.

Figure 3.4. Picture shows aphid infested *Capsella bursa pastoris*

3.4. Data analysis

A collection data form prepared for data recording classified by variable for the evolution of *A. gossypii* population and submitted for analyzes of descriptive statistics, and calculation of variance, standard error, standard deviation and also the mean. The data collected was prepared according to the different variables the evolution of different insect species was submitted to the univariate Generalized Linear Model (GLM) to compare main effects. Tukey honestly significantly different (Tukey HSD) post hoc test was used to separate significantly different means. All analyses were done using SPSS (version 20).

4. RESULTS AND DISCUSSIONS

4.1. Population fluctuation of *Aphis gossypii* nymph, adult, and its Alatae on different plants.

The population fluctuation of *Aphis gossypii* nymph, adult, and its Alatae on cucumber, pepper, eggplant, and squash are as follows:

4.1.1. Population fluctuation of *Aphis gossypii* nymph, adult, and its alatae on Cucumber.

The population fluctuation of *A. gossypii* nymph, adult, and its alatae on Cucumber plant for all season is in the figure 4.1.

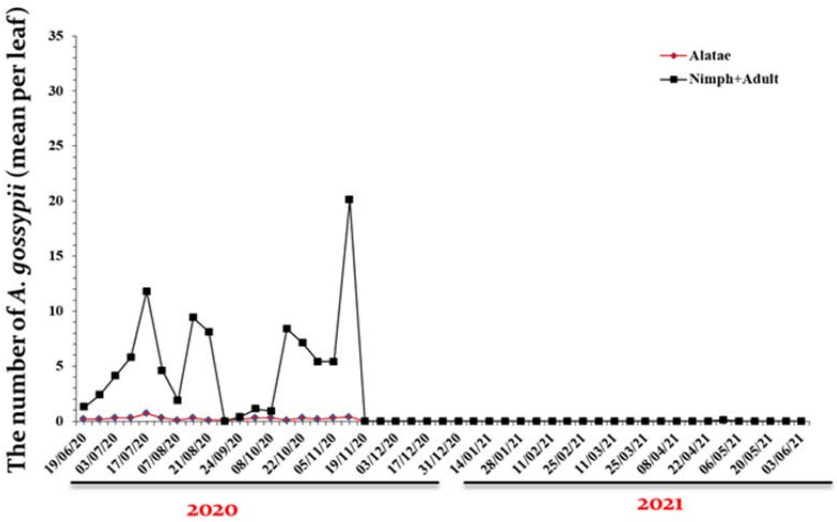

Figure 4.1. The population fluctuation of *Aphis gossypii* alatae and nymph-adult on the cucumber plant during all seasons in the field.

The fluctuation of the *A. gossypii* population varies from one season to another in cucumber. For this reason, the population dynamics of *A. gossypii* nymph-adult and its alatae show in figure 4.1. Important peak levels at the nymph and adult stages were recorded from5th November to 12th November 2020 as figure 4.1. According to consecutive observations, cucumber is suitable for the

development of *A. gossypii* except for the last season from March to June which the lowest nymph and adult stages were recorded alatae was low in any season.

4.1.2. Population fluctuation of *Aphis gossypii* nymph, adult and its alatae on Eggplant.

The population fluctuation of *A. gossypii* nymph, adult, and its alatae on Eggplant for all seasons is in the figure 4.2.

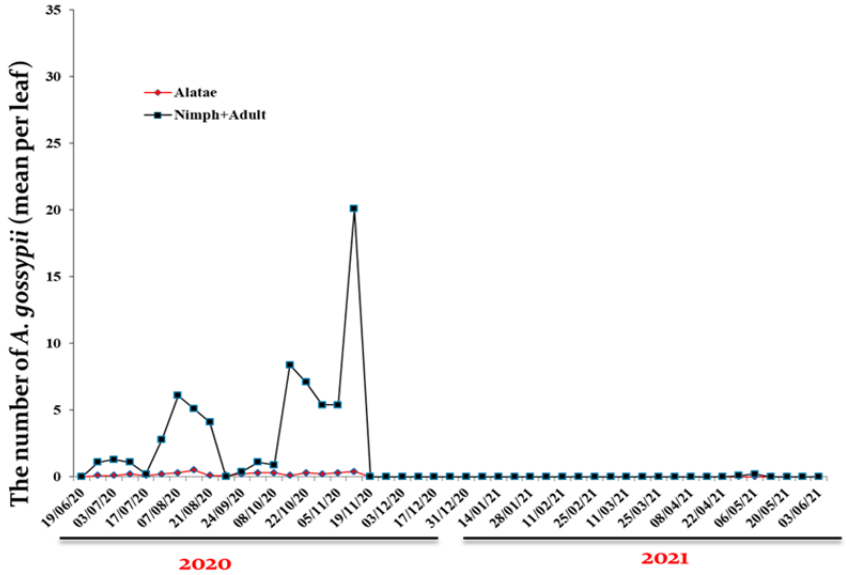

Figure 4.2. The population fluctuation of *Aphis gossypii* alatae and nymph-adult on the cucumber plant during all seasons in the field.

The fluctuation of the *A. gossypii* population varies from one season to another in the eggplant. For this reason, the population dynamics of *A. gossypii* alatae, nymph-adult show in (figure 4.2. Important peak levels at the nymph and adult stages were recorded from 3th July to 24th July 2020 while 16 April to June lowest nymph and adult was recorded as Figure 4.2.

4.1.3. Population fluctuation of *Aphis gossypii* nymph, adult and its alatae on Pepper

The population fluctuation of *A. gossypii* nymph, adult, and its alatae on Pepper for all seasons is in the figure 4.3.

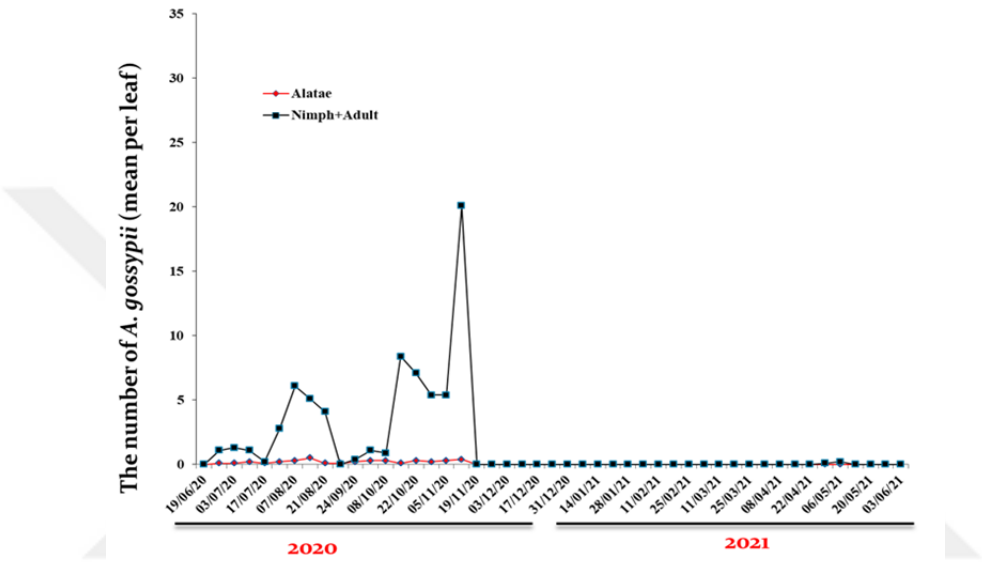

Figure 4.3. The population fluctuation of *Aphis gossypii* alatae and nymph-adult on the Pepper during all seasons in the field.

The fluctuation of the *A. gossypii* population varies from one season to another in the pepper. For this reason, the population dynamics of *A. gossypii* alatae, nymph, and adult show in figure 4.3. Important peak levels at the nymph and adult stages were recorded from 17th July to 7th August 2020 as Figure 4.3.

4.1.4. Population fluctuation of *Aphis gossypii* nymph, adult and its alatae on Squash

The population fluctuation of *A. gossypii* nymph, adult, and its alatae on Squash for all season is in the figure 4.4.

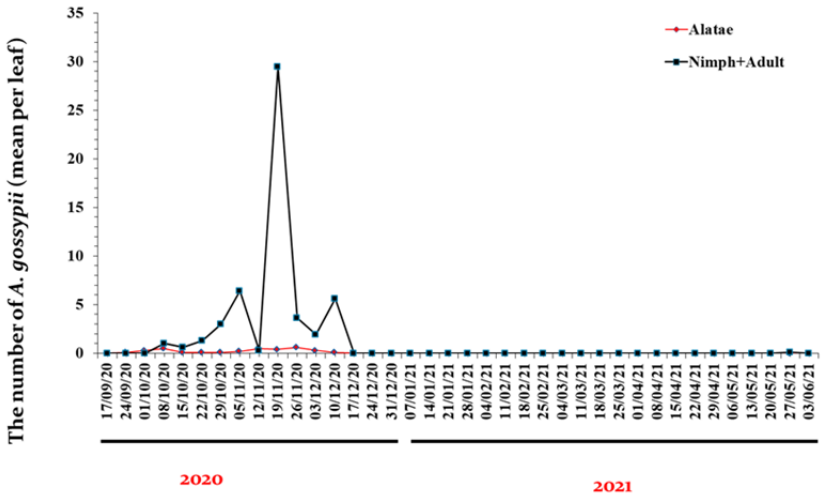

Figure 4.4. The population fluctuation of *Aphis gossypii* alatae and nymph-adult on the Pumpkin plant during all seasons in the field.

The fluctuation of the *A. gossypii* population varies from one season to another in the Squash. For this reason, the population dynamics of *A. gossypii* alatae, nymph-adult show in figure 4.3. Important peak levels at the nymph and adult stages were recorded from17th July to 7th august 2020 as Figure 4.3.

4.2. Statistical analysis of the Population fluctuation of *Aphis gossypii* nymph, adult and its alatae on different plants in the autumn season

4.2.1 Population fluctuation of *Aphis gossypii* alatae on different plants in the autumn season

Aphis gossypii alatae population fluctuation in the autumn season was 0.244 alatae per leaf for a total average of 9 weeks in the cucumber plant. *A.gossypii* alatae population fluctuation in the autumn season was 0.222 alatae per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* alatae population fluctuation in the autumn season was 0.111 alatae per leaf for a total average of 9 weeks in the citrus plant as Table 4.1. There is a significant difference

in the alatae population in the autumn season between plants but not between the week as Table 4.2.

Table 4.1. *Aphis gossypii* alatae population fluctuation in autumn season on different plants

	Plants			
weeks	Cucumber	Squash	Citrus	Total
1	0.1	0.0	0.0	0.03
2	0.2	0.1	0.0	0.1
3	0.3	0.3	0.0	0.2
4	0.3	0.6	0.0	0.3
5	0.1	0.1	0.0	0.1
6	0.3	0.1	0.1	0.16
7	0.2	0.1	0.0	0.1
8	0.3	0.2	0.0	0.16
9	0.4	0.5	0.0	0.3
total	0.244	0.222	0.111	

There is significant difference in alatae autumn between plants but not weeks

Table 4.2. Total of *Aphis gossypii* alatae population fluctuation in autumn season on different plants

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	7.252[a]	26	.279	1.113	.327
Intercept	6.848	1	6.848	27.325	.000
Weeks	2.185	8	.273	1.090	.371
Plants	2.985	2	1.493	5.956	.003
weeks * plants	2.081	16	.130	.519	.936
Error	60.900	243	.251		
Total	75.000	270			
Corrected Total	68.152	269			

a. R Squared = .106 (Adjusted R Squared = .011)

4.2.2. Population fluctuation of *Aphis gossypii* nymph and adult on different plants in autumn

Aphis gossypii nymph and adult population fluctuation in the autumn season was 5.267 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* nymph and adult population fluctuation in the autumn season was 1.400 nymph and adult per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* nymph and adult population fluctuation in the autumn season was 0.056 nymph and adult per leaf for a total average of 9 weeks in the citrus plant as Table 4.3. There is a significant difference in the nymph and adult population in the autumn season between plants but not between the weeks as Table 4.4.

Table 4.3. Representative of *Aphis gossypii* nymph and adult population fluctuation in autumn season on different plants

	Plants			
weeks	Cucumber	Squash	Citrus	Total
1	0.0	0.0	0.0	0.0
2	0.4	0.0	0.5	0.4
3	0.1	0.0	0.0	0.03
4	0.9	1.0	0.0	0.6333
5	8.0	0.6	0.0	2.86
6	7.1	1.3	0.0	2.8
7	5.4	3.0	0.0	2.8
8	5.4	6.5	0.0	3.933
9	20.1	0.3	0.0	6.8
total	5.267	1.400	0.056	

There is significant difference of nimfs and adults in the autumn between plants but not weeks

Table 4.4. The total of *Aphis gossypii* nymph and adult population fluctuation in autumn season on different plants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4955.052[a]	26	190.579	2.415	.000
Intercept	1355.648	1	1355.648	17.177	.000
Weeks	1227.385	8	153.423	1.944	.054
Plants	1317.430	2	658.715	8.346	.000
weeks * plants	2410.237	16	150.640	1.909	.020
Error	19178.300	243	78.923		
Total	25489.000	270			
Corrected Total	24133.352	269			

a. R Squared = .205 (Adjusted R Squared = .120)

4.3. Statistical analysis Population fluctuation of *Aphis gossypii* nymph, adult and its alatae on different plants in the spring season

4.3.1 Population fluctuation of *Aphis gossypii* alatae on different plants in the spring season

Aphis gossypii alatae population fluctuation in the Spring season was 0.222 alatae per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.8 alatae per leaf for a total average of 9 weeks in the Eggplant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.111 alatae per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.0 alatae per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.233 alatae per leaf for a total average of 9 weeks in the citrus plant as Table 4.5. There is a significant difference in the alatae population in the autumn season between plants but not between the weeks as Table 4.6.

Table 4.5. Representative of *Aphis gossypii* alatae population fluctuation in spring season on different plants

	Plants					
weeks	Cucumber	Eggplant	Squash	Pepper	Citrus	Total
1	0.0	0.5	0.0	0.0	0.1	0.12
2	0.0	0.0	0.0	0.0	0.1	0.02
3	0.0	0.0	0.0	0.0	0.2	0.04
4	2.0	0.2	0.0	0.0	0.1	0.46
5	0.0	0.1	0.0	0.0	0.3	0.08
6	0.0	0.0	0.0	0.0	0.2	0.04
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	1.10	0.22
total	0.222	0.8	0.111	0.0	0.233	

There is no significant difference of alatae for both between weeks and plants in spring

Table 4.6. Total of *Aphis gossypii* alatae population fluctuation in spring season on plants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	51.764[a]	44	1.176	1.274	.120
Intercept	5.336	1	5.336	5.779	.017
weeks	8.884	8	1.111	1.203	.296
plants	4.720	4	1.180	1.278	.278
weeks * plants	38.160	32	1.192	1.292	.137
Error	373.900	405	.923		
Total	431.000	450			
Corrected Total	425.664	449			

a. R Squared = .122 (Adjusted R Squared = .026)

4.3.2. Population fluctuation of *Aphis gossypii* nymph and adult on different plants in the spring season.

Aphis gossypii nymph and adult population fluctuation in the Spring season was 0.01 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* nymph and adult population fluctuation in the Spring season was 0.03 nymph and adult per leaf for a total average of 9 weeks in the Eggplant. *Aphis gossypii* nymph and adult population fluctuation in the Spring season was 0.01 nymph and adult per leaf for a total average of 9 weeks in the squash plant. *Aphis gossypii* alatae population fluctuation in the Spring season was 0.24 nymph and adult per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* nymph and adult population fluctuation in the Spring season was 2.833 nymph and adult per leaf for a total average of 9 weeks in the citrus as Table 4.7. There is a significant difference in the nymph and adult population in the Spring season between plants but not between the weeks as Table 4.8.

Table 4.7. Representative of *Aphis gossypii* nymph and adult population fluctuation in spring season on different plants

	Plants					
weeks	1.Cucumber	2.Eggplant	3.Pumpkin	4.Pepper	5.Citrus	Total
1	0.0	0.0	0.0	0.0	1.1	0.22
2	0.0	0.0	0.0	0.0	3.2	0.64
3	0.0	0.0	0.0	0.0	12.3	2.46
4	0.1	0.2	0.0	2.0	5.6	1.58
5	0.0	0.1	0.0	0.2	1.2	0.3
6	0.0	0.0	0.0	0.0	1.0	0.2
7	0.0	0.0	0.0	0.0	1.1	0.22
8	0.0	0.0	0.1	0.0	0.0	0.02
9	0.0	0.0	0.0	0.0	0.0	0.0
total	0.01	0.03	0.01	0.24	2.833	

There is significant difference of nymph and adult for both between plants and weeks in spring

Table 4.8. Total of *Aphis gossypii* nymph and adult population fluctuation in spring season on different plants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1841.880[a]	44	41.861	5.138	.000
Intercept	176.720	1	176.720	21.692	.000
weeks	282.520	8	35.315	4.335	.000
plants	551.280	4	137.820	16.917	.000
weeks * plants	1008.080	32	31.503	3.867	.000
Error	3299.400	405	8.147		
Total	5318.000	450			
Corrected Total	5141.280	449			

a. R Squared = .358 (Adjusted R Squared = .289)

4.4. Statistical analysis Population fluctuation of *Aphis gossypii* nymph, adult and its alatae on different plants in summer season

4.4.1. Population fluctuation of *Aphis gossypii* nymph and adult on different plants in summer season

Aphis gossypii alatae population fluctuation in the Summer season was 0.3 alatae per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* alatae population fluctuation in the Summer season was 0.2 alatae per leaf for a total average of 9 weeks in the Eggplant plant. *Aphis gossypii* alatae population fluctuation in the Summer season was 0 alatae per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* alatae population fluctuation in the Summer season was 0 alatae per leaf for a total average of 9 weeks in the citrus plant as Table 4.9. There is a significant difference in the alatae population in the Summer season between plants but not between the weeks as Table 4.9.

Table 4.9. Representative of *Aphis gossypii* nymph and adult population fluctuation in spring season on different plants

	Plants				
weeks	1.Cucumber	2.Eggplant	3.Pepper	4.Citrus	Total
1	0.2	0.5	0.1	0.0	0.2
2	0.2	0.2	0.1	0.0	0.13
3	0.3	0.0	0.1	0.0	0.1
4	0.3	0.2	0.2	0.0	0.175
5	0.7	0.0	0.1	0.0	0.2
6	0.5	0.5	0.2	0.0	0.3
7	0.1	0.1	0.3	0.0	0.12
8	0.3	0.1	0.5	0.0	0.2
9	0.1	0.3	0.1	0.0	0.125
total	0.3	0.2	0.0		

There is significant difference of alatae summer between plants but not weeks

Table 4.10. Total of *Aphis gossypii* nymph and adult population fluctuation in the spring season on different plants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11.675[a]	35	.334	.884	.661
Intercept	11.025	1	11.025	29.208	.000
weeks	1.300	8	.162	.430	.902
plants	4.297	3	1.432	3.795	.011
weeks * plants	6.078	24	.253	.671	.879
Error	122.300	324	.377		
Total	145.000	360			
Corrected Total	133.975	359			

a. R Squared = .087 (Adjusted R Squared = -.011)

The seson which its temperature was over 30°C prolonged development, increased the mortality of the immature stages, shortened adult longevity, and reduced fecundity. The optimal range of temperature for population growth of A. gossypii on cotton was 25/30–30°C in the Cucumber as (Kersting et al.1999). This work the nimf and adult population was higher in the vegetables when temperature was high compared to the citrus and the C. bursa-pastoris A.gossypii nimf and adult population.

Capsella bursa-pastoris is the key host for overwintering of Aphididae such as A.gossypii, A. craccivora, A. fabae, Rhopalosiphum maidis (Fitch), Brevicoryne brassicae (L.), Lipaphis erysimi (Kaltenbach), and Rhopalosiphum padi (L.) This weed is an important overwintering host for A. gossypii and other aphids as well and are believed these aphids move after the winter to vegetables and fruits of the field as (Satar et al.2012). The result is same as the result of this work which A. craccivora, A. gossypii, B. brassicae, Lipaphis erysimi, Rhopalosiphum padi, and R.maidis was recorded from the C. bursa-pastoris.

The seson which its temperatures was over 30°C prolonged development, increased mortality of immature stages, shortened adult longevity and reduced fecundity. The optimal range of temperature for population growth of A. gossypii on cucumber was very broad and ranged between 22.5°C and 30°C as (Satar et al.2005). This work the nimf and adult population was higher in Cucumber and other vegetables when temperature was high compared to the citrus and the weed A.gossypii nimf and adult population.

The M. persicae performed better at cooler temperatures, having the capability to colonize pepper plants in greenhouses during winter and spring. As soon as average daily temperatures exceed 20.0°C, the cotton aphid will outperform the green peach aphid and has a higher likelihood to colonize pepper plants quickly as (Satar et al.2008). This is another work that explains that a gossypii is more likely to increase in pepper and vegetables compared to other plants and this work the nimf and adult population was higher in the vegetables

when temperature was high compared to the citrus and the C. bursa-pastoris A.gossypii nimf and adult population.

4.4.2 Population fluctuation of *Aphis gossypii* alatae on different plants in the summer season

Aphis gossypii nymph and adult population fluctuation in the Summer season was 5.5 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant. *Aphis gossypii* nymph and adult population fluctuation in the Summer season was 2.0 nymph and adult per leaf for a total average of 9 weeks in the Eggplant plant. *Aphis gossypii* nymph and adult population fluctuation in the Summer season was 2.5 nymph and adult per leaf for a total average of 9 weeks in the Pepper plant. *Aphis gossypii* nymph and adult population fluctuation in the Summer season was 0.02 nymph and adult per leaf for a total average of 9 weeks in the citrus plant as Table 4.11. There is a significant difference in the nymph and adult population in the Summer season between plants but not between the weeks as Table 4.12.

Table 4.11. Representativeof *Aphis gossypii* alatae population fluctuation in the summer season on different plants

	Plants				
weeks	1.Cucumber	2.Eggplant	3.Pepper	4.Citrus	Total
1	0.1	0.0	1.1	0.2	0.35
2	2.4	0.0	1.1	0.0	0.87
3	0.4	0.0	0.13	0.0	0.13
4	5.8	2.0	1.2	0.0	2.2
5	11.8	4.9	0.2	0.0	4.23
6	4.8	4.1	2.8	0.0	2.9
7	1.9	3.1	6.1	0.0	2.8
8	9.2	2.2	5.1	0.0	4.125
9	8.1	4.1	2.1	0.0	3.6
total	5.5	2.00	2.5	0.02	

There is significant difference of nymph and adult in summer season between plants but not weeks

Table 4.12. Total of *Aphis gossypii* alatae population fluctuation in the summer season on different plants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3055.389[a]	35	87.297	.857	.703
Intercept	2240.011	1	2240.011	21.984	.000
weeks	627.039	8	78.380	.769	.630
plants	1305.367	3	435.122	4.270	.006
weeks * plants	1122.983	24	46.791	.459	.987
Error	33012.600	324	101.891		
Total	38308.000	360			
Corrected Total	36067.989	359			

a. R Squared = .085 (Adjusted R Squared = -.014)

4.5. Population fluctuation of *Aphis gossypii* nymph, adult and its alatae on Citrus

The population fluctuation of *A. gossypii* nymph, adult, and its alatae on Citrus for all seasons is in the Figure 4.5.

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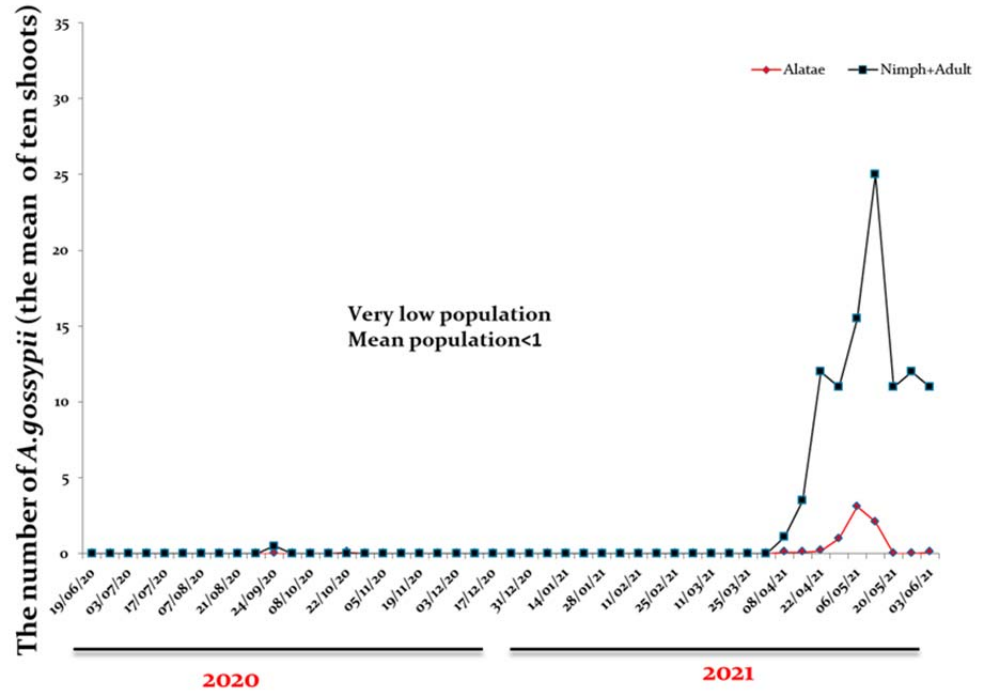

Figure 4.5 The population fluctuation of *A. gossypii* alatae and nymph-adult on the Citrus during all seasons in the field.

Seven aphid species were determined in the studied region, i.e., *A. gossypii*, *A. spiraecola*, *Aphis craccivora* Koch, *Myzus persicae* (Sulzer), *T. aurantii*, Brachycaudus helichrysi (Kaltenbach), and *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae). Although there were seven aphid species on citrus, *A. gossypii* had the most diverse aphidiine spectrum. For all 316 *A. gossypii* samples in this work.The plot in Alata Erdemli, the highest *A.gossypii* population was determined as 47.3 individuals/plant on 22.04.2008, and 67.8 *A. spireacola* populations/plant on the same date. However, the highest population of 2.5 *A.gossypii* was found on 02.04.2008 in the parcel in Paksoy.

4.6. The seasonal population fluctuation of different aphid species on *Capsella bursa-pastoris*

The aphid population followed during the season is shown in the figure below and followed for 16 weeks during the winter and 7 different aphid species were found these are *A.gossypii, A. craccivora, A. fabae, Rhopalosiphum maidis* (Fitch), *Brevicoryne brassicae* (L.), *Lipaphis erysimi* (Kaltenbach), and *Rhopalosiphum padi* (L.) and *A. gossypii*, which is taken as a basis in this study, is one of them as reported (Satar et al.2012), *C. bursa-pastoris* is the key host for overwintering of Aphididae such as *A. fabae*, *A. craccivora*, *A. gossypii*, *B. brassicae*, *Lipaphis erysimi*, *Rhopalosiphum padi*, and *R. maidis*. This weed is an important overwintering host for *A. gossypii* and other aphids as well and are believed these aphids move after the winter to vegetables and fruits of the field.

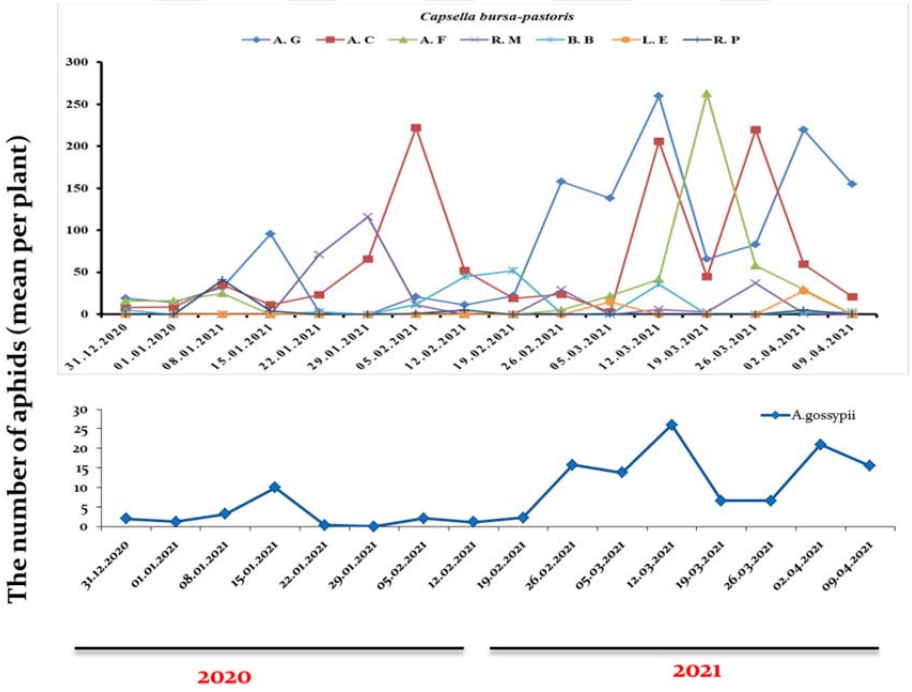

Figure 4.6. The seasonal population fluctuation of different aphid species on *Capsella bursa-pastoris* in winter season

5. CONCLUSION AND RECOMMENDATIONS

Aphis gossypii nymph and adult population fluctuation in the autumn season was 5.267 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant, 1.400 nymphs, and adult per leaf in the squash plant, and 0.056 nymphs and adult per leaf in the citrus plant. This result shows that the Citrus *A. Gossypii* population was lower compared to the Cucumber and Squash plants.

Aphis gossypii alatae population fluctuation in the autumn season was 0.244 alatae per leaf for a total average of 9 weeks in the cucumber plant, 0.222 alataes per leaf in the squash plant, and 0.111 alataes per leaf in the citrus plant.

Aphis gossypii nymph and adult population fluctuation in the Spring season was 0.01 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant, 0.03 nymph, and adult per leaf in the Eggplant, and 0.01 nymph and adult per leaf in the squash plant, 0.24 nymph, and adult per leaf in the Pepper plant, and 2.833 nymphs and adult per leaf in the citrus plant. This result shows that citrus *A. Gossypii* population was higher in spring compared to the Cucumber, Eggplant, Pepper, and Squash plants.

Aphis gossypii alatae population fluctuation in the Spring season was 0.222 alatae per leaf for a total average of 9 weeks in the cucumber plant, 0.8 alataes per leaf in the Eggplant plant, and in the Spring season 0.111 alatae per leaf in the squash plant, was 0.0 alatae per leaf in the Pepper plant and was 0.233 alatae per leaf in the citrus plant.

Aphis gossypii nymph and adult population fluctuation in the Summer season was 5.5 nymph and adult per leaf for a total average of 9 weeks in the cucumber plant, 2.0 nymph, and adult per leaf in the Eggplant 2.5 nymph and adult per leaf in the Pepper plant and 0.02 nymph and adult per leaf in the citrus plant. This result shows that citrus *A. Gossypii* population was lower in summer compared to the Cucumber, Eggplant, and Pepper plants.

Aphis gossypii alatae population fluctuation in the Summer season was 0.3 alatae per leaf for a total average of 9 weeks in the cucumber plant, 0.2 alataes per leaf in the Eggplant plant, 0.1 alataes per leaf for a total average of 9 weeks in the Pepper plant, and 0.1 alataes per leaf in the citrus plant.

There was no population recorded in both Citrus and vegetables in the winter season while the population of 7 aphid population including *A. gossypii* was recorded from *Capsella bursa-pastoris* in the Winter Season.

The *A. gossypii* was found on the Citrus in spring more than any other vegetables in this study after the number of aphids overwintering *C. bursa-pastoris* ended in April the number of *A. gossypii* citrus increases in spring season while the other two seasons the number of *A. gossypii* in vegetables was more than those in Citrus.

There for, this work recommends:

1. Further study on the flight activity of *A.gossypii* on these plants
2. Studying the relationship between aphid migration and Alatae populations

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I was born in Somalia particularly at Adado and studied primary and secondary school at Ablaal primary school (Mogadishu-Somalia), and high school at Ablaal Foundation (Dusmareeb-Somalia). I licensed in agriculture General sciences at Zamzam University of Science And Technology (ZUST), started in 2013, and graduated in 2017. During this year, I won a Turkish government scholarship at the Cukurova University at Graduated School of Natural And Applied Sciences for studying a Master's degree in Department of Plant Protection (Entomology) and I was completed in June 2021 with the Turkish preparation.

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