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Some Aspects of Life for Egg Parasite *Pseudoligosita babylonica* Viggiani (Hymenoptera: Trichogrammatidae)

Nidaa Saud Al-Shammary [a*] and Mohammed Shakir Manjy [a]

[a] Department of Plant Protection, Collage of Agricultural Engineering Sciences, University of Baghdad, Iraq.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Due to the importance of egg parasitoids inthe natural and biological control of economically important insects, including egg parasitoid *Pseudoligositaba bylonica* Viggiani on dubas bug, the spread of the parasitoid and population distribution of parasitoid, In order to estimate the role of parasitoid as one of the biological factors in decreasing population density of dubas bug on date palm. Some aspects of the life of parasitoids were also studied, including the role of insect parasitoids in organizing the population of their families, geographical distribution and hosts range of genus *Pseudoligosita*, seasonal presence of parasitoid *Pseudoligositaba bylonica* Viggiani (Hymenoptera: Trichogrammatidae) , life studies and percentages of parasitism, chemical control, and its negative effects on the side-infested insect parasitoids.

Keywords: Egg parasite; Pseudoligosita babylonica; viggiani; date palm; dubas bug.

**Corresponding author: E-mail: nedaa.abd@coagri.uobaghdad.edu.iq;*

1. INTRODUCTION

1.1 The Role of Insect Parasites in Natural Control

The ability of parasitoids to create a high percentage of targeted stages of the host and respond to increase the density of these individuals in a positive density dependent pattern. It is vital in reducing the host population and one of the characteristics of effective natural enemies, especially insect parasites, is their ability to cluster spatially as a response to the distribution of its host colonies, which makes the female parasite remain for a longer period of time or increase its focus in spaces where its hosts are more abundant, It has been assumed that responding to gatherings of host members would increase search efficiency of parasitoids It leads to a dependant parasitic response that contributes to regulating the host population [1].

Laboratory studies have shown that female parasitoids can parasitize, preferring higher densities from targeted host groups When there is a discrepancy within these groups, The association of this clustering pattern in many species has been explained by chemical stimuli such as the kirormones that emanate from host's eggs and honeydew, as well as sexual pheromones released by the host [2,3]. Female parasitoids lay their eggs in or on their hosts,The developing offspring eventually leads to the death of the host [4].

Also, the host searching behavior of parasites is directly related to the success of reproductive ages, all factors affecting them will subsequently affect their suitability. The reproductive behavior of parasites can also change by changing their response to environmental signals. Research activity and decisions related to it are influenced by each of the external variables such as abundance and spatial distribution of host, and internal variables such as the number of mature eggs present in the female parasitoid [5].

Al-Shamsi [6], when studying the field life tables of dubas bug, noticed that there is a certain percentage of insect eggs for both spring and autumn generations have not hatched, when placing the wicker containing eggs in sealed plastic boxes, After a period of time, adults of a parasitic insecticide no more than 1 mm in length emerged from it inside the box. The adults of this parasite were collected and sent to Italy for the purpose of being diagnosed by a specialist with the order of Hymenoptera, It was later revealed that the parasite is a new species of the genus *Pseudoligosita* and the family Trichogrammatidae. The name *babylonica* was given to this species, as the scientific name for the Dubas bug egg parasite, *Pseudoligosita babylonica* Viggiani [7].

Insect parasites play an important role in natural and biological control of insect pests through the mortality rates that they inflict on their hosts [8]. Understanding role of insect parasites in dynamics of the population of insect pests is an essential aspect of modern integrated management of these pests, The finding of a host for parasites and the ability to exploit it is also necessary to gain a full understanding of their role in the dynamic of the host population [9,10].

Description of the adult role and life span of the adult parasitoid *Pseudoligosita babylonica*: Egg parasite *P. babylonica* was collected for the first time in Iraq from Tuwaitha area, south of the capital, Baghdad [11]. The adult role of the parasite was described by Professor Gennaro Viggiani of the University of Naples / Department of Entomological and Agricultural Animal Sciences, Which depended on some phenotypic and anatomical characteristics of both the male and the female, such as shape of the front wings, antennae and the organ of sexual conjugation in males are different from those found in other species of same sex [7].The life span of males and females also varies according to the species. There are many species in which the life span of females is longer than that of males [12].

Pilkington and Hoddle [13] also show that the growth rate of insects in general increases from the zero critical limit to the optimum growth rate with increasing temperature, but it quickly decreases again to the zero critical limit after reaching the upper growth threshold. The correspondence between the activity of natural enemies and the life cycle of their families is one of the most important features of the performance of successful intruders [14]. AL-Khatiri [15] indicated that *P. babylonica* egg parasite develops successfully within a temperature range of 22.3 - 32.4°C. And that the optimum temperature for the growth and development of its various roles is 30°C, Alshamsi [16] also found that 30°C is the best temperature for development from egg to adult emergence, as well as *P.babylonica* adult life.

Geographical distribution and familial range of the species of the genus *Pseudoligosita*: The number of species of the genus *Pseudoligosita* registered according to a database of the British Natural History Museum until April of 2016 is (55) species.It is widely spread in India, Malaysia, China, Philippines, Thailand, Turkey, Germany, France, Sweden, Australia, and the United States of America. As for South America, it is spread in Argentina, Bolivia, Brazil, Colombia, Uruguay, and Venezuela. The species of this genus most commonly infects large leafhoppers, known as Sharpshooters. And other leafhoppers belong to the family Cicadellidae, whose females are characterized by laying eggs by inserting them completely into plant tissue of leaves of host plant. Female parasites of this species insert an egg-laying machine into the plant tissue and into the eggs for the purpose of parasitism [17,18].

Some sources indicated that some species of the genus *Pseudoligosita* parasitize the eggs of some insects of other insect orders. Pinto and Viggiani [18] mentioned Species in this genus are considered white parasites against insects of the suborder Auchenorrhyncha and straight-winged Tettigoniidae. In addition some insects of the Sheath wing order form under the Hispinae family of Chrysomelidae. And it is spread in limited areas of the Arab world, Al-Khatiri [19] noticed that eggs of the Dubas bug insect in the Sultanate Oman were infected with an intruder, initially diagnosed as belonging to the genus *Oligosita*, but later it turned out to be same species recorded inside Iraq.

Querino and Hamada [20] also found that *P. longifrangiata* parasitizes *Argiainsipida* (Odonata: Coenagrionidae) eggs in Brazil and it is the only species collected from eggs lying on leaves and branches of the aquatic plant *Toninafluviatilis*. A subspecies of this parasitic genus *P. plebeia* parasitizing grasshopper eggs *Homalodisca liturata* in Mexico [21]. Virla et al. [22] observed when exposing 1,600 eggs to *Dalbulusmaidis* maize grass hopper to field conditions the emergence of 923 parasites of that egg belonging to five species, one of which was *Pseudoligosita* sp. The parasitoid *P. babylonica* has also been recorded in Yemen [23]. After he was isolated from the eggs of the dubas bug insect for the first time in the Hadramout valley in 2007, and he was diagnosed at the end of 2008 in France by The French Agricultural Research and International Cooperation Organization (CIRAD).

Due to the weakness of taxonomic keys specific to this genus, this species has not been identified, and it has been found that *H. vitripenis* infects the same parasite in California [24-26]. It also affects *Tapajosa rubromarginata* eggs in Argentina [26]. It was later revealed that *D. maidis* maize grasshopper eggs in Argentina were infected with *P. longifrangiata* [27]. Triapitsyn and Shih [28] found that *P. nephotetticum*(Mani) parasitizes grasshopper eggs *Kollapaulula* (Walker) (Hemiptera: Cicadellidae) in Taiwan.

1.2 Seasonal Presence of *Pseudoligosita babylonica*

Abdul Hussein [29] noted that an intruder belonging to the order Hymenoptera infects the eggs of the spring and autumn generations of the Dubas bug palm insect. The summer and winter months spend hibernating inside insect's eggs. The survey conducted in the Sultanate of Oman for the period from 2005 to 2008 revealed the presence of the parasite in all areas planted with palms and infected with dubas bug It also showed results of field studies on the relationship between parasite and dubas bugs insect for the period from July 2005 to June 2006.The parasite adults appear twice during the spring generation and four times during the autumn generation, The first appearance, which is the highest, was recorded during period from July to September, while the second appearance was the lowest during period from the second half of September until end of first week of January. The first appearance of inhabitants of the autumnal generation of intruder was recorded in the second half of January, what is the second, it was recorded in the second half of February, while the third was in first week of April, The fourth and last was during May [19]. In Yemen, Hubaishan and Bagwaigo [23] found that adults of parasitoids exist throughout the months of year and do not resort to summer or winter Hibernationin in all areas of the study.

1.3 Egg-laying Behavior of Female *P. babylonica*

Egg-laying behavior was observed by female egg parasites because of its importance due to the presence of the largest part of dubas bug eggs inside wicker plant tissue and stiffness of protruding part of egg above wicker surface its thickness ranges from 6 to 25 m compared to section below surface of wicker which is 1.7 Gm thick [30].

The newly emerging female parasite, after releasing eggs of dubas bug insect, and before starting the egg search process, cleans its body and then feeds on honeydew, after completion of feeding, the process of searching for eggs begins by touching the surface of the plant tissue with ends of two antennae to locate egg. Female parasites sometimes rest or clean their wings and antennae while they search when finding an egg, move around and go towards and back from it several times. Then begin to advance antennae forward and bend it perpendicularly to surface of wicker and touch protruding part of egg, In a process akin to drumming described by Edwards [31] when studying behavior of host-finding and spawning by parasite *Mormoniella vitripennis* after completing the drumming stage female stands near protruding part of egg and in an area completely above implanted part inside plant tissue then body straightens and implants ovipositor into plant tissue with a so-called drilling process, after that, gradually introduces ovipositor by moving abdomen up and down while digging until it fully enters it to its base after female lays egg, it pulls ovipositor from plant tissue to clean body and settle slightly near egg that has intruded on.

It was noted that the parasitism process takes from 4-17 minutes, and this wide range may be due to differences in the nature of the plant tissue of wicker. Such an attitude is possessed by *Anaphesiole* parasitoids for bug eggs *Lygus hesperus* [32] and also the egg-parasite *Anagyrus atomus* which parasitize eggs leaf hopper *Arboridia kermanshah*their eggs are embedded within plant tissue [33].

The ability of female egg parasitoid *P.babylonica* to infect eggs lying on upper surface of palm wicker was observed from opposite side on lower surface. the vegetative tissue on opposite side of egg on lower surface of wicker has a light color that differs from color of surrounding plant tissue [16].

1.4 Life Studies and Parasitism Percentages

Ratte [34] mention that temperature is one of most important environmental factors affecting physiology and behavior of insects, and that effect on rate of growth and development of insect is one of the most important aspects of effect. Hassan et al. [11] explained that it is possible to breed *P. babylonica* on dubas bug eggs under laboratory conditions, at 28°C, 70% relative humidity, and 12:12 light duration. it was also mentioned that newly emerging adults of parasite began to parasitize eggs of dubas bug insect after they mate within 15 minutes and that they are able to parasitize 4-5 eggs during one hour.

The emergence of adults of the first laboratory generation was also observed after 31 days from the date of parasitism, The adults of parasitoids, both male and female, feed on honeydew produced by nymphs and Dubas bug adults. The percentages of parasitism in spring and autumn eggs of Dubas bug insect within field conditions of Tuwaitha area south of the capital Baghdad reached 22% and 17%, respectively. The results of the survey conducted in Sultanate Oman indicated that percentages of parasitism varied, ranging between 0.3-3.5% in Musandam Governorate. And 0.7-50.5% in Al-Batinah region, 10-60.5% in Al Sharqiyah region, and 0.8-58.8% in Al Dakhiliyah region [19].

One of most important features of the performance of successful intruders is compatibility between activity of natural enemies and life cycle of their families [3]. Hubaishan and Bagwaigo [23] found that percentages of parasitism in Wadi Hadramawt in Yemen ranged between 4.1-30.4% for palm groves of Dooan Valleyand 7.1-34.4% for Asid and Shkawee Valley orchards. AL-Khatiri [15] also studied the evolution and reproduction of parasite in the Sultanate of Oman, where it was mentioned that emergence of parasitic adults was affected by temperature and that parasitoid develops successfully within a range of temperatures between 22.3 - 32.4°C and that its optimum temperature is 30°C while the humidity had no significant effect and parasite reproduces early by producing males from unfertilized eggs, and there are three sexual forms of the parasitoid, which are female, male and deformed males that mates with females to produce the three mentioned sexual forms.

AL-Khatiri [15] reported that *P. babylonica* successfully develops within a temperature range of 22.3 - 32.4°C, and optimum temperature for growth and development of its various roles is 30°C. Lytle et al. [25] showed that this parasite is considered a grouped parasite As the number of adults emerging from a single parasitic egg of leafhopper, *Homalodisca vitripenis*, reached 6 adults. When feeding a female parasite on a mixture of honey and water or water only or

leaving it without food, the female's life span was 64.1, 2.3, and 2.0 days, respectively.

It was also found that female parasitoid was able to parasitize on the host's eggs of different ages, which ranged between 1-8 days however, the highest percentage of parasitism was on eggs 1-3 days old compared to 5-7 days old eggs it was also observed that there is a trend towards an increase in the production of offspring by the female parasite, beginning at the age of 2 days and up to the age of 26 days, followed by a decrease that continues until the age of 75 days. It was clear that female parasites were continuous laying eggs synovigenic because her ovaries contain a small number of mature eggs during early ages (1-3 days) compared to their preparation during advanced ages of her life (5-35 days). As for the other 55 species of parasitoids of the genus *Pseudoligosita*, The studies did not cover its life or parasitism ratios of any kind except for one study on *P. plebeia*.

1.5 Side Effects of Herbicides in the Natural Enemies

The indirect effects of chemical pesticides on natural enemies must be assessed to determine whether these pesticides are compatible or incompatible with natural enemies in order to achieve success in long-term biological control programs [35]. However, many manufacturers and suppliers of chemical pesticides have made unproven claims that pesticides are safe for natural enemies without any indication of testing methodology. which may be refuted when taking into account that any indirect effects may differ according to a concentration of pesticide, type of natural enemy, time of exposure to the pesticide, as well as stage or age stage of insect's life, and effect of pesticide residues and repellant effect [36]. Therefore, studying the compatibility of natural enemies with chemical pesticides is important if both management strategies can be integrated into programs aimed at regulating populations of insect pests and minimizing damage to plants.

Methods of testing the side effects of pesticides on natural enemies have gained increasing importance by researchers in various parts of the world, Accordingly, propagation techniques suitable for natural enemies and standard testing methods for side effects of pesticides on natural enemies became an urgent and basic need. Finney and Fisher [37], Smith [38], and Morrison and King [39] all refer to methods for building colonies of arthropods that feed on insects. As well as research that referred to test methods in various parts of the world [40,41]. The International Organization for Biological Control has sought it is one of the organizations concerned with studying natural enemies and ways to preserve them by developing standard methods for assessing the side effects of chemical pesticides on natural enemies and the organization of joint programs to test the side effects of various pesticides on beneficial insects.

A working group consisting of 50 members from different research institutions and chemical pesticide factories from 11 countries was formed to share ideas and increase international cooperation in the field of developing standard methods for estimating the side effects of pesticides on natural enemies, realizing that a single test method does not give sufficient information to demonstrate side effects of pesticides in natural enemies, The IOBC team has recommended a set of tests that include laboratory, semi-field, and field conditions. The working group was able to determine the side effects of pesticides in four ranks depending on the percentage of the pesticide's reduction to the population of the parasite or predator [42].

2. CONCLUSION

It is necessary to establish natural reserves for an intruder in order to preserve it and activate its role in the local environment by stopping the spraying of chemical pesticides, especially in the orchards of low and medium infestation by dubas bug. Breeding and propagating the egg parasitoid in facilities prepared for this purpose and releasing it into an environment of date palm orchards at a specified date within integrated control programs for dubas bug. Conducting biological evaluation tests for pesticides proposed to be used against dubas bug in different roles of the parasitoid before approving their use. Conducting other studies to select selective pesticides that are less harmful to the parasitoid and more effective on dubas bug. Completion of field studies to determine the spread of intruders in other governorates that were not included in the study, and expanding conduct of studies that would determine the living and non-living factors of death for various roles of intruders. Avoid spraying insecticides that affect rates of emergence of parasitoid adults from parasitoid eggs, as well as avoid delaying aerial and ground spraying with pyrethroid insecticides until the emergence of parasitoid adults in order to preserve them.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Stiling PD. The frequency of density dependence in the insect host-parasitoid systems. Ecology. 1987;68:844 –856.
2. Bouchard Y, Cloutier C. Honeydew as a source of host-searching kairomones for the aphid parasitoid *Aphidius nigripes* (Hymenoptera: Aphidiidae). Can. J. Zool. 1984;62:1513–1520.
3. Reznik SY, Umarova TY. Host population density influence on host acceptance in *Trichogramma.* Entomologia Experimentalis et Applicata. 1991;58:49–54.
4. Eggleton P, Belshaw R. Insect parasitoids: an evolutionary overview. Philos. Trans. R. Soc. B. 1992;331:1–20.
5. Godfray HCJ. Parasitoids behavioral and evolutionary ecological. Princeton University Press. Princeton. USA. 1994;473.
6. Al-Shamsi, Bassem Hassoun. Life performance of the Palmate Dubas insect (Homoptera: Tropiduchidae) Ommatissus lybicus De Berg. Under field conditions and predict their emergence using the thermal units model. Master Thesis, University of Baghdad - College of Agriculture; 2003.
7. Hassan BH, Al-Jboory IJ Al-Rubeae HF, Viggiani G. *Psedoligosita babylonica* n.sp. (Hymenoptera: Trichogrammatidae), egg parasitoid of *Ommatissus lybicus* Brgevin (Homoptera:- Tropiduchidae) in Iraq. Boll. Lab. Ent. agr. Filippo Silvestri. 2003;59:75-78.
8. Mills NJ, Wanjberg E. Optimal foraging behavior and efficient biological control methods. In: Wajnberg, E., Bernstein, C., Van Alphen, J. (Eds.), Behavioural ecology of insect parasitoids. from theoretical approaches to field applications. Blackwell Publishing. Oxford. 2008;3–30.
9. Morrison G, Strong, Jr. DR. Spatial variations in host density and the intensity of parasitism: some empirical examples. Environ. Entomol. 1980;9:149-152.
10. Fraser SEM, Dytham C, Mayhew PJ. Patterns in the abundance and distribution of ichneumonid parasitoids within and across habitat patches. Ecol. Entomol. 2008;33:473–483.
11. Hassan, Bassem Hassoun; Ibrahim Jadou 'Al-Jubouri and Hussein Fadel Al-Rubaie. Notes on Oligosita spp. On the eggs of the Dubas insect. Research note. Basra Journal of Date Palm Research. 2001;2(1):4.
12. Hoogendoorn G, Schneider M, Kerssens MV, Dols EAFHM, Van Alphen JJM. Male versus female longevity in parasitoid wasps. Proc. Exper. Appl. Entomol. 2002;13:73-75.
13. Pilkington LJ, Hoddle MS. Reproductive and developmental biology of Gonatocerus ashmeadi (Hymenoptera: Mymaridae), an egg parasitoid of Homalodisca coagulata (Hemiptera: Cicadellidae). Biol. Cont. 2006;37:266–275.
14. Reznik SV, Vaghina NP. Effect of temperature on the reproduction and development of *Trichogramma buesi* (Hymenoptera: Trichogrammatidae). Eur. J. Entomol. 2009;106:535–544.
15. AL-Khatiri SA. Biological, ecological and phylogenic studies of *Pseudoligosita babylonica* Viggiani, a native egg parasitoid of Dubas Bug *Ommatissus lybicus* de Bergevin, the major pest of date palm in the sultanate of Oman. Ph.D. thesis. Sultanate of Oman; 2011.
16. Alshamsi BHH. Biological and Ecological studies of the Egg Parasitoid *Pseudoligosita babylonica* Viggiani (Hymenoptera: Trichogrammatidae) on Dubas Bug *Ommatissus lybicus* De Berg. (Hemiptera: Tropiduchidae). Ph.D. thesis. College of Agricultural Engineering Sciences. University of Baghdad. 2016;120.
17. Rakitov RA. Powdering of egg nests with brochosomes and related sexual dimorphism in leafhoppers (Hemiptera: Cicadellidae). Zoological Journal of the Linnaean Society. 2004;140:353-381.
18. Pinto JD, Viggiani G. A review of the genera of Oligositini (Hymenoptera: Trichogrammatidae) with a preliminary hypothesis of phylogenic relationships. J. Hym. Res. 2004;13:269-294.
19. AL-Khatiri SA. Egg parasitoid *Oligosita* sp. as a component of biological control of dubas insect. The workshop on biological control of pests in Oman, 3 to 4 March 2008, The General Directorate of Agricultural and Animal Research. Sultanate of Oman. Book of abstracts. 2008;32.

20. Querino R, Hamada N. An aquatic microhymenopterous egg-parasitoid of *Argia insipida* Hagen in selys (Odonata: Coenagrionidae) and biological observations in the central amazon, Brazil. Neotropical Entomology. 2009;38(3):346-351.
21. Triapitsyn SV, Bernal JS. Egg parasitoids of Proconiini (Hemiptera: Cicadellidae) in northwestern Mexico, with description of a new species of *Gonatocerus* (Hymenoptera: Mymaridae). Journal of Insect Science. 2009;9(5):1-9.
22. Virla EG, Albarracin EL, Moya-Raygoza G. Egg Parasitoids of *Dalbulus maidis* (Hemiptera: Cicadellidae) in Jalisco State. Mexico. Florida Entomologists. 2009;92(3):508-510.
23. Hubaishan MA, Bagwaigo AA. The effect of the egg parasitoid *Pseudoligosita babylonica* Viggianion dobas infestation in Doaan, Shichawi and Asid (Hudramout, Yemen). Acta Hort. 2010;451-456.
24. AL-Wahaibi AK, Morse GM. Immature development and adult eclosion of *Ufens principalis* Owen (Hymenoptera: Trichogrammatidae), an egg parasitoid of *Homalodisca* spp. (Hemiptera: Cicadellidae) in southern California. Bull. Entomol. Res. 2010;100:467–479.
25. Lytle JM, Bernal JS, Morse JG. Biology of *Pseudoligosita plebeia* (Hymenoptera: Trichogrammatidae), an egg parasitoid of *Homalodisca* spp. (Hemiptera: Cicadellidae) collected From northwestern mexico as a potential biocontrol agent of *H. vitripennis*in california. J. Econ. Entomol. 2012;105(5):1532-1539.
26. Triapitsyn SV. Vouchering specimens of egg parasitoids of the glassy-winged sharpshooters collected by the CDFA pierce's disease biological control program in California and texas A and M in texas. p8-11. In: Pierce's Disease Research Progress Reports. December 2012 (Esser, T. and R. Randhawa, eds). California Department of Food and Agriculture. Sacramento. CA. US. 2012;255.
27. Virla EG, Moya-Raygoza G, Luft-Albarracin E. Egg parasitoids of the corn leafhopper, *Dalbulus maidis*, in the southern most area of its distribution range. Journal of Insect Science. 2013;13(10):1-7.
28. Triapitsyn SV, Shih HT. Egg parasitoids (Hymenoptera: Mymaridae and Trichogrammatidae) of *Kolla paulula* (Walker) (Hemiptera: Cicadellidae) in Taiwan. Journal of Asia-Pacific Entomology. 2014;17:673–678.
29. Abdul Hussein Ali. Date palm pests and methods of controlling them in Iraq, Local Administration Press – Baghdad. 1963;209.
30. Guglielmino A, Tadderi AR, Carcupino M. Fine structure of the eggshell of *Ommatissus binotatus* Fieber Homoptera: Auchenorrhynca: Tropiduchidae). Int. J. Insect. Morph. Embryol. 1997;26:85-89.
31. Edwards RL. The host finding and oviposition behavior of *Mormoniella vitripennis* (Walker) (Hymenoptera: Pteromalidae), a parasite of Muscoid flies. Behavior. 1954;7:88-112.
32. Conti E, Jones WA, Bin F, Vison SB. Oviposition behavior of *Anaphes iole* (Hymenoptera: Mymaridae) an egg parasitoid of *Lygus Hesperus* (Heteroptera: Miridae). Ann. Entomol. Soc. Am. 1997;90(1):91-101.
33. Hesami S, Seyedoleslami H, Ebadi R. Biology of Anagrus atomus (Hymenoptera: Mymaridae), an egg parasitoid of the grape leafhopper Arboridia Kermanshah (Homoptera: Cicadellidae). Entomological Science. 2004;7:271–276.
34. Ratte HT. Temperature and insect development. In Hoffmann K. H. (ed.): Environmental Physiology and Biochemistry of Insects. Springer. Berlin. 1985;33–66.
35. Rosenheim JA, Hoy MA. Sublethal effects of pesticides on the parasitoid *Aphytismelinus* (Hymenoptera: Aphelinidae). J. Econ. Entomol. 1988;81:476-483..
36. Bernard MB, Horne PA, AA. Hoffmann. Developing an ecotoxicological testing standard for predatory mites in Australia: acute and sublethal effects of fungicides on *Euseius victoriensis* and *Galendromus occidentalis* (Acarina: Phytoseiidae). J. Econ. Entomol. 2004;97(3):891-899.
37. Finney GL, Fisher TW. Culture of entomophagous insects and their hosts. In biological control of insect pests and weeds (ed. DeBach, P.). Chapman and Hill. London. 1964;329-355.
38. Smith CN. Insect colonization and production. Academic Press. New York. 1966;618.
39. Morrison RK, King EG. Mass production of natural enemies. In biological control by augmentation of natural enemies (eds

Ridgway, R. L. and S. B. Vinson) Plenum Press. New York. 1976;185-217.
40. Franz JM. Testing the side-effects of pesticides on beneficial arthropods in the laboratory-a review. Zeitschriftfur P'anzenkrankheiten und P'anzenschutz. 1974;81:141-174.
41. Croft BA, Brown AWA. Responses of arthropod natural enemies to insecticides. Ann. Rev. Entomol. 1975;20:285-335.
42. Hassan SA. Standard methods to test the side-effects of pesticides on natural enemies of insects and mites developed by the lOBC/WPRS Working Group 'Pesticides and Beneficial Organisms'. Bulletin OEPP/EPPO Bulletin. 1985; 15:214-255.

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