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Evaluation of predatory efficiency of Staphylinidae predators *Philonthus limbukus* and *Atheta basraiensis* on aphids *Myzus persicae*

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Abstract

This study investigated the presence and predatory efficiency of Staphylinidae beetles in relation to aphid populations. Field observations revealed that *Philonthus* reached its peak number of 2.5 on March 1st, while *Atheta* and aphid populations peaked at 1.4 and 27.7, respectively, on February 1st. A positive correlation (R = 0.2) was found between aphid numbers and *Atheta*, whereas *Philonthus* exhibited a negative correlation (R = -0.5). Laboratory experiments demonstrated that *Atheta*'s predation efficiency declined as prey density increased, with the highest and lowest means of prey consumed being 7.7 and 4.6 at prey densities of 20 and 5, respectively. The predation efficiency of *Atheta* was negative and showed no significant differences with increasing prey numbers, dropping to -0.2 and -0.3 at prey densities of 10 and 20, respectively. Conversely, *Philonthus* displayed significant increases in prey consumption with higher prey densities, with the highest mean at 13.4 and the lowest at 9.4 for prey densities of 20 and 10, respectively. These findings provide insights into the predatory dynamics of Staphylinidae beetles and their potential role in biological control.

Key words: Atheta, Philonthus, Staphylinidae, aphid, Basrah,Iraq

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Introduction

The predators of Staphylinidae are multiple preys or polyphagous, which are not active by searching for one prey, but rather feed on everything available, which leads to a natural balance in the aphid community (Holland and Thomas, 1997).Several species belonging to the genus *Philonthus* : *P. laminatus* ,*P. sagnatus* ,*P. decorus* ,*P. varianus* and *P. glubatus* have a major role in the management system of oats (Shah *et al.*, 2003).Some species of *Philonthus* regulate the density of aphid in wheat fields (Bryan and Wratten, 1984). *Philonthus* is one of the most efficient zoophytophagous predators in the maize fields(García *et al.*, 2012). In a study of the natural enemies of aphids, it was found that many species that prey on aphids follow the subfamilies of Aleocharinae, Paederinae, Staphylininae and Tachyporinae(Macleod *et al.*, 1994). Many species of the genus *Tachyporus* and *Xantholinus* have an important role in balancing the aphid community(Sunderland *et al.*, 1987). The species *Tachyporus* and *Drusilla* are predators of the pea aphids(Balog, *et al.*, 2013). Bohac, (1999)concluded that Staphylinidae beetles are among the most important natural enemies of the agricultural system, and it is one of the most important insect predators in the fields of the alfalfa. There are few studies on the biological control of aphids in the province of Basrah. Khamis (2021) published the predator *Orius sp* was present with five species of aphids in the vegetable fields. Abbas *et al.*,(2020) tested the effect of the insect pathogen *Beauveria bassiana* and *Bacillus thuringiensis* on aphids *Myzus* *persicae*. Al-Hussine and Alyousuf (2021) studied the nutritional preference of aphids *Rhopalosihum padi* over 12 varieties of wheat. Kalaf *et al.,*(2013) illustrated the effect of the insect pathogen *Trichoderma harzianum* and *Trichoderma viride* on wheat aphids. Khamis and Jabbar (2021) explained that Aphid nymphs are the favorite prey of *Orius sp* predator. To explore the most important predators of Staphylinidae associated with aphids, the paper was published.

Materials and methods

Field experiment

The experiment was carried out in a field planted with alfalfa in the Shatt al -Arab region (coordinates, 30.65800 ,47.89619) from the period of 15January to 15March, 2020.

The field is divided into 5 sectors on each 3 plates, insects collected every 15 days by a network and preserved samples in bags transferred to the entomology laboratory in the College of Sciences, Department of Biology. Temperatures and humidity measured during the collection period.

laboratory experiment

Using petri dish with a diameter 9 cm. In each dish, put a wet filter paper to maintain moisture and some alfalfa leaves. 10, 15 and 20 aphids were placed with one predator of beetles and 5 replicates for each group(Sunderland *et al.*, 1987).

The numbers of eaten and remaining prey were calculated in each replicate after one day, the laboratory temperature was 22±3 and the relative humidity was 40±5 .

According to (Cupples *et al.*, 2011) the efficiency of predation was calculated by applying Ivlev's index (Ivlev 1961):

$$E=(r-p)/(r+p)$$

E= efficiency of predation, r= represents the number of prey eaten by the predator, and p= represents the number of prey remaining (Example when eating 3 preys out of 10 prey Predatory efficiency is 3-7/3+7=-0.4). Calculated value of pointer bands from -1 to +1. A negative value indicates that the predator Leaves of a number of prey, and zero means that the predator picks them up randomly and A positive value indicates a predator's preference for a particular prey (Shimoda *et al.*, 1997).

The results were analysed by SPSS program to calculate correlation coefficient between the numbers of aphids *Myzus persicae* and Staphylinidae beetles *Philonthus limbukus* and *Atheta basraiensis* and the means were tested with the Tukey test.

Results

Field study

Seasonal presence of Staphylinidae with aphids.

The study focused on Staphylinidae that is constantly present with *Aphid*. Results of the statistical analysis showed that there were significant differences in the number of insects caught in the net during the time periods, where the highest number was 2.5 for *philonthus* on 1st of March as present in **Table 1**. While the highest numbers were 1.4 and 27.7 for *Atheta* and aphid, respectively that recorded on 1st of February

Table (1) means ± Sd. of *aphid* and accompanying predators of Staphylinidae, in the field

date	Aphid	philonthus	Atheta	hum	temp
15-jan	15.5±6.0	1.5±0.7	0.6±0.7	47.1±4.1	19±0.8
01Feb	27.7±8.6	1.0±0.8	1.4±1.5	61.7±7.3	20.4±0.7
15Feb	19.2±5.2	1.3±0.7	0.1±0.3	63.3±10.1	21±0
01Mar	9.3±3.4	2.5±1.3	0.4±0.8	39.6±8.2	23.4±1.0
15Mar	7.3±1.8	2.4±0.8	0.1±0.3	41.4±7.8	25.4±2.0
mean	15.8±9.1	1.8±1.2	0.5±0.9	50.6±12.5	21.8±2.5
±SD	3.7	0.6	0.6	5.2	1.7

Linear correlation between numbers of Aphid and Staphylinidae

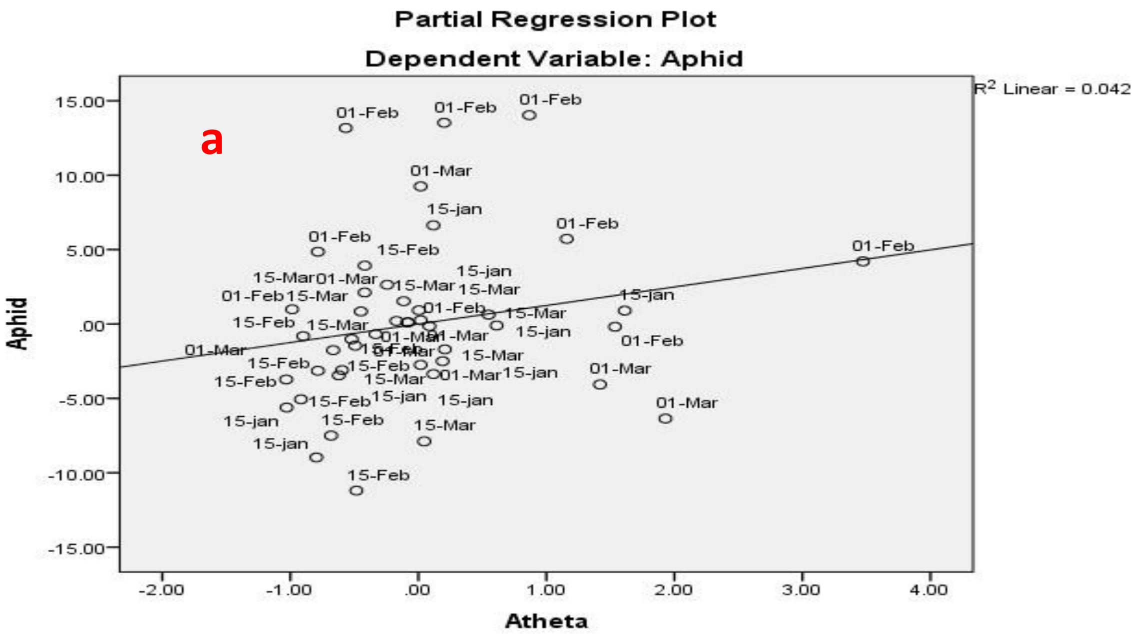
Figure 1 shows the results of statistical analysis that indicate a positive correlation between the number of *aphid* and *Atheta (*p value=0.057, R = 0.2, F 23.64 and df = 44). While the correlation was negative with the number of *philonthus (*p value < 0.05, R = -0.5, F 34.12 and df = 44).

linear correlation insect numbers and relative humidity in the field

Figure 2 indicates a positive correlation between relative humidity and the number of insects, (p value < 0.05, R = 0.6, F 7.58 and df = 44) and (p value < 0.05, R = 0.3, F 6.45 and df = 44) for *aphid* and *Atheta*, respectively. While the correlation was negative with the number of *philonthus* (p value<0.05, R=- 0.3, F 9.39, df = 44).

linear correlation between insect numbers and temperature in the field.

The results in **figure 3** indicate a negative correlation between temperature and numbers of insects (p value < 0.05, R = -0.5, F 2.06 and df = 44) and (p value < 0.05, R= -0.2, F 3.03 and df = 44) for *aphid* and *Atheta*, respectively. While the correlation was positive with numbers of *philonthus* (p value < 0.05, R= 0.4, F 2.22 and df = 44).



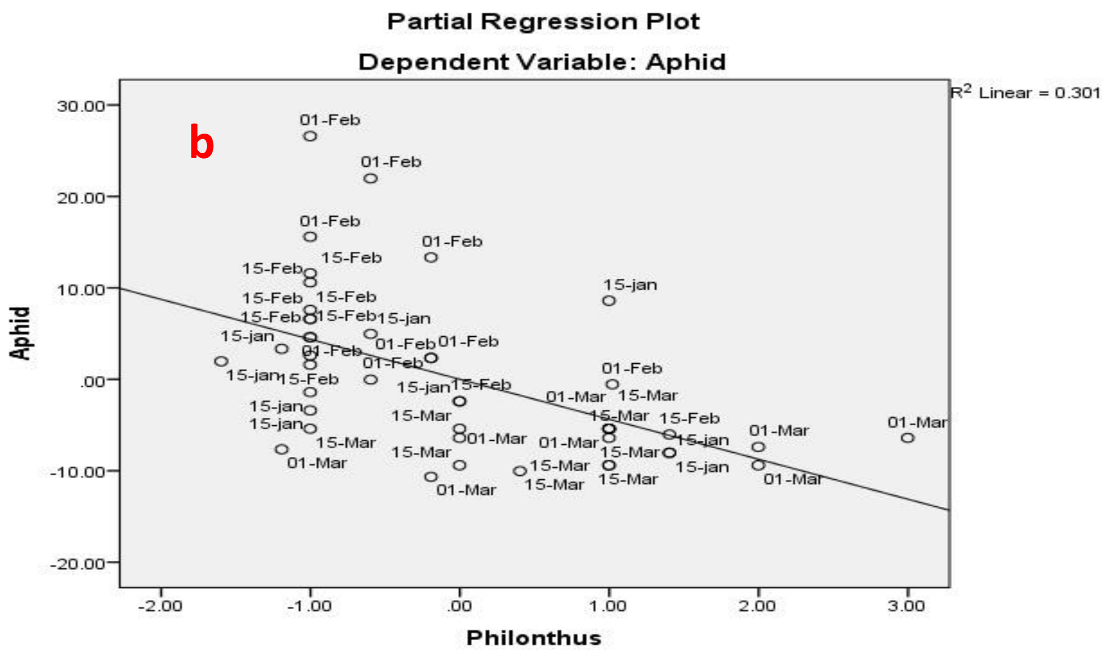


Figure (1), linear correlation between numbers of *Aphid* and Staphylinidae in the field, a *Atheta* , b *philonthus*

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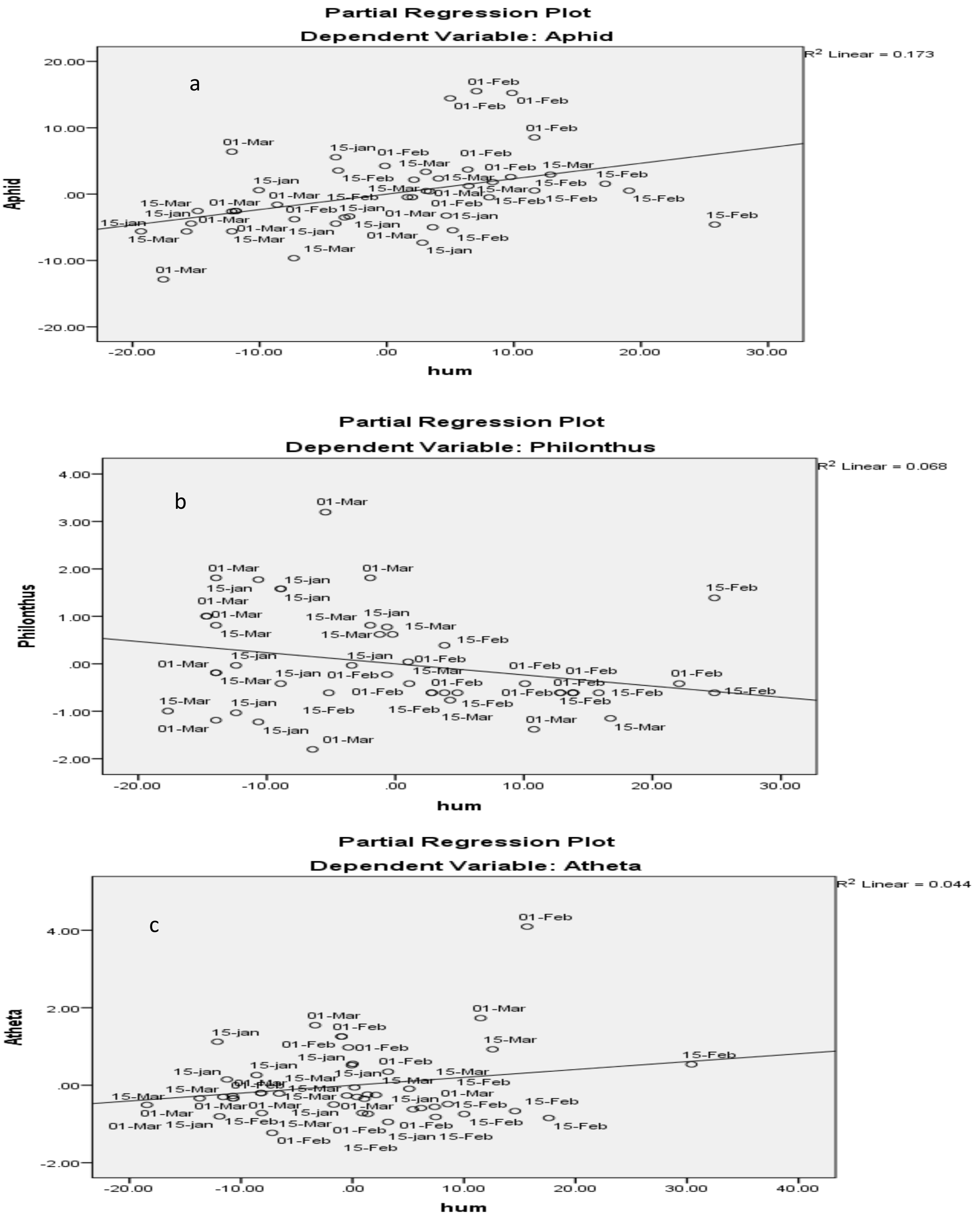

Figure (2) Linear correlation between insect numbers and relative humidity in the field,

a *Aphid* ,b *philonthus* , c *Atheta*

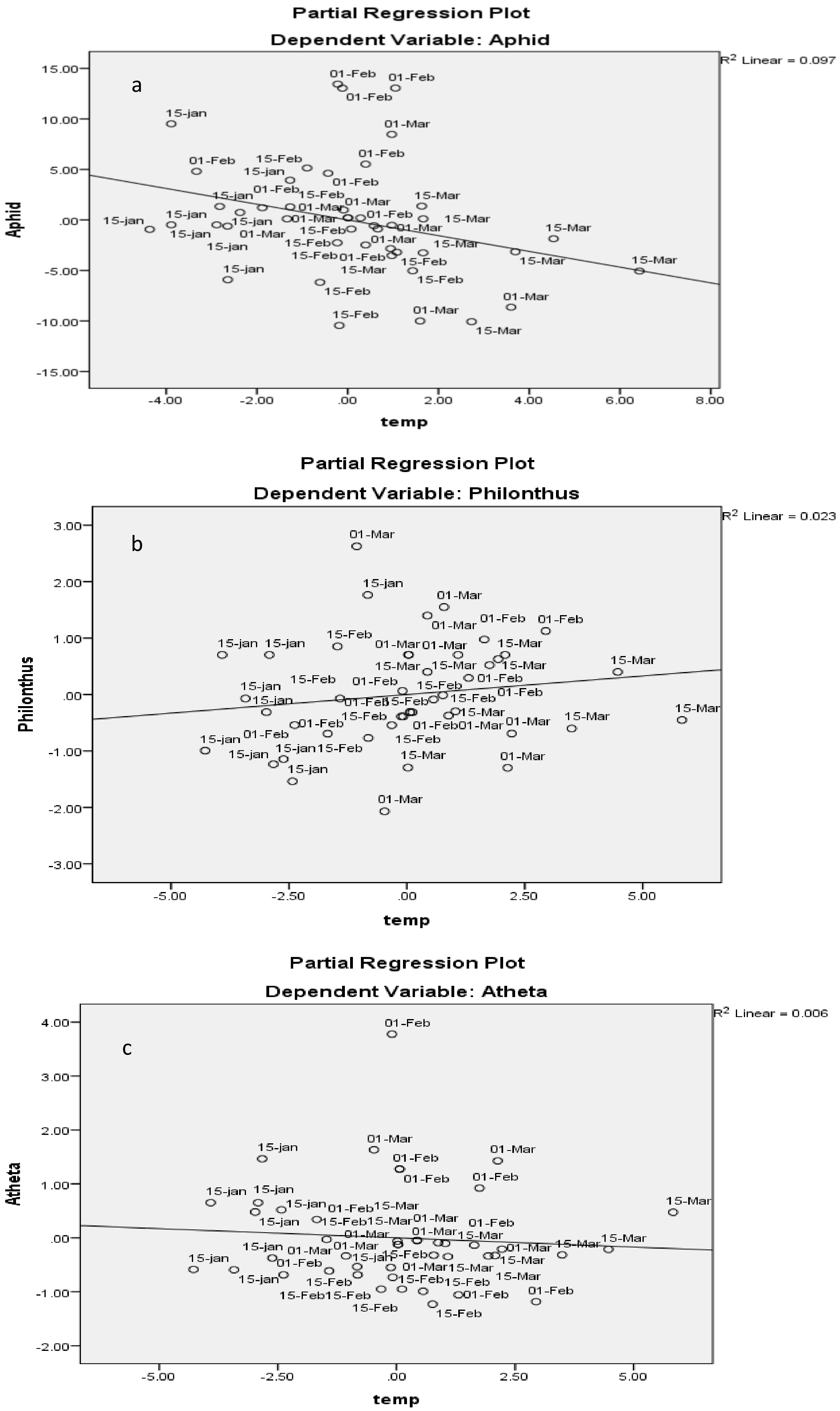

Figure (3) linear correlation between number of insects and temperature in the field,

a *Aphid* ,b *philonthus* , c *Atheta*

A laboratory study

Efficiency of *Atheta* predation in the laboratory

The results of statistical analysis in **Figure 4** show significant differences in the number of eaten preys, when increasing the number of prey (F = 5.09, df = 14 and P value = 0.02). The highest mean was 7.7 and the lowest was 4.6 when presenting 20 and 5 prey, respectively. As for the predation efficiency is negative without significant differences (F = 2.44, df = 14 and P value = 0.12). While the predation efficiency decreased when the number of preys increased, it amounted to -0 .2 and -0.3 when giving 10 and 20 prey, respectively.

Efficiency of *Philonthus* predation in the laboratory

The results present in **Figure 5** show significant differences in the number of eaten prey when increasing the number of prey (F =11.39, df = 14 and P value = 0.002). The highest mean was 13.4 and the lowest was 9.4 when offering 20 and 10 prey, respectively. The predation efficiency was positive with significant differences (F = 13.01, df = 14 and P value = 0.001). It decreases when the number of prey increases, reaching 0.88 and 0.34 when giving 10 and 20 prey, respectively.

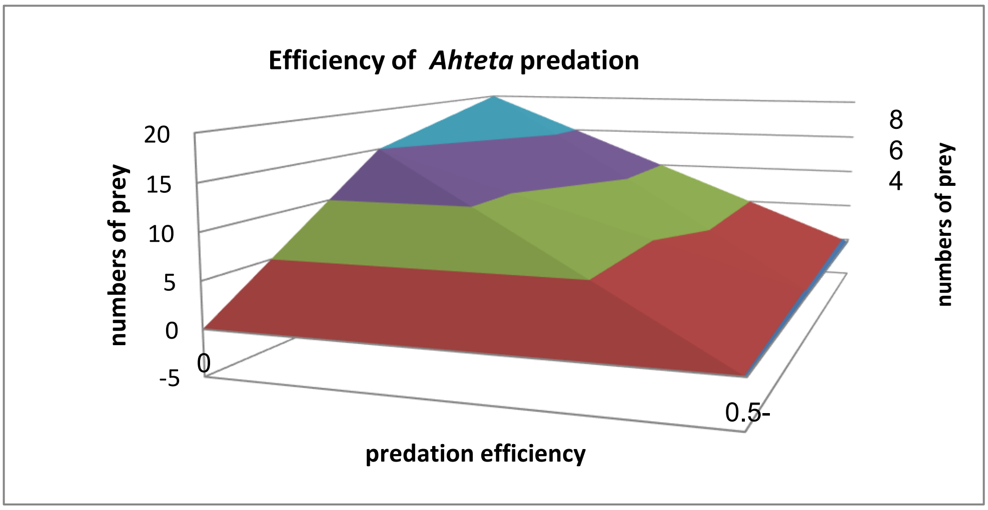

Figure (4): Efficiency of *Atheta* predation in the laboratory

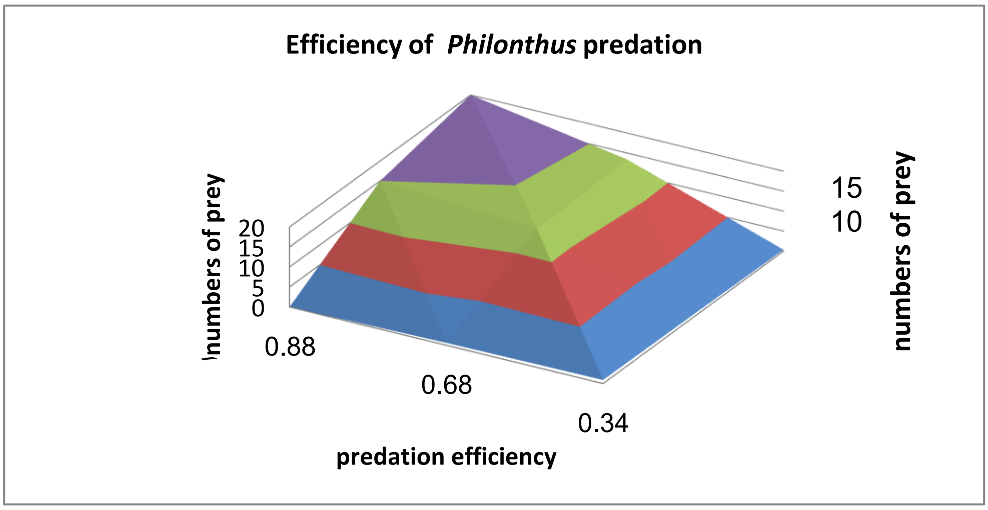

Figure (5): Efficiency of *Philonthus* predation in the laboratory.

Discussion

From the study of the correlation, we noticed that the *Aphid* has the same correlation with the *Atheta* in terms of numbers and environmental conditions. While the *philonthus*, it has an inverse relationship. This result may indicate that the *Atheta* has other prey, and the *philonthus* is a dominant predator.

The results show that *Atheta* has a negative predatory efficiency. While the *philonthus* has a positive predatory efficiency, as well as the predation efficiency decreases with the increase in the number of preys.

The abundance of prey different species for predatory Staphylinidae provides a long-term dynamic in the farming system (Guseva and Koval, 2013). An increase in the prey community is regulated by the diversity of predatory arthropods and the ability of each predator and the extent of competition, so there is an interaction relationship between predators (Rosenheim, 1998). There is a negative correlation between the community evolution of *Aphid* and predators of Staphylinidae (Schmidt *et al.*, 2003).There are a pre -prey interaction between *Aphid gossypii* and Staphylinidae (Rosenheim, *et al.*,1993). Increasing the density of *Aphid* on the plant leads to an increase in honey dew, and an increase in ants leads to crowding in the unit area, which can be reflected in the presence of predators (Bartlett, 1961).In natural conditions, there are few restrictions on the movement of the predator, as it may migrate from the area before reaching the level of prey exploitation or negative impact (García *et al.*, 2012).Each predator has a fixed ability to search for prey during the time period, this is reflected in the efficiency of predation (Sunderland *et al.*, 1986).Increasing the number of preys leads to an increase in the time to search for prey and an increase in feeding time, which causes a decrease in the efficiency of predation (Andr *et al.*, 2011).The amount of available prey will affect the extent of competition between predators of one species or other species, which will negatively affect the efficiency of predation (Eveleigh and Chant, 1982).Some *Atheta* species are involved in bio-control in greenhouses (Klimaszewski *et al.*, 2018).

Conclusions

This study found that *Philonthus limbukus* exhibited higher predation efficiency on *Myzus persicae* compared to *Atheta basraiensis*, especially at moderate prey densities. *Philonthus* showed a negative correlation with aphid numbers, while *Atheta* had a positive one, indicating different predatory strategies. Environmental factors like temperature influenced these dynamics, favoring *Philonthus* predation at higher temperatures. These results highlight the potential of *Philonthus* in pest management, particularly in moderate aphid density environments, while emphasizing the importance of considering environmental conditions.

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تقييم كفاءة الافتراس للخنافس الرواغة *Philonthus limbukus* و*Atheta basraiensis* على حشرات المن *Myzus persicae*

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المستخلص

تشير الدراسة الى وجود كفاءة افتراسية لحشرات الخنافس الرواغة Staphylinidae المتواجدة في مجتمع حشرات المن ***Myzus persicae***. ففي الدراسة الحقلية وصلت اعلى معدل 2.5 حسرة للمفترس ***Philonthus*** في الاول من شهر اذار بينما بلغت اعلى معدلات 1.4 و27.7 حشرة للمفترس ***Atheta*** وحشرات المن على التوالي في الاول من شهر شباط , بينما كان معامل الارتباط بين حشرات المن موجبا R=0.2 مع المفترس ***Atheta*** وسالبا R=-0.5 مع المفترس ***Philonthus*** . في حين اظهرت التجارب المختبرية انخفاظ معدلات الافتراس للمفتس ***Atheta*** عند زيادة اعدادالفرائس حيث بلغ اعلى وادنى معدل للفرائس المأكولة 7.7 و 4.6 عند كثافة فرائس20 و5 فريسة على التوالي اما كفاءة الافتراسية كانت سلبية وبدون اختلافات معنوية مع زيادة اعداد الفرائس حيث بلغت 0.2- و0.3- عند كثافة فرائس 10و20 على التوالي , وعلى العكس من ذلك اظهر المفترس ***Philonthus*** كفاءة افتراسية عالية عند زيادة اعداد الفرائس فبلغ اعلى وادنى معدل للافتراس 13.4و9.4 عند كثافة فرائس 10 و20 فريسة على التوالي . توفر هذة النتائج رؤى حول ديناميكية الافتراس لحشرات الخنافس الرواغة ودورها المحتمل في المقاومة الحيوية لحشرة المن

الكلمات المفتاحية :افتراس ، المن ، البصرة ، العراق.