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Efficiency of Three Coccinellid Species against *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) in Cabbage Fields at El-Behera Governorate, Egypt

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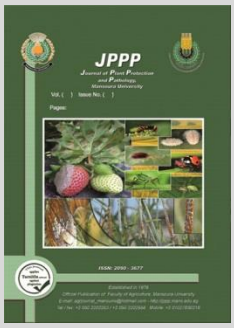

ABSTRACT

The efficiency of three Coccinellidae species against *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) in cabbage fields were carried out at El-Behiera Governorate, Egypt in tow successive season during the period from 4th August to 27th October, 2017 and 2018. When *Coccinella septempunctata* was released with 100 adults/ 1000 plants, the general mean number of *B. brassicae* was 29.24 and 31.96 in season 2017 and 2018, respectively. On the other hand, releasing *C. septempunctata* with 500 adults/ 1000 plants decreased the general mean number of *B. brassicae* by 13.16 and 13.86 in season 2017 and 2018, respectively. In season 2017, when 100 adults of *C. undecimpunctata* were released at the beginning of the study the population increased after four weeks recording 0.25 adult individual / plant. Meanwhile when 500 *C. undecimpunctata* were released in the same season, the population increased gradually and recorded the highest number at the end week of the study period. The Population fluctuations of *S. interruptus* did not affect the density of *B. brassicae* as well as the adult predator released. Number of *B. brassicae* increased gradually in season 2017 recording the highest number of 148 individuals/ plant.

Keywords: preferential feeding; release; field control; cabbage; Coccinellidae; *Brevicoryne brassicae*

INTRODUCTION

The cabbage aphid, *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) is one of economic pests of cruciferous crops attacking cabbage and cauliflower. This aphid is considered one of the most damaging pest and consistently present on cabbage and cauliflower crops (Theunissen, 1989). The pest caused damage to plants occurred with different ways, known to be the viruses vectors (Brunt *et al.*, 1996; Buchen-Usmond 2002; Strauss *et al.*, 2002 and Asi *et al*., 2009). Feeding in colonies of large numbers on young leaves, mostly on the undersurface and also on tender parts causes considerable damage, also the individuals suck the cell sap from leaves.

In Egypt, the coleopteran coccinellid is known as ladybird beetles, are important predators of many pests like aphid species; eggs and small nymphs of mealybugs, jassids, eggs and larvae of cotton leafworm (Ibrahim, 1948 & 1955 and Bilashini *et al*., 2007). Both adult and larval stages feed on insects harmful to plants, such as aphids and scale insects (Anonymous, 1997); so they have potential to control aphids on their host plants. Adults can consume up to 100 aphids per day (Arnett *et al.*, 1980). Under field conditions, numerous coccinellids consume nectar, honeydew, pollen, fruit, vegetation, and fungus. These non-prey foods are used by coccinellids to increase survival when prey is scarce. Each of these non-prey foods has unique nutritional and defensive characteristics that influence its suitability for lady beetles (Lundgren, 2009). The present study aimed to evaluate the management of the cabbage aphid, *B. brassicae* (L.) infesting cabbage plants by releasing different levels three species of coccinellidae which were *Coccinella septempunctata* L., *Coccinella undecimpunctata* L. and *Scymnus interruptus* L. (Coleoptera : Coccinellidae) in cabbage fields at El-Beheira Governorate, Egypt.

MATERIALS AND METHODS

Source and culture of plants, aphids and Coccinellid predators.

Cabbage plants were grown in plastic pots (25 cm diameter, 20 cm high) placed in glass cages (50*60*60) cm under climate-controlled room at 25 ± 2°C, 65–5% RH in the laboratory. One-month-old plants with five leaves were used for rearing *B. brassicae*. Cabbage aphids, *B. brassicae* were collected outdoor from cabbage filed cultivated in El-Behera Governorate, Egypt. A colony of aphid was reared at the laboratory on cultivated cabbage and kept under same condations. Under the same laboratory conditions, three colonies species of coccinellidae originally collected from several fields were reared, *i.e.*, *Coccinella septempunctata* L., *Coccinella undecimpunctata* L. and *Scymnus interruptus* L. They were fed and reared for several generations (Al-Solami *et. al* 2016) to provide high numbers of individuals before being used for field release.

Field experiments design.

The experiments were carried out at El-Behiera Governorate, Egypt in tow successive season during the

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period from 4th August to 27th October, 2017 and 2018. Six cabbage fileds for predators release and other filed for control were selected with distance between the seven selected farms with about one km away from each other. An area of a half fedden was selected as cultivated with cabbage in 11th July of the two years 2017 and 2018 and received no pesticide treatmen. This area was divided into five replicates and applied randomly in CRD design. Numbers of the aphid *B. brassicae* were recorded in each before reling the tested coccinellid species. . C. *septempunctata* , *C. undecimpunctata* and *S. interruptus* were released separately as treatment in each filed for on time as aphids appeared on cabbage plants. In three fields, predators were released as adult stage with number of 100 adults/ 1000 plants. On the other three fields, 500 predator adults/ 1000 plants were released once. The predators were released randomly in all distances of each field. Weekly data were recorded for numbers of each coleopteran coccinellid as well as numbers of *B. brassicae* on 20 plants.

Sampling data.

After one day from releasing the predators, weekly data were recorded for randomly collected numbers of predators and aphids on 20 plants in each treatment and the control. Averages were tabulated to evaluate predator's activity and efficiency in the field on one plant.

Data Analysis.

Data were analyzed using (SAS Institute, 1988) to test standard error between treatments ($p < .005$) and estimate LSD among treatment and estimated relation coefficient (r) for aphid and predators.

RESULTS AND DISCUSSION

1. Natural occurrence of *B. brassicae* and its coccinellad predators

To evaluate predation efficiency of the three coccinellad beetles, the natural occurrence of the aphid *B. brassicae* and the major predator in the field was recorded and reported in table (1). Data showed that few numbers were recorded for the predators, while *B. brassicae* was found with high number averaged 79.385 and 86.885 individual/ plant in season 2017 and 2018 respectively. *B. brassicae* showed few numbers in the first week, then aphid population increased gradually recordeing 177.00 and 200.70 individual/ plant in season 2017 and 2018, respectively. In addition, in season 2017, *C. septempunctata*, *C. undecimpunctata* and *S. interruptus* were recorded with few numbers of .015, 0.028 and 0.005/ plant, respectively. In season 2018, numbers of the three coccinellid predators was not increased than in season 2017; so it recorded average numbers of 0.014, 0.027 and 0.005 for each predator, respectively. *C. undecimpunctata* was the most dominant predator than others which recorded the highest number (Table 1).

Table 1. Population density and natural occurrence of three coccinellids and *B. brassicae* befor releasing in the seasons 2017 and 2018.

Date	Average numbers/ plant							
	2017				2018			
	C. septempunctata	*C. undecimpunctata*	*S. interruptus*	*B. brassicae*	*C. septempunctata*	*C. undecimpunctata*	*S. interruptus*	*B. brassicae*
04-August	0.00	0.00	0.00	12.00	0.00	0.00	0.00	17.80
08- August	0.00	0.00	0.00	15.00	0.00	0.00	0.00	19.00
15- August	0.00	0.00	0.00	15.00	0.00	0.00	0.00	20.10
22- August	0.00	0.01	0.00	21.00	0.00	0.00	0.00	31.20
29- August	0.00	0.01	0.00	38.60	0.00	0.01	0.00	44.80
5-September	0.01	0.03	0.00	44.30	0.00	0.04	0.00	56.50
12-September	0.01	0.02	0.00	88.50	0.01	0.03	0.00	87.90
19-September	0.01	0.04	0.01	97.40	0.00	0.04	0.00	122.30
26-September	0.02	0.06	0.00	112.70	0.01	0.04	0.00	106.60
3-October	0.03	0.07	0.00	97.20	0.04	0.05	0.01	124.30
10-October	0.03	0.02	0.02	134.30	0.02	0.04	0.01	158.80
17-October	0.03	0.05	0.02	179.00	0.04	0.03	0.02	139.50
24-October	0.05	0.06	0.01	177.00	0.06	0.07	0.03	200.70
Mean	0.015	0.028	0.005	79.385	0.014	0.027	0.005	86.885

2. Efficiency of *C. septempunctata* against *B. brassicae* after release in the seasons 2017 and 2018 on cabbage crop.

To evaluate offence of *C. septempunctata* against *B. brassicae* during the period between 4th August and 24th October in season 2017 and 2018, two levels of releasing the predator were applied for 1000 cabbage plants once in each season (table 2). In season 2017 when 100 *C. septempunctata* were released, *B. brassicae* decreased after two weeks then increased again recording the highest number of 47.60 in 5th November. In season 2017, *B. brassicae* ended the season with the lowest number of 10 individuals/plant and C. *septempunctata* recorded the highest number of 0.5 individual / plant. On the other hand, on the same season, *C. septempunctata* was released with 500/1000 plants as shown in table (2), data reflected that, *B. brassicae* decreased gradually and recorded the lowest number of 4.4 individual/ plant. Meanwhile, *C. septempunctata* decreased but recorded the highest number at the end week of 2017 with 1.6 individuals/plant. As well, in season 2018, when 100 *C. septempunctata* adults were released, *B. brassicae* decreased from 55 to 7 individual/ plant

In case of releasing 500 of *C. septempunctata* adults, *B. brassicae* recorded few numbers during all season 2018 weeks (Table 2). There is a significant difference between all density for the prey and predator. When *C. septempunctata* was released with 100 adults/ 1000 plants, the general mean number of *B. brassicae* was 29.24 and 31.96 in season 2017 and 2018, respectively. On

the other hand, when *C. septempunctata* was released with 500 adults/ 1000 plants the general mean number of *B. brassicae* was 13.16 and 13.86 in season 2017 and 2018, respectively. Habeeb *et al*. (2016) recorded that the seven-spotted ladybird, *C. septempunctata* could be used successfully as a biocontrol agent in an integrated program for controlling *B. brassicae* on alfalfa plants. They also recorded that the reduction percentages in the population of *B. brassicae* increased gradually with elapse of time reaching the maximum. The achieved average reductions in aphid population on alfalfa were 42.0, 53.7, 68.0, 80.0 and 89.8% on mid-February, first-March, mid-March, first-April and mid-April, respectively. In addition, the same trend was achieved in the second season (2013).

Table 2. Population density of *B. brassicae* after releasing 100 and 500 individuals of *C. septempunctata* adults once in season 2017 and 2018.

Date	Average numbers/ one plant							
	100/1000 plants				500/1000 plants			
	2017		2018		2017		2018	
	C. septempunctata	*B. brassicae*	*C. septempunctata*	*B. brassicae*	*C. septempunctata*	*B. brassicae*	*C. septempunctata*	*B. brassicae*
04-August	0.01^{l}	19.40^{g}	0.00^{j}	22.00^{g}	0.02^{m}	26.60^{a}	0.03l	21.60a
08- August	0.01^{k}	48.00^{a}	0.02^{i}	55.00^{b}	0.04^{l}	21.40^{b}	0.04l	21.40a
15- August	0.09^{j}	42.80^{b}	0.10h	57.00a	0.19^{k}	13.60^{f}	0.11k	13.60e
22- August	0.01^{l}	22.40^{f}	0.01^{i}	51.00^{c}	0.23^{j}	18.20^{c}	0.27^{g}	18.20^{b}
29- August	0.10^{i}	38.60^{c}	0.11^{g}	38.60^{e}	0.40^{i}	14.60^{e}	0.40^{i}	14.60^{d}
5-September	0.15^{e}	47.60^{a}	0.14^{e}	47.60^{d}	0.62^{h}	16.40^{d}	0.62^{h}	16.40^{c}
12-September	0.14^{f}	38.80^{c}	0.14^{e}	38.80^{e}	0.73^{g}	12.40^{g}	0.73^{f}	12.40^{f}
19-September	0.20^{d}	27.90^{d}	0.22^{d}	27.90^{f}	0.81^{f}	8.20^{j}	0.66^{g}	18.20^{b}
26-September	0.22^{c}	12.70^{i}	0.24^{c}	12.70^{i}	0.90^{e}	10.20^{h}	0.90^{e}	10.20^{h}
3-October	0.11^{h}	27.60^{d}	0.13^{f}	27.60^{f}	0.93^{d}	8.80^{i}	0.93^{d}	8.80^{h}
10-October	0.13^{g}	18.40^{h}	0.13^{f}	18.40^{h}	1.05^{b}	8.20^{j}	1.25^{b}	12.20^{f}
17-October	0.40^{b}	26.00^{e}	0.40^{b}	12.00^{i}	1.00^{c}	8.20^{j}	1.00^{c}	8.20^{i}
24-October	0.50^{a}	10.00^{j}	0.54^{a}	7.00^{j}	1.60^{a}	4.40^{k}	1.40^{a}	4.40^{j}
Mean	0.16	29.24	0.15	31.96	0.65	13.16	0.64	13.86
LSD	0.01	0.58	0.01	0.767	0.02	0.28	0.02	0.23

3. Efficiency of *C. undecimpunctata* against *B. brassicae* after release in season 2017 and 2018 on cabbage crop.

As shown table (3) data reflected that, *C. undecimpunctata* was more active in season 2017 than in season 2018 and moreover when released by 500 than 100 adults. In contrast, population density of *B. brassicae* decreased gradually in season 2017 and 2018 as well as *C. undecimpunctata* decreased in number. In season 2017, when 100 adults of *C. undecimpunctata* were released at the beginning of the study, its population increased after four weeks recording 0.25 l adults/plant. Meanwhile, in the same season, when 500 *C. undecimpunctata* adults were released, its population increased gradually and recorded the highest number at the end week of the study period. In season 2018, *C. undecimpunctata* recorded the highest number in the week before the study ended and recorded 1.38 individual/ plant. Taha *et al.* (2014) reported that, after two weeks from *C. undecimpunctata* release, the reduction percentage reach its maximum (91.2, 86.0 and 89.7 %) for three treatments during two successive seasons respectively.

Table 3. Population density of *B. brassicae* after release of *C. undecimpunctata* in season 2017 and 2018.

Date	Average numbers/ plant							
	100/1000 plants				500/1000 plants			
	2017		2018		2017		2018	
	C. undecimpunctata	*B. brassicae*	*C. undecimpunctata*	*B. brassicae*	*C. undecimpunctata*	*B. brassicae*	*C. undecimpunctata*	*B. brassicae*
04-August	0.03^{ij}	44.20^{i}	0.06^{k}	43.20^{j}	0.05^{k}	35.00^{c}	0.04^{i}	36.00^{c}
08- August	0.02^{j}	39.60^{k}	0.09^{i}	72.40^{e}	0.07^{j}	46.00^{a}	0.08^{k}	45.00^{a}
15- August	0.02^{j}	62.40^{g}	0.09^{i}	61.40^{g}	0.15^{h}	27.00^{d}	0.14^{i}	28.00^{e}
22- August	0.02^{j}	32.40^{l}	0.08^{j}	54.60^{i}	0.11^{i}	20.00^{g}	0.12^{j}	34.00^{d}
29- August	0.04^{i}	40.50^{j}	0.07^{j}	41.50^{k}	0.45^{g}	18.20^{i}	0.44^{h}	18.20^{i}
5-September	0.25^{g}	62.40^{g}	0.15^{h}	45.00^{j}	0.69^{e}	22.40^{f}	0.65^{g}	21.40^{g}
12-September	0.45^{d}	55.20^{h}	0.44^{c}	56.20^{h}	0.86^{d}	36.20^{b}	0.87^{e}	37.20^{d}
19-September	0.32^{f}	80.40^{e}	0.42^{d}	67.20^{f}	0.99^{d}	26.40^{e}	0.77^{f}	25.40^{f}
26-September	0.36^{e}	78.60^{f}	0.37^{e}	62.80^{g}	0.65^{f}	17.80^{h}	0.64^{g}	18.80^{h}
3-October	0.22^{h}	89.60^{d}	0.21^{f}	88.60^{b}	0.98^{d}	16.40^{j}	0.92^{d}	18.20^{i}
10-October	0.80^{a}	109.40^{b}	0.81^{a}	74.70^{d}	1.23^{c}	22.20^{f}	1.22^{b}	21.20^{g}
17-October	0.77^{b}	98.60^{c}	0.67^{b}	99.60^{a}	1.37^{b}	16.20^{j}	1.38^{a}	26.20^{f}
24-October	0.69^{c}	123.40^{a}	0.18^{g}	87.40^{c}	1.56^{a}	12.60^{k}	1.11^{c}	10.60^{j}
Mean	0.30	70.74	0.28	65.96	0.70	24.64	0.69	26.48
LSD	0.01	1.31	0.011	0.81	0.02	0.44	0.02	0.43

4. Efficiency of *S. interruptus* against *B. brassicae* after release in season 2017 and 2018 on cabbage crop.

Data in table (4) recorded that, *S. interruptus* in season 2017 after it's released level of 100 adults / 1000 plants, its population increased gradually till it recorded the highest number of 0.27 in 3rd October. *S. interruptus* was also recorded with few numbers in season 2018 when released by 100 adults/1000 plants with the highest number of 0.77 in 17th October. On the other hand, when *S. interruptus* was released by 500 adults for 1000 plants, the

population recorded high level as the highest number of 0.45 and 0.87 individual in 17th October and 24th October respectably. Population fluctuation of *S. interruptus* showed no effect on *B. brassicae* density as the predator adult released. *B. brassicae* increased gradually in numbers in season 2017 recording the highest number of 148 individuals/plant. Meanwhile, *B. brassicae* population recorded few numbers in season 2018 when *S. interruptus* was released by 100 and 500 adults/1000 pwhere number *B. brassicae* recorded the average of 37.86/plant. Aleixandre, (2018) *et al*., indicated that *S. interruptus* initially reduced the aphid population; however, in the long-term, the infestation was not controlled. *S. interruptus* were recorded on the plants due to natural differences in the flight propensity of the species tested (Hodek *et al.,* 1993) or due to decreased flight activity in the captive population of *Adalia bipunctata*. Migration away from the plants has been mentioned as one of the main reasons for the ineffectiveness of ladybirds in aphid control (Hamalainen, 1977).

Table 4. Population density of *B. brassicae* after release of *S. interruptus* in season 2017 and 2018.

Date	Average numbers/ plant							
	100/1000 plants				500/1000 plants			
	2017		2018		2017		2018	
	S. interruptus	*B. brassicae*	*S. interruptus*	*B. brassicae*	*S. interruptus*	*B. brassicae*	*S. interruptus*	*B. brassicae*
04-August	0.00^{j}	32.40^{l}	0.01^{j}	32.40^{k}	0.01^{l}	42.20^{f}	0.01^{k}	36.60^{g}
08- August	0.01^{jk}	60.40^{k}	0.01^{j}	60.40^{j}	0.02^{k}	48.60^{c}	0.04^{j}	48.60^{c}
15- August	0.01^{k}	73.40^{i}	0.00^{k}	73.40^{g}	0.57^{c}	38.40^{f}	0.57^{c}	38.40^{f}
22- August	0.02^{i}	79.20^{h}	0.02^{i}	79.20^{f}	0.89^{a}	28.00^{k}	0.69^{a}	26.40^{i}
29- August	0.04^{g}	68.90^{j}	0.04^{g}	68.90^{i}	0.12^{i}	29.00^{j}	0.16^{h}	22.80^{j}
5-September	0.02^{i}	72.20^{i}	0.04^{g}	72.20^{h}	0.10^{j}	22.20^{l}	0.28^{g}	22.20^{k}
12-September	0.03^{h}	84.90^{g}	0.03^{h}	84.90^{e}	0.12^{h}	29.60^{i}	0.14^{i}	29.60^{i}
19-September	0.18^{c}	95.20^{e}	0.21^{c}	95.20^{c}	0.38^{e}	44.60^{d}	0.38^{e}	44.60^{d}
26-September	0.27^{a}	89.40^{f}	0.27^{b}	89.40^{d}	0.29^{g}	49.20^{b}	0.29^{g}	70.20^{a}
3-October	0.15^{d}	118.60^{d}	0.15^{e}	88.40^{d}	0.36^{f}	56.20^{a}	0.36^{f}	56.20^{b}
10-October	0.19^{b}	134.20^{b}	0.19^{d}	78.80^{f}	0.49^{d}	35.40^{h}	0.49^{d}	35.40^{h}
17-October	0.12^{e}	122.60^{c}	0.14^{f}	22.60a	0.77^{b}	43.20^{e}	0.87^{b}	43.20^{e}
24-October	0.07^{f}	148.20^{a}	0.45^{a}	17.80b	0.57^{c}	38.00^{g}	0.57^{c}	18.00^{i}
Mean	0.08	90.73	0.12	81.82	0.36	38.81	0.38	37.86
LSD	0.01	1.48	0.01	1.03	0.01	0.44	0.01	0.66

5. Comparison between the three coccinellid predators against *B. brassicae*.

To determine the effect of *B. brassicae* on dispersal of the three tested coccinellids, regression equation and correlation values were calculated and presented in table (5). Data showed negative correlation between aphid prey and each of *C. septempunctata* and *C. undecimpunctata* but the correlation was positive when *S. interruptus* was released.

Table 5. Correlation values , simple regression equation between *B. brassicae* and the three released coccinellieds during season 2017 and 2018.

No. of Predator released	2017			2018		
	C. septempunctata	*C. undecimpunctata*	*S. interruptus*	*C. septempunctata*	*C. undecimpunctata*	*S. interruptus*
100/1000 plants	Y= 21.32-17.42X	Y= 33.79-27.31X	Y= 45.76-33.87X	Y= 37.56-11.22X	Y= 24.23-17.47X	Y= 46.67-43.55X
500/1000 plants	Y= 29.77-21.02X	Y= 31.09-24.31X	Y= 39.46-33.47X	Y= 23.56-16.20X	Y= 34.43-15.97X	Y= 56.17-33.35X
100/1000 plants	-0.76	-0.44	0.56	-0.43	-0.56	0.51
500/1000 plants	-0.86	-0.64	0.61	-0.49	-0.67	0.54
100/1000 plants	0.16	0.30	0.08	0.15	0.28	0.12
500/1000 plants	o.65	0.70	0.36	0.64	0.69	0.38

Y= *B. brassicae*, X= coccinelliden

Regression equation recorded in table (5) calculated efficiency of the released predator in relation to the prey recorded numbers. In the general, mean number representing population of each coccinellid predator showed *C. undecimpunctata* as the important tested predator recording high numbers compared with *C. septempunctata* and *S. interruptus*. On the other hand, when the predator was released at level of 500 adults/ 1000 plants, *C. undecimpunctata* recorded 0.70 adult individual / plant. *S. interruptus* showed few numbers less than 0.38/plant. Eid *et al.* (2018) mentioned in his study that the cost of aphid biological control was more than that of the insecticide one, but the yield was much higher, recording 63.88% increase in 2015 and 64.91% in 2016. Askar, and El Husseini (2020) recorded that, *C. septempunctata* was the most efficient in predation on aphid

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كفاءة ثلاثة أنواع من مفترسات ابو العيد ضد **Brevicoryne brassicae (L.) (Homoptera: Aphididae)** في حقول الكرنب بمحافظة البحيرة ، مصر

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أجريت التجارب في محافظة البحيرة بمصر في موسمين متتاليين خلال الفترة من ٤ أغسطس إلى ٢٧ أكتوبر ٢٠١٧ و ٢٠١٨. عندما تم إطلاق *C. septempunctata* بمعدل ١٠٠ حشرة كامله / ١٠٠٠ نبات ، كان المتوسط العام لعدد *B. brassicae* 29.24 و ٣١,٩٦ في موسم ٢٠١٧ و ٢٠١٨ على التوالي. من ناحية أخرى ، أدى إطلاق *C. septempunctata* مع ٥٠٠ حشرة كاملة / ١٠٠٠ نبات إلى انخفاض متوسط العدد العام لحشرة المن من النوع *B. brassicae* بمقدار ١٣,١٦ و ١٣,٨٦ في موسم ٢٠١٧ و ٢٠١٨ على التوالي. في موسم ٢٠١٧ ، عندما تم إطلاق ١٠٠ حشرة كاملة من *C. undecimpunctata* في بداية الدراسة ، ازداد عدد عشيرة بعد أربعة أسابيع مسجلاً ٠,٢٥ فردًا / نباتً. وفي الوقت نفسه ، عندما تم إطلاق ٥٠٠ *C. undecimpunctata* في نفس الموسم ، زاد عدد العشيرة تدريجيًا وسجل أعلى معدل في نهاية أسبوع من فترة الدراسة. لم يظهر تذبذب عشيرة *S. interruptus* أي تأثير على كثافة *B. brassicae* بإطلاق حشرات مفترسة حيث ارتفع عدد المن من النوع *B. brassicae* تدريجياً في موسم ٢٠١٧ مسجلاً أعلى عدد بلغ ١٤٨ فرد / نبات.