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Studies on Predatory Insects Attacking *Parlatoria ziziphi* (Lucas) (Hemiptera : Diaspididae) on Navel Orange Trees

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Abstract: This study was carried out two years 2021-2022 in neglected citrus orchard located at Motubas, Kafer El-Sheikh Governorate, Egypt. Ten predators were found associated with citrus trees infested with *P. ziziphi* population. Three predators named *Chilocorus bipustulatus* L., *Cybocephalus flavipes* Reitter and *Scymnus syriacus* Mars. (Coleoptera: Coccinellidae) were recorded all over two years of study by relatively high number. Seven predators were recorded rarely in few numbers on the infested orange trees namely *Exochomus flavipes* Thunb., *Rodalia cardinalis* Muls, *Coccinella undecimpunctata* L., *Coccinella septempunctata* L, *Pharoscymnus various* Kirsch., (Coleoptera: Coccinellidae) *Orius laevigatus* Fieb. (Hemiptera: Anthocoridae) and *Chrysoperla carna* Steph. (Neuroptera: Chrysopidae). The value of total mortality in first year is higher than second year. The insect predators' activities were recorded highest value in spring season in both years of study. Also, the percentage of predation rate were recorded the highest on spring season in both years of study. *C. bipustulatus* population showed the highest number of insect predators all over two years of study. The predator *C. flavipes* and *S. syriacus* had recorded three peaks in two years of study. Evaluation of searching rate for three predator's *C. bipustulatus*, *C. flavipes* and *S. syricus* under the laboratory and field conditions at different densities**.** The predator *C. bipustulatus* had highest searching rate. This study highlighting the future importance of the predator *C. bipustulatus* as a biocontrol agent against this pest by multiply it in the laboratory and release it in the field to combat this pest.

Key words: *Parlatoria ziziphi*, *Chilocorus bipustulatus* L., Cybocephalus flavipes, Reitter and Scymnus syriacus Mars., Citrus trees.

INTRODUCTION

In Egypt, the navel orange, *Citrus sinensis* (L.), is one of the most economical crops. Much attention has been paid to improve the quality and quantity of this culture **(Nabil, 2018)**. Citrus planting area has increased significantly over the last few decades and is now around 530,415 hectares, fruit area reached 440,706 Fed., produced about 4402180 tons at an average of 10.42 tons/fed. **(Ministry of Agriculture, Forestry and Fisheries statistics, 2014)**. Scale insects deprive citrus trees of vital fluids, impairing fruit quality and tree health **(Wawrzynski and Ascerno, 2009)**.

The black scale insect *Parlatoria ziziphi* (Lucas) (Hemiptera: Diaspididae) is one of the most destructive citrus pests. It is a cosmopolitan species and is actually very common in citrus fruits in some countries. It was native to Europe and later had numerous hosts in all tropical and subtropical regions of the world, especially citrus **(Ferris, 1937; Tawfeek and Abu-shall, 2010)**. Populations then often exceed acceptable limits, so the citrus must be protected from all risks that can cause direct or indirect damage **(Garcia Morales *et al.*, 2016)**.

Moustafa (2012), Nabil *et al.* (2019) and Eldefrawy *et al.* (2021) reported that the black scale, *P. ziziphi*, is one of the major scales that infest citrus trees.

Abd-Rabou, *et al.* (2012) recorded predators associated with hard scale insects. They were three families, (Coleoptera: Coccinellidae; *Chilocorus bipustulatus* L., Coccinella *undecimpunctata L.*, Exochomus *flavipes Thunb.*, *Pharoscymnus various* Kirsch., Rhyzobius *lophanthae* (Blaisdell), Rodalia *cardinalis* Muls, *Scymnus syriacus* Mars. and Stethorus sp.), (Hemiptera: Anthocoridae, Orius *laevigatus* Fieb.) and (Neuroptera: Chrysopidae, Chrysoperla *carna* Steph. and *Chrysopa vulgaris* L.).

In Greece recorded the predator *Cybocephalus fodori* Endrödy- Youga (Coleoptera: Cybocephalidae) on scale insect **(Japoshvili *et al.*, 2010)**.

Chilocorus nigritus (F.) was one of the most successful coccidophagus coccinelides in the world. A history of classical biological control. It is an effective predator of many species of Diaspididae. some coccidae and some asterocyridae with the ability to colonize relatively large areas tropical and subtropical environments **(Ponsonby, 2009).**

The green lacewing, *Chrysoperla carnea* (Steph.), is a voracious predator with a variety of soft bodies Arthropods including aphids, scales, mealybugs, caterpillars, leafhoppers, plantains, whiteflies, thrips, and insect eggs; Spiders, ticks, etc. **(Canard and Principi, 1984)**.

Since then, functional responses have received much attention in the entomological and ecological literature **(Holling, 1959&1963 (Rogers, 1972; Fan & Petitt, 1994and Williams & Juliano, 1996)**. They showed functional responses as changes in the number of preys consumed by each predator in response to changes in prey density over time. Also, they divided it into 3 major type's graphical representation of the relationship between prey density and the number consumed by each predator at a specific time.

The aim of this study focused on the role of predators associated with the *P. ziziphi* on citrus trees and evaluation of the functional response of its main predators.

MATERIALS AND METHODS

1- Survey and influence of insect predators on *Parlatoria ziziphi* (Lucas) (Hemiptera : Diaspididae) population

The experiment was conducted in neglected citrus orchard located at Motubas, KaferEl-Sheikh Governorate, Egypt.

Sample Procedures

Five navel orange trees *Citrus sinensis* L. infested with *P. ziziphi* homogenous in size and age were selected and marked for the present study. Samples were collected biweekly during two successive years from the 5th of January 2021 till 26th of December 2022.Each sample consisted of 75infested leaves (15leaves / tree) collected from north, south, east, west and middle of the trees, leaves were covered with paper bag pulled up well tied and taken to the laboratory for examination. Leaves of each tree were investigated on both surfaces using a binocular microscope. The black parlatoria *P. ziziphi* instars were recorded as living, dead and predated.

To estimate the seasonal abundance of predators associated with *P. ziziphi* infested navel orange citrus trees, five double strokes of sweeping net of a regular size were carried out in each of the cardinal direction of the chosen trees, so that each sample was presented by twenty double strokes for each trees.

The catch of each direction for each tree was transferred in a paper bag containing a piece of cotton saturated with ether for anesthetizing the collected insects. These bags were transferred to the laboratory for identification and counting.

Simple correlation and regression values were calculated to evaluate the role of predation on suppressing *P. ziziphi* population.

2- Evaluation of the searching rate of *Chilocorus bipustulatus* L., *Cybocephalus flavipes* Reitter and *Scymnus syriacus* Mars. (Coleoptera: Coccinellidae)

2.1. Under field conditions

To determine the searching rate of three tested predators in the navel citrus orchard. Orange leaves were selected and marked on the trees. The marked leaves were artificially infested with crawlers of *P. ziziphi*. The total number of settled crawlers recorded and caged by using muslin (15 Cm in diameter X 40 Cm length).

Each cage continued 200 individuals. Five predator densities namely 1, 2, 4, 6 and 8 were examined with each predator density in the cage for one day. Each predator density was replicated five times.

The searching rate was calculated according to **Rogers and Hassell, 1974** as follow:

$$a= 1/p \text{ Log } N/S$$

Where:

P= the number of predators

N= the number of preys

S= the number of unpredeceased *P. ziziphi*

2.2- Under laboratory conditions

To compare the searching rate of three tested predators (*C. bipustulatus*, *C. flavipes* and *S. syriacus*) in the laboratory for predator's densities namely 1, 3, 5 and 7 were examined by confining 100 individuals of *P. ziziphi* 1^{st} nymph stage with each predator density in petri-dish. The searching rate was calculated according to the same pervious equation.

RESULTS AND DISCUSSION

1. Predator insects associated with the black Parlatoria Scale, *Parlatoria ziziphi* (Lucas) (Hemiptera: Diaspididae).

1.1. Survey

This study was carried out during two years 2021-2022 in neglected citrus orchard located at Motubas, KaferEl-Sheikh Governorate, Egypt. Ten predators were found associated with citrus trees infested with *P. ziziphi* population.

Three predators were *Chilocorus bipustulatus* L., *Cybocephalus flavipes* Reitter and *Scymnus syriacus* Mars. (Coleoptera: Coccinellidae) were of them recorded numbers all over two years of study by high number relatively. Seven predators were recorded rarely in few numbers on the infested orange trees namely *Exochomus flavipes* Thunb., *Rodalia cardinalis* Muls, *Coccinella undecimpunctata* L., *Coccinella septempunctata* L, *Pharoscymnus various* Kirsch., (Coleoptera: Coccinellidae) *Orius laevigatus* Fieb. (Hemiptera: Anthocoridae) and *Chrysoperla carna* Steph. (Neuroptera: Chrysopidae).

This result agrees with **Awadalla *et al.* (2021)** recorded seven predators associated with *P. ziziphi* on citrus in Mansoura region they were *C. undecimpunctata*, *C.septempunctata*, *C. bipustulatus*, *Paederus alferii* Koch.,*Cheilomenes propinqua isis* (mulsant), *Cheilomenes propinqua nilotica* mulsant and *C. carnea* (Steph). Also, **Abd-Allha *et al.* (2002) and Ducattia *et al.* (2020)** reported that the most important order was Coleoptera.

1.2. Population dynamic of insect predators

Data illustrated in Fig. (1), showed the average number of main insect predators in each sample collected by sweeping net in first year of study 2021 on orchard located at Motubas, KaferEl-Sheikh Governorate, Egypt.

C. bipustulatus population showed the highest number of insect predators all over two years of study. In fig. (1& 2) this predator had recorded tow peaks were on the second week of May (56 individuals), end of October (58 individuals) in the first year. In the second year of study the predator *C. bipustulatus* population recorded number less than in first year, also recorded two peaks in spring and autumn by (47 & 49 individuals, respectively).

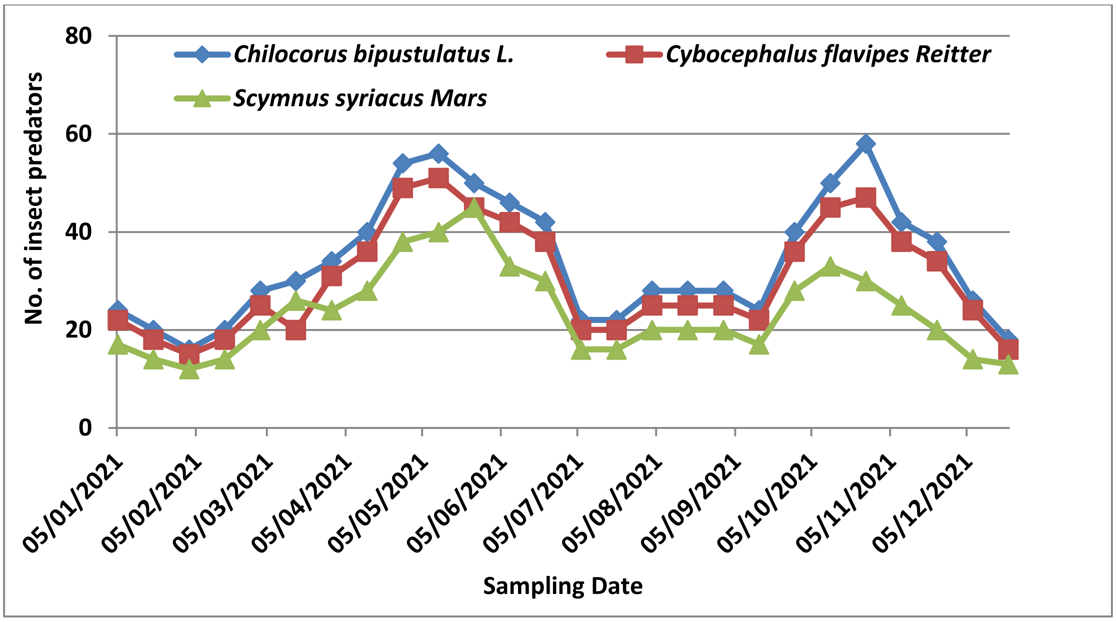

Fig. 1. Population dynamic of insect predators associated with the black scale insect *Parlatoria ziziphi* (Lucas) on orange trees during 2021 at Motubas, KaferEl-Sheikh Governorate, Egypt.

In first year of study *C. flavipes* appeared in second degree in the value of number of populations between the three predators (Fig. 1).

C. flavipes population showed four peaks in tow year of study fig. (1). These peaks on 2nd of March, 11th of May, 31th of Augustus and 26th of October by (25, 51,25 and 47 individuals), respectively. Also, in second year the predator *C. flavipes* recorded four peaks the highest one in spring by 30 individuals (Figure 2).

The predator *S. syriacus* had recorded four peaks in the first year of study 2021 these peaks were recorded on 16th of March, 25th of May, 31th of Augustus and 12th of October by (26, 45, 22 and 33 individuals), respectively Fig. (1). In the second year of study 2022 the predator *S. syriacus* recorded three peaks but the highest peak was on 11th of October by (30 individuals).

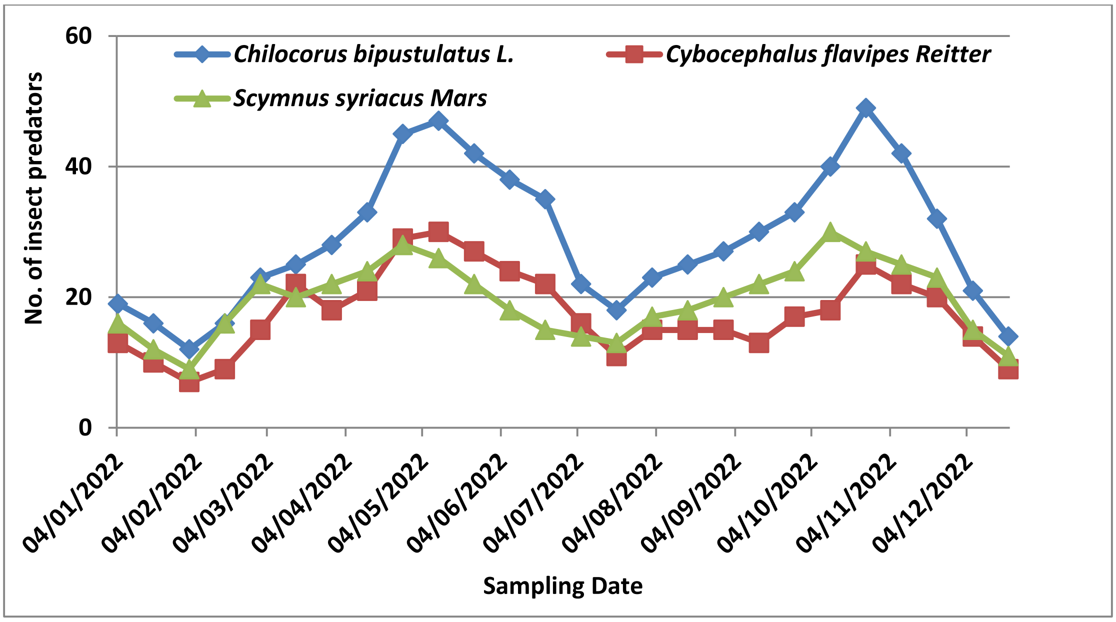

Fig. 2. Population dynamic of insect predators associated with the black scale insect *Parlatoria ziziphi* (Lucas) on orange trees during 2022 at Motubas, KaferEl-Sheikh Governorate, Egypt.

These results agreement with in Kafr el-Sheikh all insect predators had recorded two peaks on citrus trees on spring and autumn season **(El-Agamy *et al.* 1994). Also, Abd-Allah *et al.* (2002) and AbdRabou *et al.* (2012)** they found that five predators were associated with *Chrysomphalus aonidum* (L.) and *Lepidosaphes beckii* New (Homoptera : Diaspididae).

C. bipustulatus predators the most important of scale insect **(El-Agamy *et al.* 1994, Abou Hatab 1999 and Abd-Allah *et al.*, 2002)**.

2- Efficiency of insect predators on the black Parlatoria Scale, *Parlatoria ziziphi* (Lucas) (Hemiptera: Diaspididae)

This study evaluate the role of insect predators on the black scale insect *Parlatoria ziziphi* (Lucas) in neglected citrus orchard located at Motubas, KaferEl-Sheikh Governorate, Egypt. Data illustrated in Table (1) the average number of the total mortality (TM) of *P. ziziphi* and the number of individual's predation (No. pred.) and the percentage of predation % in four seasons of each year.

The value of total mortality in first year is higher than second year. The insect predators' activities were recorded highest value in spring season (85.2 ±20.9) and (56.8 ±13.9) in both years of study. Also, the percentage of predation rates were recorded the highest on spring season (77.9±21.0) and (67.5±18.1) in both years of study (Table 1).

The lowest predation rates of the insect predators were noticed in the winter season by (34.8±7.5) and (30.2±6.5) in both years of study.

These results agreement with **Awadalla, *et al.* (2021)** they found the highest average of predation % was in autumn followed by spring on *P. ziziphi*. **Abd - Allah *et al.* (2002)**, they found the predators attacking *Lepidosaphes beckii* New and *Chryysomphalus aonidum* (L.). on citrus trees the highest activity on autumn and lowest one in winter season, also **El-Agamy *et al.* (1994)** found similar result.

Table (1). Total mortality, predation number and percentages of the black scale insect *Parlatoria ziziphi* (Lucas) caused by predation during four seasons of the two years 2021-2022

Seasons	2021			2022		
	TM	No. pred.	Pre. %	TM	No. pred.	Pre. %
Winter	40.3 ± 4.8	12.0±2.0	34.8±7.5	26.8 ±3.2	9.2 ± 1.5	30.2±6.5
Spring	85.2 ±20.9	58.7±25.0	77.9±21.0	56.8 ±13.9	45.2 ± 19.2	67.5±18.1
Summer	47.7± 11.5	19.4 ±6.2	47.3 ±11.4	31.8 ± 7.6	14.9 ± 4.8	41.0 ±9.9
Autumn	72.5±18.3	44.1±25.3	65.1±23.7	48.3 ±12.2	33.9 ± 19.5	56.4±20.6
All the year	61.3± 22.1	33.4± 24.4	56.3 ±22.1	25.7 ±18.7	40.9 ±14.7	48.8±19.2

3. Searching rate of *C. bipustulatus*, *C. flavipes* and *S. syriacus*

3.1. Under laboratory conditions

Evaluation the value of searching rate for three predators *C. bipustulatus*, *C. flavipes* and *S. syricus* on the laboratory conditions at different densities illustrated in Figure (3).

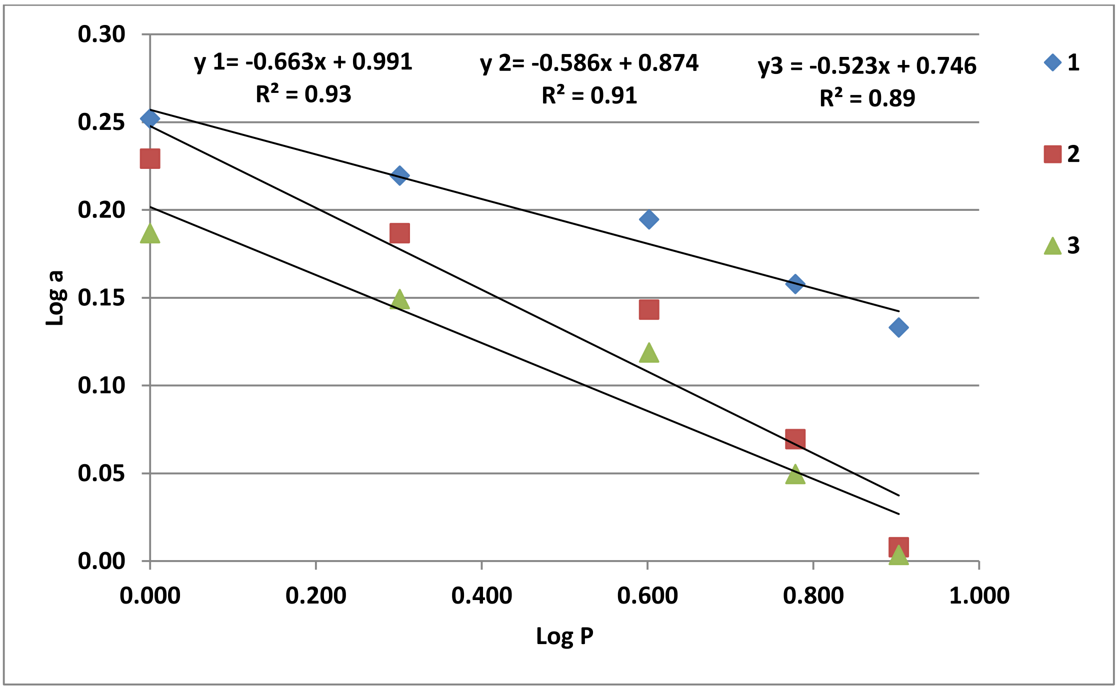

Figure 3. The regression between predator density (Log P) and searching rate (Log a) of *C. bipustulatus* (1), *C. flavipes* (2) and *S. syriacus* (3) under the laboratory conditions.

Obtained data in figure (3), showed the predator *C. bipustulatus* had highest searching rate. When density of the predators increased the interference effect between predator individuals (the rate of predation) decreased.

From the regression equation on figure (3). the interference for *C. bipustulatus*, *C. flavipes* and *S. syricus* were (-0.663, -0.586 and -0.523) respectively.

3.2. Under field conditions

As shown in Fig. (4) the searching rate for three predator's *C. bipustulatus*, *C. flavipes* and *S. syricus* with different densities under field conditions. In allover densities of the predator *S. syricus* had recorded the lowest value of the searching rate. From the regression equation in Fig. (4), the interference for *C. bipustulatus*, *C. flavipes* and *S. syricus* were (-0.261, -0.23 and -0.194), respectively.

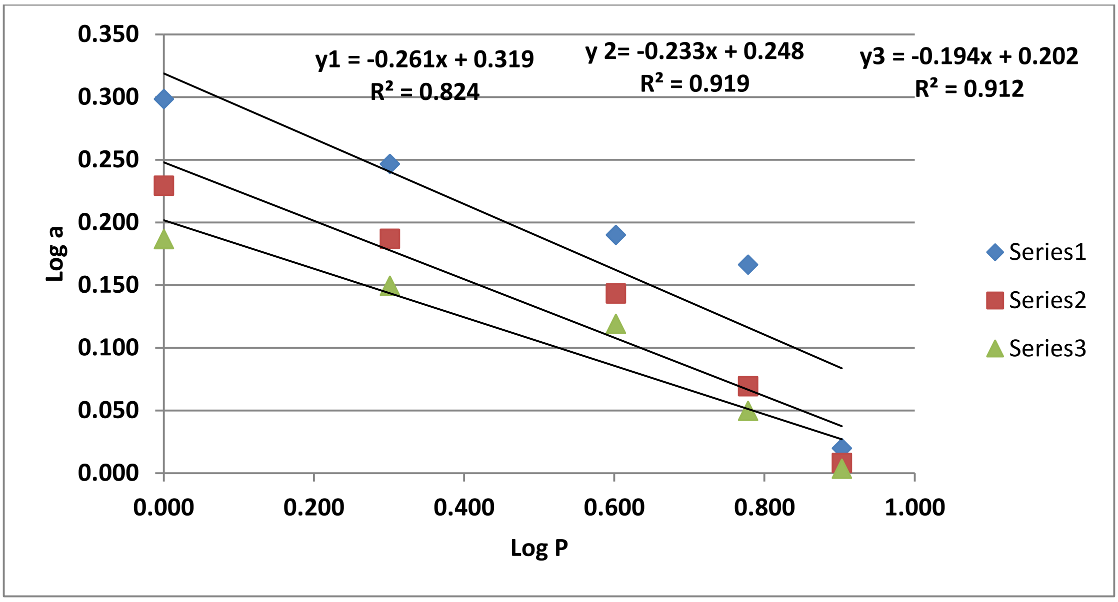

Figure 4. The regression between predator density (Log P) and searching rate (Log a) of *C. bipustulatus* (1), *C. flavipes* (2) and *S. syriacus* (3) under the field conditions.

This result similar to **Henen and Podoler (1986) and Abd – Allah *et al.* (2002)** they found that *C. bipustulatus* increased in densities increased the searching rate.

Evaluation is essential before using natural enemies in biological control programs its efficiency under laboratory conditions. One of the most informative evaluation natural enemies efficiency examines behavioral characteristics including functional response **(Fathipour *et al.*, 2010)**. Differences in killing efficiency of natural enemies against different host species can be estimated by comparing functional response parameters **(Juliano, 2001 and Bayoumy *et al.*, 2009)**.

A type I response is characterized by a linear increase, a type II response with a monotonically decreasing increase, and a type III response with a sigmoidal increase of the attacked host. Functional responses are important for implementing the rapid population control required for biological flood control **(Mills and Lacan, 2004)**.

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