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Latania Scale -Insect Parasitoid Interactions under Field Conditions

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Abstract

Studying the natural relationship between the insects and their natural enemies under field condition is useful for determining their response to the density of their hosts. This study was carried out to evaluate the density-dependent response for insect parasitoids associated with the latania scale, *Hemiberlesia lataniae* (Signoret) (Diaspididae: Hemiptera) on fig, guava, and loquat plants. The density dependent response was affected by several factors i.e season, plant and parasitoid species. Two parasitoid species, *Aphytis diaspidis* Howard (Aphelinidae: Hymenoptera) and *Signiphora* sp. (Signiphoridae: Hymenoptera) were found associated with *H. lataniae* on all host plants. The parasitoid *A. diaspidis* showed a positive density-dependent response to density of its host during winter, spring, and summer generations on loquat tree; inverse-density response on guava tree during winter and summer, and both responses to latania scale densities on fig tree. The parasitoid, *Signiphora* sp. showed differences in its response on the tested host plant species. On guava, it showed a positive-density dependent response to *H. lataniae* populations during winter and spring, but negatively during summer. On the other hand, fig tree, this response was negative during winter and positive during summer, whereas it is disappeared during spring season. On loquat, *Signiphora* sp. exhibited positive responses to its host during winter and spring seasons, whereas this response was negative during summer season. This variation in parasitoid responses could be attributed to several reasons, among them the effects of interspecific competition and host plant. Almost, both parasitoid species showed a tendency to aggregate where host density is highest on loquat.

Keywords: Aggregation; *Aphytis diaspidis*; *Hemiberlesia lataniae*; killing power *Signiphora* sp

Introduction

Armored scale insects (Hemiptera: Diaspididae) are one of the most important groups of agriculture pests. Many species are highly destructive to fruit trees and ornamental plants [1]. The latania scale (LS), *Hemiberlesia lataniae* (Signoret) is one of the most serious diaspidid pests worldwide [2-5]. Natural enemies of diaspidid species include pathogens, predators, and parasitoids. Pathogens and predators are rather non-specific and often depend on high prey densities. Parasitoid is able to remarkably reduce population levels of scale insects [5]. Parasitoids as abio-control agent provide an opportunity for significant reduction in LS populations [6,7]. The parasitoid, *Aphytis diaspidis* Howard (Aphelinidae: Hymenoptera) is among the main mortality factor regulating the populations of several diaspidid species including LS [7-9]. The signiphorid parasitoid, *Signiphora* sp. was recorded for the first time attacking latania scale in Mansoura region [10]. The *Signiphora fax* Girault was also recorded for the first time on ornamental plants in the Alexandria district, Egypt [11], *S. flavella* and *S. perpauca* on LS in Queensland [12], *S. merceti* (Malenotti) on *Hemiberlesia rapax* (Comstock) in Italia [13] and New Zealand [14] and S. flavopalliata reared from *Aspidiotus nerii* Bouch., *Hemiberlesia latastei* (Ckll.), *Chrysomphalus aonidum* (L.), *Aonidiella aurantii* (Mask.) and *Coccus hesperidum* L in Argentine Republic [15]. Generally, the most of *Signiphora* species are known to be specific on some hemipterous pests especially *Bemisia* sp. and there is lack in evaluating the potential role of this species against diaspidid scale insects.

There are some searching characteristics that should be evaluated in in the biocontrol agent prior to its use in the biological control programs. They include characteristics which will tend to reduce the average population density of the host, such as tendency to aggregate where host density is high (density-dependent response) [16,17]. Most of the previous research have been evaluated the response of natural enemies to the populations of their hosts under lab conditions, however few studies assessed their behavioural responses under natural conditions. Studying the relation between the parasitoid and its insect hosts during the different season of the year from field samples will help in determining the suitable time for either control procedures or augmentative releases. Therefore, the study was conducted to determine the reaction response of latania scale density for two parasitoids under field conditions.

Materials and Methods

Density - dependent response

The density- dependent response was determined for *A. diaspidis* and *Signiphora* sp. in response to *H. lataniae* on fig, guava, and loquat trees during 2017. Five trees of each host plant infested with parasitoid's host were marked and numbered at the experimental farm belonging to the farm of Mansoura University. In each sample, ten heavily infested leaves were collected from each tree of fig and guavas and five twigs (20 cm long) from loquat trees. Samples were collected every two weeks during the periods of December-February (winter generation), March- May (spring generation) and June–August (summer generation) of 2017 season. The numbers of 2nd instar and adult stages of the insect host per each tree and sample were recorded under laboratory conditions using binocular microscope. Then, the infested samples were kept in Petri-dishes or transparent containers until emergence of parasitoids. These parasitoids were separated, identified, and counted. The efficiency of parasitoid was estimated as k-value (killing power) according to [18] as follow:

$$K = \log_e \frac{N}{S}$$

where, N is the initial number of hosts, and S is the number of unparasitized hosts. To determine the relationship between the logarithm of the host density and the efficiency of parasitoid (K-value), linear regression analysis was performed using Excel program.

Results

Density–dependent response

A-Winter generation

The density-dependent response was determined for the parasitoids, *A. diaspidis* and *Signiphora* sp. on different host plants by plotting the values of killing power (K) for each parasitoid against the logarithm of host density (log p). The regression analysis indicated that the k-values of *A. diaspidis* and *Signiphora* sp. were relatively more correlated with the host density on loquat trees during winter season (Table 1). Both parasitoid species showed a tendency to aggregate where host density is high. The k-values of the parasitoids, *Signiphora* sp. were more correlated with the density of *H. lataniae* than *A. diaspidis* during winter generation. In opposite, the k-values for *A. diaspidis* were negatively correlated with the host density of *H. lataniae* on fig samples. The k-values of both parasitoid species positively correlated with the density of *H. lataniae* on loquat samples (Table 1). The values of Killing for both parasitoids in relation to the host density on guava, fig, and loquat during spring generation are also presented in Figures (1,2,3).

Host plant species	Parasitoids			
	A. diaspidis	R^2	*Signiphora sp.*	R^2
Guava	K= 0.1423 - 0.05 log p	0.13	K = 0.053 + 0.04 log p	0.014
Fig	K= 0.4994 - 0.204 log p	0.58	K= 0.4523 - 0.14 log p	0.13
Loquat	K=- 0.1755 + 0.11 log p	0.10	K= - 0.3 + 0.15 log p	0.70

Table 1: The relation between k-values of the parasitoids, *A. diaspidis* and *Signiphora* sp. and the logarithm of H. lataniae density on three different host plants during winter generation.

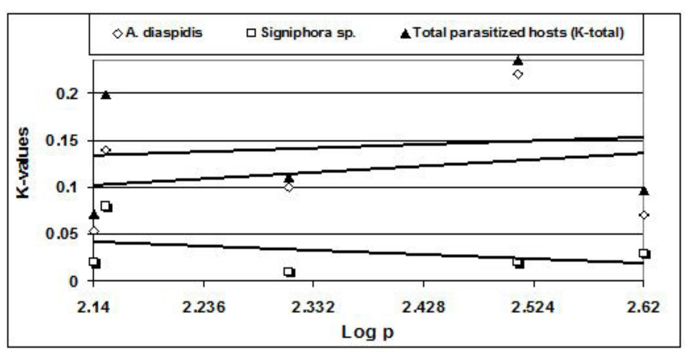

Figure 1: The relation between k-values of the parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of the insect host, *H. lataniae* density on guava trees during winter generation.

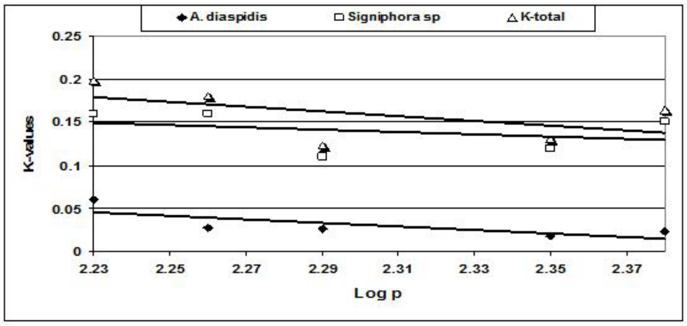

Figure 2: The relation between k-values of two parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of the insect host, *H. lataniae* density on fig trees during winter generation.

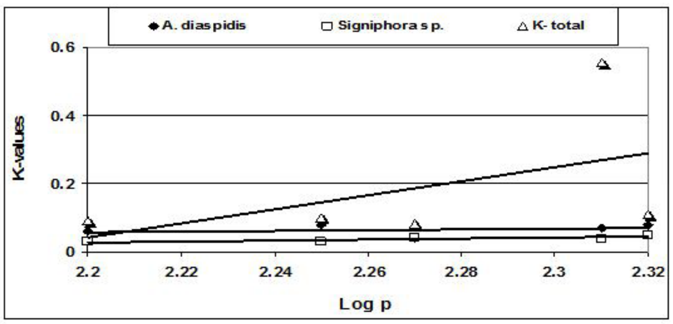

Figure 3: The relation between k-values of two parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of *H. lataniae* density on loquat trees during winter generation.

B- Spring generation

The parasitoid *A. diaspidis* exhibited a positive density-dependent response to the density of *H. lataniae* on loquat, whereas it disappeared on guava during spring generation as well as on fig due to leaves fall season. On the other hand, the *Signiphora* sp. exhibited strong responses to the density of *H. lataniae* from guava and loquat samples, with determination coefficient was the highest for the parasitoid from guava samples (Table 2). The values of Killing for both parasitoids in relation to the host density during spring generation are also presented in Figures (4,5).

Host plant species	Parasitoids			
	A. diaspidis	R^2	*Signiphora sp.*	R^2
Guava	No response	-------	K= - 0.58 + 0.284 log p	0.96
Fig	Leaves fall season			
Loquat	K = - 0.315 + 0.18 log p	0.93	K= - 0.223 + 0.114 log p	0.91

Table 2: The relation between k-values of the parasitoids, *A. diaspidis* and *Signiphora* sp. and the logarithm of *H. lataniae* density on three different host plants during spring generation.

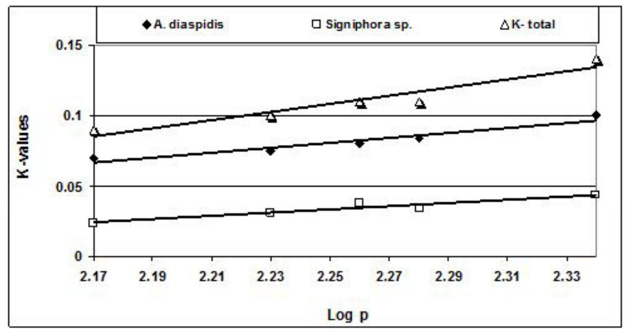

Figure 4: The relation between k-values of two parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of the insect host, *H. lataniae* density on loquat trees during spring generation

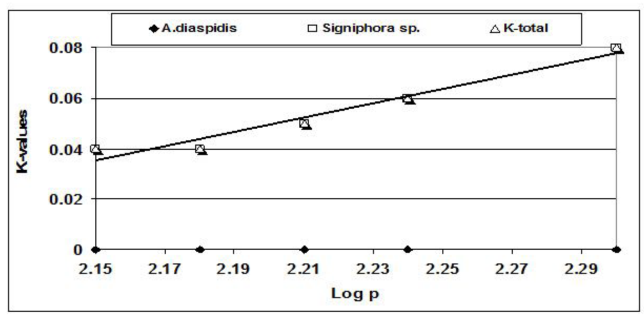

Figure 5: The relation between k-values of two parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of the insect host, *H. lataniae* density on guava trees during spring generation.

Summer generation

The parasitoid response to its host varied on host plants. The parasitoid, *A. diaspidis* exhibited a positive density-dependent response for *H. lataniae* on loquat and fig trees with determination coefficients of 0.7 and 0.6, respectively, whereas this response was negative on guava trees with weak determination coefficient. The parasitoid *Signiphora* sp. showed a density-dependent response to density of *H. lataniae* on fig samples with a determination coefficient of 0.81, an inverse density-dependent response on guava with a determination coefficient of 0.71, and a weak response on loquat (Table 3). The values of Killing for both parasitoids in relation to the host density during spring generation on guava, loquat, and fig are presented in Figures (6,7,8).

Host plant species	Parasitoids			
	A. diaspidis	R^2	*Signiphora sp.*	R^2
Guava	K = 0.2647- 0.0385 log P	0.01	K = 2.0217 - 0.8578 log p	0.71
Fig	K = - 0.0663 + 0.03 log p	0.60	K = - 0.5398 + 0.24 log p	0.81
Loquat	K= - 0.0707+ 0.33 log p	0.70	K = 0.1405 - 0.0356 log p	0.02

Table 3: The relation between k-values of the parasitoids, *A. diaspidis* and *Signiphora* sp. and the logarithm of *H. lataniae* density on three different host plants during summer generation.

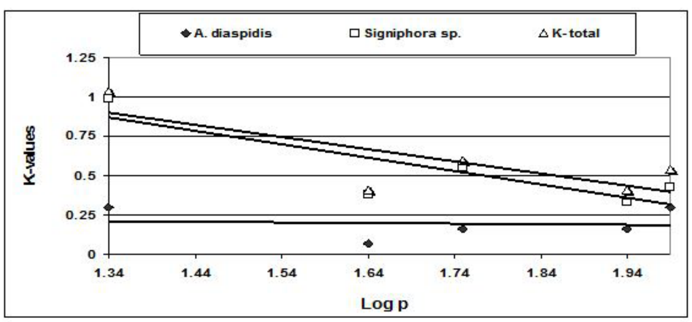

Figure 6: The relation between k-values of two parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of the insect host, *H. lataniae* density on guava trees during summer generation.

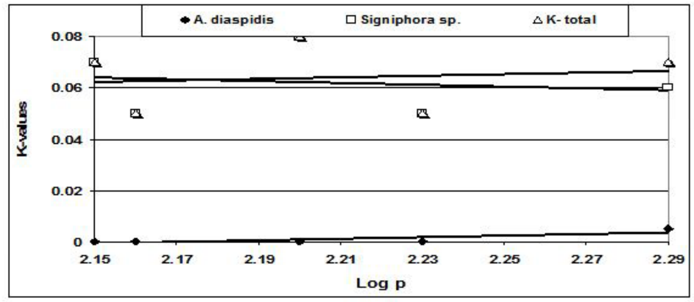

Figure 7: The relation between k-values of two parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of the insect host, *H. lataniae* density on loquat trees during summer generation.

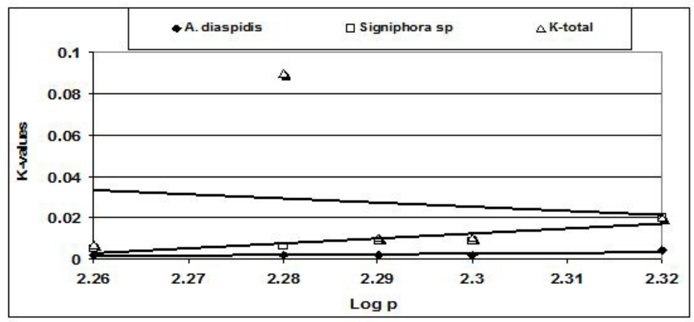

Figure 8: The relation between k-values of two parasitoids, *A. diaspidis* and *Signiphora* sp., and the logarithm of the insect host, *H. lataniae* density on fig trees during summer generation.

From the previous results, it could be concluded that, the parasitoid *A. diaspidis* showed a positive density- dependent response to host density on loquat during, winter, spring, and summer generations. While, the parasitoid, *Signiphora* sp. showed differences in his response on the tested host plant species. It showed the highest density dependent response on loquat, guava, and fig during winter, spring, and summer, respectively.

Discussion

The response of parasitoids to *H. lataniae* populations varied from season to season, from plant to plant, and from species to species. Unfortunately, the scientific literature for *Signiphora* spp. is very rare. The ectoparasitoid *A. diaspidis* responded inversely to *H. lataniae* populations in guava samples during both winter and summer; however, these relations were not strong enough. In opposite, this response was positive to host density on loquat samples in all tested seasons with higher R^2 during spring and summer seasons. [19]. Reported a type II response for *A. diaspidis* to *H. lataniae* densities. For a type II response, there should be a decline in the proportion of host parasitized as the density increases, so that the linear term should be negative. Although the parasitoid exhibited an inverse parasitism to *H. lataniae* densities under laboratory conditions, this relation could be changed according to several factors: one of them is host plant [19-22] and inter specific competition among parasitoid species on available stages. Parasitoids show different functional responses to host on different host plants. This is related to host size, to differences in defensive and other behaviors of the host, and to effects on searching time of parasitoids [23]. Another factor is the weather factors [e.g., 24-27]. This could be confirmed by the response of *Signiphora* sp. to *H. lataniae* populations, in which *Signiphora* sp. responded positively to populations of its host on guava samples during winter and spring and negatively during summer. The coefficient of determination represents this relation more appropriately during spring and summer. Similarity, both parasitoid species responded negatively to host populations on fig leaves during winter, and positively during summer with a coefficient of determination seems to be high. The same relation has been obtained from loquat samples, but this relation was weak during summer season. The variation in parasitoid responses could be attributed to several reasons, among them the effects of interspecific competition and host plant species. Almost, both parasitoid species showed a tendency to aggregate where host density is highest on loquat.

Conclusion

Parasitoids show different behavioural responses to host scale on different host plants. The hardness of scale cover, host size, plant cues might be among the main reasons for such variations. Both parasitoid species have a complementary effect of its host. In other words, the response of each parasitoid species to its host and the alternation in this response from season to season, and from host to host could confirm this synergistic effect in regulating the host population.

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