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Ecological and biological studies on the main insect pests attacking navel orange trees and their associated natural enemies

By

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CONTENTS

CONTENTS

SUMMARY

The present studies were conducted on navel orange trees, *Citrus sinensis* (L.), at the experimental farm belonging to the Faculty of Agriculture, Mansoura University during the two successive seasons (2017/18 and 2018/19). Five adjacent navel orange trees (> 10 years old) homogenous in size and age were chosen and marked for the present studies. Samples were collected biweekly for the two successive seasons and started from 24th of June until 22nd of June 2019. Each sample consisted of 100 navel orange leaves from the five marked trees (20 leaves/ tree) were collected randomly from the different directions (North, East, South, and West) of the tree.

Field Experiments were conducted in navel orange, *Citrus sinensis* L. and repeated in mandarin, *Citrus reticulata* Blanco orchards belong to Mansoura University farm, Dakahlia governorate, Egypt. The used fields were about 3.24 hectares (= eight feddans) for each orchard species. Experiments were carried out during the periods from the 11th of November 2019 till the 25th of November 2019 in the navel orange orchard and from the 26th November till 10th of December 2019 in the mandarin orchard. The current study examined the effectiveness of several mixtures of the protein-based bait, Buminal, and ammonia compounds (ammonium acetate, ammonium chloride, di-ammonium phosphate and phosphoric acid) in attracting the Mediterranean fruit fly, *Ceratitis capitata*. Traps provided with each of these different mixtures were hanged in two fruit orchards (Novel orang and Mandarin) and inspected every three-days for a period of 12 days. In each inspection time, fifty milliliters of each mixture in the field were taken to estimate the pH-level.

The most important results of this study can be summarized as follows:

5.1. The black scale insect *Parlatoria ziziphi* and its natural enemies:

1) The living scales of the black scale insect, *P. ziziphi* had three peaks annually. The highest peaks were those appeared during October and September of the first and second seasons. The plateau of these peaks a had been achieved by 441 and 317 individuals per 100 leaves of navel orange, respectively.
2) The ectoparasitoid *Aphytis* sp. had four peaks of abundance during each year of the study and the highest peaks were partially synchronized with those of the insect since the highest peaks were occurred during May and October during the first and second year, respectively. These peaks presented by 194 and 147 individuals, respectively.
3) The endoparasitoid *H. aspidioti* exhibited three-four peaks of abundance during the first and second year and the highest peak were coincided partially with those of the scale insect. These peaks occurred during May and September of the first and second seasons and gained by 67 and 66 individuals, respectively.
4) The relation between the number of living scales and parasitism rates by *Aphytis* species during both seasons of the study was significantly negative, whereas that for *H. aspidioti* were significantly positive or non-significant during the first and second year, respectively. *Aphytis* therefore seems to be and inverse-density mortality agent and its releases must be early in the season on low pest populations.
5) Parasitism% by *Aphytis* sp. had two peaks annually, almost occurred in the period from May to August, the highest seasonal activity (parasitism%) was in May-June, the parasitism percentages by *Aphytis* sp. ranged from 14.6 to 35.4%.

6) The highest seasonal activity (parasitism%) by *H. aspidioti* was in January and its parasitism percentages ranged from 5.7 to 16.5%, and the total parasitism by both parasitoid species was the highest during the period from March to June in both seasons of the study.
7) Parasitism% on *P. ziziphi* populations ranged from ٢١.٢ to ٤٧.٦%. These rates translated in contribution rates ranged from 48.6 to 67.6% in the total population mortalities.
8) Predation% in *P. ziziphi* populations ranged from 5.8 to 18.9%. These rates translated in contribution rates ranged from 19.7 to 31.8% in the total population mortalities.
9) The highest percentages of unknow mortality (12.3-17.8%) were in the period from December to January annually. These rates translated in contribution rates ranged from 12.5 to 21.4% in the total population mortalities.
10) The total population mortality caused by all mortality factors ranged from 37.9 to 73.9%.
11) The ectoparasitoid *Aphytis* sp. was the key mortality factor that contributed with the highest fate in the total population mortality of *P. ziziphi* in all seasons of the year compared with the other mortality.
12) Within seasons of the year, the ectoparasitoids *Aphytis* sp. contributed with the highest fate in the total population mortality during spring and summer, the endoparasitoid (*H. aspidioti*) in winter and autumn, predators in spring and autumn, and unknown mortality factors were in winter and spring seasons in the first and second year, respectively.
13) Both parasitoid species contributed with the highest fate in the total population mortality of *P. ziziphi*. However, among them, *Aphytis* sp.

contributed more than *H. aspidioti* in the total population mortality of *P. ziziphi*,

14) The annual mortalities of all mortality factors acting the populations of *P. ziziphi* averaged 56.4 and 55.6% in the first and second seasons, respectively.

5.2. The California red scale, *Aonidiella aurantii*

1) The living scales of the California red scale insect, *A. aurantii* had three peaks of abundance annually. In the first year, they occurred in August 2017, February 2018, and in May 2018. In the second year, these peaks were in August 2017, October 2017, and April 2018. The highest peaks were in the period from April to May. The plateau of these peaks a had been achieved by 194 and 443 scales per 100 leaves of navel orange, respectively.

2) The ectoparasitoids *Aphytis* spp. had three-four peaks of abundance annually and these peaks were positively synchronized with those of the insect since the highest peaks were occurred during March of both seasons.

3) The endoparasitoid *H. aspidioti* exhibited two peaks of abundance annually and its populations did not coincide with those of the scale insect. The highest peaks were during the period April-May.

4) Although the numbers of parasitized scales by *Aphytis* spp. significantly synchronized with those of their host scales, parasitism rates did not in both *Aphytis* species and *H. aspidioti*.

5) Parasitism percentages on living scales of *A. aurantii* by *Aphytis* spp. had four peaks annually. They were in August 2017, October 2017, January 2018, and March 2018 in the first year, whereas they were in October 2018, in January 2019, in March 2019, and in June 2019 during the second year. In

both seasons, the highest seasonal activity (parasitism%) was in March and January in the first and second year, respectively. The parasitism percentages by *Aphytis* spp. ranged from 20.5 to 38.3%.

6) Parasitism% by *H. aspidioti* recorded two-three peaks annaully. In both seasons, the highest seasonal activity (parasitism%) was in February and September of the first and second year, respectively. The parasitism percentages by *H. aspidioti* ranged from 1.6 to 36.8%.

7) The total parasitism by both parasitoid species had two-three peaks of activity annually with the highest peaks were during the period from January to February in both seasons of the study.

8) Parasitism% on *A. aurantii* populations ranged from 26.2 to 67.1%. These rates translated in contribution rates ranged from 53.6 to 68.9% in the total population mortalities.

9) Predation% on *A. aurantii* populations ranged from 7.2 to 23.9%. The highest predation percentages were occurred in the period of June-July during both seasons. These rates translated in contribution rates ranged from 17.15 to 30.44% in the total population mortalities.

10) The percentages of mortality caused by unknow factors ranged from 5.1 to 25.1% with the highest percentages were in September and November in the first and second year of investigations, respectively. These rates translated in contribution rates ranged from 12.95 to 19.04% in the total population mortalities.

11) The ectoparasitoids *Aphytis* spp. contributed with the highest fate in the total population mortality of *A. aurantii* in all seasons of the year compared with the other mortality factors.

12) All parasitoid species (total parasitism %) contributed with the highest fate in the total population mortality of *A. aurantii*.
13) The annual mortalities of all mortality factors acting the populations of *A. aurantii* averaged 63.9 and 73.1% during the first and second seasons, respectively.

5.3. The purple scale insect, *Lepidosaphes beckii*

1) The living scales of the purple scale insect, *L. beckii* had three peaks of abundance annually. In the first year, they occurred in October 2017, December 2017, and in May 2018. In the second year, these peaks occurred in the same months of the first year. The highest peaks were in December and October in the first and second year. The plateau of these peaks had been achieved by 188 and 272 scales per 100 leaves of navel orange, respectively.
2) The ectoparasitoid *A. lepidosaphes* had three peaks of abundance annually and these peaks were positively synchronized with those of the insect since the highest peaks were occurred during the period from September-October.
3) Although the numbers of parasitized scales by *A. lepidosaphes* synchronized significantly with those of their host scales, parasitism rates did not.
4) Parasitism percentages on living scales of *L. beckii* by *A. lepidosaphes* had four peaks annually. They were in September 2017, November 2017, January 2018, and May 2018 in the first year, whereas they were in in August 2018, December 2019, March 2019, and May 2019 during the second year. The highest seasonal activity (parasitism%) was appeared in the period from August to September.

5) Parasitism% on *L. beckii* populations by *A. lepidosaphes* ranged from 8.1 to 27.8% in both seasons. These parasitism rates translated in contribution rates ranged from 22.03 to 49.52% in the total population mortality.

6) Predation% on *L. beckii* populations ranged from 5.8 to 29.6%. The highest predation percentages were in the period of March - June during both seasons. These predation rates translated in contribution rates ranged from 18.57 to 53.85% in the total population mortality.

7) The percentages of mortality caused by unknow factors ranged from 0.3 to 28.3% with the highest percentages were in November and February in the first and second year of investigations. These rates translated in contribution rates ranged from 5.71 to 40.71% in the total population mortality.

8) The mortality caused parasitoid contributed with the highest fate in the total population mortality during the second year, whereas insect predators contributed with the highest fate during the first year. Unknow factors occupied the lowest fate in the total population mortality of *L. beckii*.

9) The ectoparasitoid *A. lepidosaphes* contributed with the highest fate in the total population mortality of *L. beckii* during summer season of the first year, whereas it contributed with the highest fate in winter, spring and summer seasons of the second year.

10) Predation contributed with the highest fate in the total population mortality during all seasons of the year except summer in the first year, while it had the highest fate autumn season of the second year compared with the other mortality factors.

11) The highest efficiency of predators was counted in spring and autumn seasons of the first and second year, whereas that for unknown mortality factors was in winter season of both seasons.

12) The annual population mortalities caused by all mortality factors on populations of *L. beckii* averaged 43.2 and 47.6 % during the first and second seasons, respectively with the highest values estimated in November of both seasons.

13) Only, the seasonal mortality caused by *A. lepidosaphes* on populations of *L. beckii* differed between seasons of the study.

5.4. Mediterranean fruit fly, *Ceratitis capitata*

1) The protein-based baits can be enhanced by adding ammonia and the pH-level of these baits plays a fundamental role in attracting fruit flies, since the effectiveness of bait is diminished by decreasing the pH-level. Regardless, the concentration of ammonia compounds, addition of di-ammonium phosphate to Buminal attracted more fruit flies than other mixtures. Further, all the tested mixtures attracted more females than males in both orchard species. Although, the highest captures of *C. capitata* were by mixture of Buminal 5%+di-ammonium phosphate 1%, it did not coincide with changing in pH levels of this mixture.

2) Only, the changes in pH-level of Buminal 5%+di-ammonium phosphate 2% led to significant increase in the number of trapped flies. This study might suggest that increasing the pH-level of food lure above 7.6 might adversely decline the number of trapped flies.

3) Buminal + di-ammonium phosphate mixture can be generalized in IPM programs for *C. capitata* in Egyptian fruit farms.