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Impact of the Flowering Weed, Sow Thistle *Sonchus oleraceus* L. in enhancing parasitism of *Pegomyia mixta* (Vill). Larvae by *Opius nitidulator* in Sugar Beet Fields

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Abstract: Flowering weeds have frequently been cited as important resources of pollen and nectar for nutrition of adult parasitoids, as they increase insect longevity and fecundity. Thus, this experiment was done at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh Gavemorate, Egypt during 2021/2022 and 2022/2023 seasons to assess the role of the flowering weed, sow thistle *Sonchus oleraceus* L. (Fam: Asteraceae) in enhancing the parasitism of *Opius nitidulator* on *Pegomyia mixta* Vill. (Diptera: Anthomyiidae) larvae in sugar beet fields. Results showed that average number of sugar beet fly, *Pegomyia mixta* eggs and larvae fluctuated during the first season, peaking by 225.00 and 188.50 individuals / 15 plants on first of March, respectively. In the second season, they were 247.50 and 183.00 individuals / 15 plants on mid February and first of March, respectively. Overall averages of parasitism of *P. mixta* larvae in the first season (first, second and third cultivation) were higher (79.11, 80.72 and 76.16 %) in plots with the weed. *S. oleraceus* than in weed - free ones in the three cultivations, of sugar beet with average of 34.39, 36.58 and 33.37 %, respectively. In the second season (first, second and third cultivation), also they were higher (69.54, 74.27 and 83.00%) in plots with the weed *S. oleraceus* than in weed - free ones in the three cultivations, of sugar beet with average of 31.62, 34.81 and 35.47 %, respectively. Statistical analysis (t - test) revealed significant differences in the parasitism status between the weedy plots and non- weedy ones. Negative correlation was found between eggs and larvae of *P. mixta* with temperature and relative humidity in both seasons. Accordingly, studies shoud be undertaken about the worth of flowering weeds in raising the adult parasitism efficiency. Also, we must include role of parasitoids in integrated pest programs of sugar beet insects.

Key words: Sonchus oleraceus · Pegomyia mixta · Opius nitidulator · Sugar beet

INTRODUCTION

Sugar beet crop *Beta vulgaris* L. (Family: Chenopodiaceae) with the sugar cane, are a very important source of producing sugar in Egypt. Great efforts are practiced by the growers and Ministry of Agriculture to enhance the sugar beet production.

Unfortunetely, this vital crop is attacked by several insect pest species throughout the crop growing season [1]. Sugar beet fly, *Pegomyia mixta* Vill. (Diptera: Anthomyiidae) is a serious insect pest attacking sugar beet in Egypt Abou-El-Kassem [2] with 3-4 peaks of abundance of eggs and larvae throughout the season [3, 4].

The highest *P. mixta* infestation on sugar beet was reported during March and April, however, the infestation by this beet fly was always observed from the first week of November till the end of May [5].

Insect biological control is an important constituent of integreted pest management, particularly with food crops, from which is sugar beet. The internal larval parasitoid, *Opius nitidulator* proved to be a vital agent against *P. mixta*, with an average parasitism of about 18-20%, this level ranged from 25 - 27 % according to Bazazo *et al*., [3] and from 8 - 36 % [4].

Numerous authors proved the efficacy of *O. nitidulator* in controlling *P. mixta* populations [6-8].

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Parasitoid wasps that control insect pests need additional resources from non- crop plants, of nectar and pollen from non- crop plants to improve their reproduction capacity [9]. Barbosa [10] recommended conservation of biological control practices to enhance the occurring natural enemies in grown crops through some alteration in the field environment.

In multiple studies, flowering weeds increased parasitoid abundance [11, 12]. Field studies indicated that access of nectar and pollen may be vital to parasitoid survival and reproduction. Zhang *et al*. [13] reviewed the effects of natural plant foods on adult parasitic wasps and found that feeding on nectars increase the longevity and fecundity of parasitoids.

One of alterations to enhance nectar sources is keeping some areas of crops having some weeds to the extent of no damage to the crop, or with no yield losses. The value of buckwheat flower strips have been revealed in apple orchards, where inter-sowing buckwheat increased parasitism of *Daichogenidea tasmanica* on the apple moth, *Epiphyes postvitanta* [14]. Balzan *et al*. [15] advised that parasitoids often require pollen, nectars or honeydew, which can strongly prolong longevity and fecundity of parasitoids.

Also, Herz *et al*. [16] showed that parasitoids depend on regular access to sugar resources for nutrition. Such resources may consist of flowers with accessible or extrafloral nectaries, plant saps or tree fluids. Due to several researches, some authors recommend to insert suitable flowering plants into the cropping system for promotion parasitoid performance. Heba *et al*. [17] indicated that parasitoid species preferred to feed on flower nectars of plants that contain sugars, proteins, amino acids, lipids and many other organic and inorganic substances,which enhance parasitism rates.

The objective of the current investigation was to assess the role of flowering weed, sow thistle, *Sonchus oleraceus* L. in enhancing the activity of the hymenopterous parasitoid, *O. nitidulator* on sugar beet fly, *P. mixta* in sugar beet fields.

MATERIALS AND METHODS

Experiment Layout: The present investigation was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 2021/2022 and 2022/2023 seasons. The experimental area measured about one feddan every season. The experimental area was divided into two halves (each half was divided into three replicates), planted with sugar beet, Karam variety on three cultivation dates; 15 September, 15 October and 15 November. All recommended cultural practices were followed without any insecticidal applications. A buffer zone (about 100 m^2) was left without sowing between the two halves to avoid interference of treatments. The first half was weed-free during the whole season, while the other half was weed-free except from *S. oleraceus* (Fig. 1). Also, the weed population was intensified on dikes, furrows and ditches.

Fig. 1: *Sonchus oleraceus* L weed.

Sampling Procedures: From each replicate, weekly samples of 15 plants were chosen, randomly, to record the number of eggs and larvae to monitor the population fluctuation of *P. mixta*. The correlation coefficient values among each of eggs and larvae of *P. mixta* and average temperature and relative humidity during the two successive seasons were calculated. Daily maximum and minimum temperatures were obtained from the Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Dokki, Giza. Also, biweekly samples from each replicate, each of twenty blotches (2-5 *P. mixta* larvae each), were collected and the larvae were taken out from beet leaves and kept into Petri dishes (9cm) till pupation. Newly formed pupae were transferred into other Petri dishes till the emergence of beet flies or the parasitoids under laboratory conditions (25+2 ◎ and 60-70% RH). The total number of pupae and emerging parasitoids were recorded and the percentages of parasitism were calculated.

Statistical Analysis: Standard errors of means of treatments were calculated. Also,correlations were computed between weather factors and each of larvae and pupa population of *P. mixta* using SPSS program.

RESULTS

Population Fluctuation of *Pegomyia mixta* and its Correlation with Temperature and Relative Humidity: Data presented in Table (1) show the population fluctuation of *P. mixta* eggs and larvae throughout 2021/2022 and 2022/2023 sugar beet seasons.

Average numbers of eggs and larvae / 15 plants were quite low up to mid- December in both seasons and increased obviously up to mid- February. However, the peak of eggs (225.00 / 15 plants) and that of larvae (188.50/ 15 plants) were recorded on first of March in the first season. In the second season, the peak of eggs (247.50) was recorded on mid - February, while that of larvae (183.00) was detected on first of March.

Data in Table (2) showed that populations of both eggs and larvae of *P. mixta* correlated negatively with each of average temperature and average relative humidity in both seasons.

Parasitism of *Pegomyia Mixta*:

In the First Season (2021 / 2022): Data presented in Tables (3, 4 and 5) and Fig. (2) showed the parasitism of *P. mixta* larvae by the parasitoid *O. nitidulator* in three cultivation dates of sugar beet, as affected by the presence of the flowering weed, *S. oleraceus* in 2021/ 2022 season.

First Cultivation: In the first cultivation (Table 3), average parasitism, in the occurrence of the weed, throughout the period from first of December up to first of February, was 79.11%. The average parasitism ranged between 63.67 and 88.25%, the latter highest value of parasitism was detected on January 1st. The average parasitism was greatly less (34.39%) in weed- free plot, with averages between 24.39% on 1st February and 43.95% on 1st December, as compared to the presence of the weed.

Table 1: Population fluctuation of *Pegomyia mixta* eggs and larvae / 15 plants as related to meterological factors.

	(2021-2022) season				(2022-2023) season			
	Av. No. of *P. mixta* per 15 sugar beet plants		Weather factors		Av. No. of *P. mixta* per 15 sugar beet plants		Weather factors	
Sampling date	Egg	Larvae	Av. Temp.	Av. RH%	Egg	Larvae	Av. Temp.	Av. RH%
November 1st	0.50	0.50	25.18	74.50	1.50	0	22.79	79.50
November 15th	3.50	2.00	22.45	80.00	2.50	1.50	21.53	80.60
December 1st	13.50	16.00	19.45	74.00	7.50	3.50	19.65	80.50
December 15th	25.50	10.50	18.75	72.50	20.50	5.00	19.25	78.00
January 1st	48.50	45.00	14.38	78.25	18.00	11.50	16.88	80.75
January15th	63.00	38.50	12.88	82.50	38.00	40.00	16.48	79.75
February 1st	81.00	99.00	15.15	96.25	16.50	68.00	13.08	76.75
February 15th	165.50	132.00	15.00	75.00	247.50	161.00	15.40	68.00
March 1st	225.00	188.50	15.18	65.00	189.00	183.00	20.20	71.00
March 15th	166.00	137.00	15.38	65.50	148.00	105.00	16.63	74.00
April 1st	27.50	13.50	23.08	70.75	20.00	17.50	23.80	69.00
Average ± SE	74.5 0± 23.16	62.05 ± 19.83	17.90 ± 1.25	70.05 ± 6.80	64.45 ± 26.30	54.18 ± 20.19	18.70 ± 1.00	76.17 ± 1.47

Table 2: Correlation coefficient values among eggs and larvae of *Pegomyia mixta* and average temperature and relative humidity in two sugar beet seasons

	"r "value	
Item	2021 / 2022	2022 / 2023
Av. Temp X eggs	- 0.630	- 0.510
Av. Temp X larvae	- 0.640	- 0.390
Av. RH% X eggs	- 0.590	- 0.740
Av. RH% X larvae	- 0.630	- 0.720

Table 3: Parasitism of *Pegomyia mixta* larvae by *Opius nitidulator* as affected by the presence of the weed, *Sonchus olaraceus* in sugar beet fields, 2021/2022 (first cultivation)

	With the weed *S. oleraceus* only			Without any weeds		
Sampling date	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)
December 1st	18.33	11.67	63.67	22.00	9.67	43.95
December 15th	19.67	14.33	72.85	27.67	10.37	37.33
January 1st	28.33	25.00	88.25	36.67	14.00	38.18
January 15th	29.00	24.67	85.07	38.00	10.67	28.08
February 1st	35.00	30.00	85.71	41.00	10.00	24.39
Average ± SE	26.07±3.12	21.13 ±3.48	79.11±4.69	33.07±3.55	10.93±0.78	34.39 ± 3.57

The *t*-value is 7.59005. The *p*-value is. 000064. The result is significant at $p <. 05$.

Table 4: Parasitism of *Pegomyia mixta* larvae by *Opius nitidulator* as affected by the presence of the weed, *Sonchus olaraceus* in sugar beet fields, 2021/2022 (second cultivation)

	With the weed *S. oleraceus* only			Without any weeds		
Sampling date	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)
January 1st	26.67	18.33	68.72	29.33	10.00	34.09
January 15th	28.33	20.67	72.96	29.33	9.67	32.97
February 1st	35.00	30.00	85.71	36.00	9.67	26.86
February 15th	37.00	31.33	84.68	36.33	14.33	39.44
March 1st	43.33	39.67	91.55	37.67	18.67	49.56
Average ± SE	34.07+3.02	28.00±3.86	80.72±4.25	33.73±1.82	12.47±1.78	36.58±3.81

The *t*-value is 7.72807. The *p*-value is. 000056. The result is significant at $p <. 05$.

Table 5: Parasitism of *Pegomyia mixta* larvae by *Opius nitidulator* as affected by the presence of the weed, *Sonchus olaraceus* in sugar beet fields, 2021/2022 (third cultivation)

	With the weed *S. oleraceus* only			Without any weeds		
Sampling date	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)
February 1st	33.33	11.00	33.00	32.67	11.67	35.72
February 15th	35.33	26.67	75.49	42.00	12.67	30.17
March 1st	43.00	38.33	89.14	42. 67	11.67	27.35
March 15th	53.33	42.00	78.75	73.00	36.67	50.23
April 1st	60.00	53.33	88.88	57.00	13.33	23.39
Average ± SE	45.00±5.14	34.27±7.21	76.16±10.37	51.1675±7.9	17.20 ±4.88	33.37±4.67

The *t*-value is 3.48837. The *p*-value is. 008218. The result is significant at $p <. 05$.

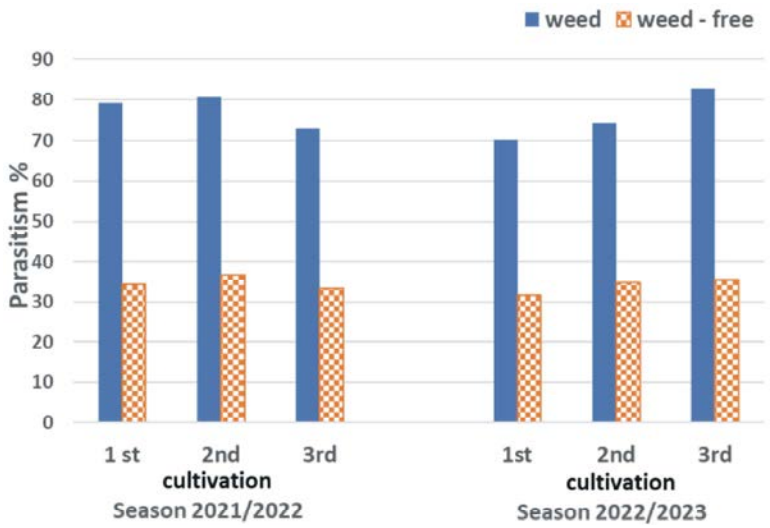

Fig. 2: Parasitism % of *Pegomyia mixta* larvae by *Opius nitidulator* as affected by the presence or absence of the weed, *Sonchus olaraceus* in sugar beet fields

Second Cultivation: In the second cultivation (Table 4), the parasitism percentage was similar to that of the first cultivation, as the average parasitism % was too much higher (80.72%) in the presence of *S. olaraceus* than in weed- free plot (36.58%). The peaks of parasitism occurred on 1st March, with values of 91.55 and 49.56% in case of weedy and weed- free plots, respectively.

Third Cultivation: In the third cultivation, data in Table (5) showed that average parasitism was 76.16% in case of weedy plots, ranging between 33.00% on February 1st and 89.14% on March 1st. In weed- free plots, the parasitism ranged between 23.39% on April 1st and 50.23% on mid- March, with a seasonal average of 33.37%.

In the Second Season (2022 / 2023): Data presented in Tables (6, 7 and 8) and Fig. (2) showed the parasitism of *P. mixta* larvae by the parasitoid *O. nitidulator* in three cultivation dates of sugar beet in 2022/ 2023 season.

First Cultivation: In the first cultivation data in Table (6), showed that the occurrence of the flowering weed enhanced the parasitism level to an average of 69.54% throughout the season, with values ranging between 63.15 and 76.00%, with the latter highest value on February 1st. In case of weed - free, the parasitism declined to 31.62%, with a range of 30.45 and 34.29% throughout the whole season.

Second Cultivation: In the second cultivation (Table 7), also, the weedy plots exhibited higher parasitism (74.27%) than the weed - free plots (34.81%). The highest parasitism was detected with February 1st and of mid-January, with values of 82.67 and 39.38% in weedy and weed - free plots, respectively.

Third Cultivation: In the third cultivation (Table 8), similar results were obtained, as the seasonal average parasitism was 83.00 % in the presence of the flowering weed

Table 6: Parasitism of *Pegomyia mixta* larvae by *Opius nitidulator* as affected by the presence of the weed, *Sonchus olaraceus* in sugar beet fields, 2022/2023 (first cultivation)

	With the weed Sonchus *oleraceus* only			Without any weeds		
Sampling date	Av. No. of *P.mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)	Av. No. of *P.mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)
December 1st	31.67	20.00	63.15	33.00	10.33	31.30
December 15th	34.33	22.00	64.08	35.00	12.00	34.29
January 1st	38.33	26.33	68.69	38.33	11.67	30.45
January 15th	39.00	28.67	73.51	39.33	12.00	30.51
February 1st	41.67	31.67	76.00	43.33	13.67	31.55
Average ± SE	37.60±4.44	25.73±2.13	69.54±2.07	37.80±1.80	11.93±0.53	31.62±0.70

The *t*-value is 14.28039. The *p*-value is <. 00001. The result is significant at $p <. 05$.

Table 7: Parasitism of *Pegomyia mixta* larvae by *Opius nitidulator* as affected by the presence of the weed, *Sonchus olaraceus* in sugar beet fields, 2022/2023 (second cultivation).

	With the weed Sonchus *oleraceus* only			Without any weeds		
Sampling date	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)
January 1st	41.67	31.67	76.00	36.67	13.33	36.35
January 15 th	48.00	33.33	69.44	42.33	16.67	39.38
February 1st	48.33	40.00	82.67	43.00	13.33	31.00
February 15th	50.00	37.33	74.66	45.00	14.33	31.84
March 1st	58.33	40.00	68.58	47.00	16.67	35.47
Average ± SE	49.27±2.67	36.47±1.71	74.27±2.54	42.80±1.74	14.87±0.76	34.81±1.53

The *t*-value is 13.28608. The *p*-value is <. 00001. The result is significant at $p <. 05$.

Table 8: Parasitism of *Pegomyia mixta* larvae by *Opius nitidulator* as affected by the presence of the weed, *Sonchus olaraceus* in sugar beet fields, 2022/2023 (third cultivation).

	With the weed Sonchus *oleraceus* only			Without any weeds		
Sampling date	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)	Av. No. of *P. mixta* Pupae	Av. No. of emerging Parasitoids	Av. Parasitism (%)
February 1st	45.00	33.33	74.07	51.67	13.33	25.80
February 15th	46.67	35.00	74.99	55.00	16.67	30.31
March 1st	51.67	43.33	83.86	46.67	17.33	37.13
March15th	53.33	50.00	93.75	54.00	21.67	40.13
April1st	58.33	50.00	85.72	50.00	22.00	44.00
Average ± SE	51±2.4	42.33±3.56	83.00±7.78	51.47±1.48	18.20±1.63	35.47±2.3

The *t*-value is 9.55878. The *p*-value is. 000012. The result is significant at $p <. 05$.

compared to 35.47% in the weed- free plots. The highest parasitism was detected with mid- March and of April 1st, with values of 93.75 and 44.00% in weedy and weed - free plots, respectively.

Statistical analysis revealed significant differences between weedy and weed-free plots in mean number of parasitism during the three cultivations in the two seasons.

DISCUSSION

Sugar beet fly, *P.mixta* is a serious insect pest of sugar beet in Egypt, with the highest infestation rates in March and April [2-4, 18]. *Opius nitidulator* is an effective parasitoid against larvae of beet fly [4].

Barbosa [10] recommended conserving biological control practices to enhance the role of occurring parasitoids and predators to improve the natural balance at local environments. Manison *et al*. [19] concluded that one strategy to intensity the role of natural enemies is by keeping the non- crop vegetation that grows naturally inside and around the fields, which provide biodiversity enhancement and natural enemies conservation [20]. Moreever, non- crop vegetation may provide shelter and food resources for natural enemies and increase their abundance and effectiveness for pest control [21, 22].

Wackers [23] demonstrated that feeding on sugar sources such as floral nectar, primarily provides metabolic energy supporting parasitoid survival. In Germany, Thorbek *et al*. [24] suggested leaving some weeds without removal to act as refuge areas for parasitoids. Also, Tylianakis *et al*. [25] found that aphid parasitism in weedy plots is higher than in weed-free ones in sugar beet fields. Fitness of several parasitoid species may be improved when they are submitted with sugar resources [26].

Pollen and sugar resources have also been observed to increase fitness of several parasitoids. This underlines the need for empirical studies investigating nutrient requirements and resource-utilisation of parasitoids to optimize conservation biological control (CBC) [27].

Lastly, Balzan *et al*. [15] reported that parasitoids require both host and non-host resources, such as a nectar, for maintenance, survival and egg maturation.

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