



## Research Article

# Evaluation of release rates of predator, *Apertochrysa astur* (Banks) (Neuroptera: Chrysopidae) against Rugose Spiraling Whitefly (RSW), *Aleurodicus rugiperculatus* Martin

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**ABSTRACT:** Evaluation of release rates of a generalist predator, *Apertochrysa astur* was carried out against Rugose Spiraling Whitefly (RSW) during 2020-21 and 2021-22 at Dr. YSRHU - SKPP Polytechnic College, Ramachandrapuram and Dr. YSRHU - Horticultural Research Station (HRS), Ambajipeta (100, 200, 300, 400, 500 and 600 eggs per palm). The overall and pooled results during the years 2020-21 and 2021-22, indicated that clipping of *A. astur* at 600 eggs/palm ( $T_6$ ) recorded the lowest number of RSW spirals, nymphs and pupae, whereas the control palms ( $T_0$ ) recorded with a maximum number of RSW spirals, nymphs and pupae per leaflet.

**KEYWORDS:** *Aleurodicus rugiperculatus*, *Apertochrysa astur*, predator, release rates

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## INTRODUCTION

Coconut or 'Kalpavriksha', the tree of life with lot of virtues, an important plantation crop which assumes the status of a high value commercial crop in India. It provides livelihood to billions of people across the world and cultivated for oil, coconut meat, coconut water and raw ingredients for the coir industry. It is grown in 2.18 million ha in India, with a production of 21,206.74 million nuts and a productivity of 9,687 nuts/ha in 2020-21 (Bhagavan *et al.*, 2021). Coconut offers scope for sustaining livelihood of growers, farm communities and industries in major coconut growing countries of the world.

An exotic and invasive RSW, *Aleurodicus rugiperculatus* Martin (Hemiptera: Sternorrhyncha: Aleyrodidae), has entered India and was first reported on coconut palm in August-September 2016 at Pollachi taluk, Coimbatore district in Tamil Nadu and Palakad taluk in Kerala (Sundararaj and Selvaraj, 2017; Josephraj *et al.*, 2017). In Andhra Pradesh, it was first reported at Kadiyapulanka nursery gardens during late December 2016 (Chalapathi *et al.*, 2020). RSW is highly polyphagous with 118 host plants belonging to 43 families (Francis *et al.*, 2016)

mainly infesting coconut palms and alternate hosts *viz.*, guava, citrus, mango, sapota, bhendi, custard apple, jatropha and hibiscus in its native range (Selvaraj *et al.*, 2016). Over reliance on pesticides and its indiscriminate use for management of RSW results in many negative consequences, *viz.*, resurgence, resistance and residues (Elango *et al.*, 2021). However, natural enemies play a vital role in bringing down the RSW population in nature. Among the natural enemies, green lace wing *A. astur*, Banks (Neuroptera: Chrysopidae) is the most effective predator against RSW because of its wide geographical distribution, good searching ability and easy rearing in the laboratory (Chalapathi *et al.*, 2021). In Andhra Pradesh, natural occurrence of *A. astur* was observed against RSW in coconut palms, and the mass-multiplication technology was standardized at Dr. YSRHU - Horticultural Research Station (HRS), Ambajipeta, Andhra Pradesh. Nevertheless, the data on release rate of predator, *A. astur* is not available, and hence an effort was made to evaluate the field efficacy of *A. astur* against RSW.

## MATERIAL AND METHODS

The laboratory-reared one-day-old eggs of *A. astur* were clipped from the fifth to tenth leaf in 6 years age-old Gauthami

Ganga variety of coconut palms with 13 functional leaves at Dr. YSRHU - SKPP Polytechnic college, Ramachandrapuram (16°83'72"N and 82°03'25"E) during 2020-21 and 13 years age-old Gauthami Ganga variety of coconut palms with 18-20 functional leaves at Dr. YSRHU - HRS, Ambajipeta (16°59'38"N and 81°95'36"E) during 2021-22.

The release rates of *A. astur* evaluated were 100, 200, 300, 400, 500 and 600 eggs per palm. The clippings were done in the first week of December 2020 and 2021 when the incidence of RSW population was on an increasing scale of around 10 to 12 spirals per leaflet. The clippings were done on these selected five leaves accessible for easy counting of all RSW stages without any leaf disturbance.

The egg, nymph and pupal stages of RSW were relatively immobile, making it suitable to get a quantifiable assessment of predation activity by *A. astur* in the field. Adequate care was also taken regularly during the study period to eliminate the parasitoids and predators other than *A. astur* already present on the selected palms.

#### Experimental details

Number of treatments	:	7
Number of replications	:	3
Statistical design	:	R.B.D

The control treatment includes three palms of the same age in the field separated by a distance of 20 m from the clipped palms and it was also ensured that no management measures were taken up on this palm to facilitate the natural build-up of the whitefly population.

In the present experiment, clipping of *A. astur* eggs was carried out once, and data was recorded on the following parameters (Table 1).

#### Data collected after field release

Pre-experiment data was made on four randomly selected pest-infested leaflets per leaf totalling 20 leaflets per palm. The post-experiment count was made after 7, 14 and

**Table 1.** Treatments of field release of *A. astur*

S. No.	Treatments of release of <i>A. astur</i>
T <sub>1</sub>	<i>A. astur</i> eggs at 100 per palm
T <sub>2</sub>	<i>A. astur</i> eggs at 200 per palm
T <sub>3</sub>	<i>A. astur</i> eggs at 300 per palm
T <sub>4</sub>	<i>A. astur</i> eggs at 400 per palm
T <sub>5</sub>	<i>A. astur</i> eggs at 500 per palm
T <sub>6</sub>	<i>A. astur</i> eggs at 600 per palm
T <sub>7</sub>	Control (No clipping)

21 Days of Clipping (DAC). Observations were made on a weekly basis.

The sample leaflets were marked carefully, sealed in a polythene cover and immediately brought to the laboratory. The data was collected on the population of RSW life stages, i.e., number of spirals, nymphs and pupae under Nikon SMZ18 13.5 x stereomicroscope and expressed as a mean number of leaflets/leaf/ palm and Per cent Reduction (PR) of live colonies was calculated and worked out by using the following formula.

$$\text{PR (\% over control)} = \frac{\text{Control count} - \text{Treatment count}}{\text{Control count}} \times 100$$

#### Statistical analysis

The statistical analysis used to evaluate the release rates of predator *A. astur* against RSW was a simple Randomized Block Design (RBD).

#### RESULTS AND DISCUSSION

The number of treatments imposed was seven including control palms replicated thrice and statistically analysed by simple RBD. The data was collected on the population of RSW life stages *viz.*, number of spirals, nymphs, pupae and PR of live colonies per leaflet and presented separately under respective headings.

#### Number of spirals per leaflet

The pooled results (2020-21 and 2021-22) revealed that a significant difference was observed among different treatments of field release of *A. astur* eggs against RSW spirals. The clipping of *A. astur* at 600 eggs/palm (T<sub>6</sub>) recorded the lowest number of RSW spirals (7.86, 5.17 and 5.83 spirals per leaflet at 7, 14 and 21 DAC) with 58.43 PR in spirals and 71.35 PR over control and proved to be superior treatment. The clipping of *A. astur* at 500 eggs/palm (T<sub>5</sub>) with 8.73, 6.47 and 6.86 spirals per leaflet (56.19 PR and 66.51 PR over control) was the next best treatment. The control palms (T<sub>8</sub>) recorded with a maximum number of spirals (18.68, 20.85 and 26.33 spirals) per leaflet throughout the observational period. The release rates at 100 to 400 eggs /palm resulted in 52.71, 58.31, 64.33 and 66.10 PR over control (Table 2).

#### Number of RSW Nymphs

The pooled results (2020-21 and 2021-22) depicted that significant difference was observed among different treatments of field release of *A. astur* eggs against nymphs. The clipping of *A. astur* at 600 eggs/palm (T<sub>6</sub>) recorded lowest number of nymphs (39.12, 24.69 and 5.78 nymphs per leaflet at 7, 14 and 21 DAC) with 74.01 PR in nymphs and 73.95 PR over control and proved to be superior treatment. The

**Table 2.** Efficacy of field release of *A. astur* against spirals of RSW, *A. rugioperculatus*

S. No.	Treatments	Pre-Count*			Post-Count*									% Reduction over pre-count			% Reduction over control		
					7 DAC			14 DAC			21 DAC								
		2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results
T <sub>1</sub>	Clipping of 100 eggs per palm	13.56 (3.81)	12.21 (3.63)	12.89 (3.73)	11.25 (3.49)	9.90 (3.29)	10.58 (3.40)	10.65 (3.41)	9.30 (3.21)	9.98 (3.31)	11.27 (3.50)	9.92 (3.30)	10.59 (3.40)	18.44	20.48	19.47	51.11	53.63	52.71
T <sub>2</sub>	Clipping of 200 eggs per palm	12.56 (3.68)	11.21 (3.49)	11.89 (3.59)	10.36 (3.37)	9.01 (3.16)	9.69 (3.27)	9.34 (3.21)	7.99 (2.99)	8.67 (3.11)	9.75 (3.28)	8.40 (3.06)	9.08 (3.17)	21.82	24.42	23.04	56.59	59.55	58.31
T <sub>3</sub>	Clipping of 300 eggs per palm	15.69 (4.08)	14.34 (3.92)	15.02 (4.00)	9.56 (3.25)	8.21 (3.03)	8.89 (3.14)	7.56 (2.92)	6.21 (2.68)	6.89 (2.80)	8.39 (3.06)	7.04 (2.83)	7.72 (2.95)	45.83	50.14	47.87	62.43	65.85	64.33
T <sub>4</sub>	Clipping of 400 eggs per palm	16.75 (4.21)	15.40 (4.05)	16.08 (4.13)	8.95 (3.15)	8.53 (3.09)	8.74 (3.12)	7.03 (2.83)	6.00 (2.65)	6.52 (2.74)	7.48 (2.91)	6.63 (2.76)	7.06 (2.84)	53.31	54.22	53.73	65.41	66.33	66.10
T <sub>5</sub>	Clipping of 500 eggs per palm	17.45 (4.29)	16.10 (4.13)	16.78 (4.22)	8.88 (3.14)	8.60 (3.09)	8.73 (3.12)	7.04 (2.84)	5.90 (2.63)	6.47 (2.73)	7.20 (2.86)	6.52 (2.74)	6.86 (2.80)	55.82	56.46	56.19	65.92	66.52	66.51
T <sub>6</sub>	<b>Clipping of 600 eggs per palm</b>	<b>15.80 (4.09)</b>	<b>14.45 (3.93)</b>	<b>15.13 (4.01)</b>	<b>8.53 (3.09)</b>	<b>7.18 (2.86)</b>	<b>7.86 (2.98)</b>	<b>5.85 (2.62)</b>	<b>4.48 (2.34)</b>	<b>5.17 (2.48)</b>	<b>6.30 (2.70)</b>	<b>5.36 (2.52)</b>	<b>5.83 (2.61)</b>	<b>56.39</b>	<b>60.76</b>	<b>58.43</b>	<b>69.54</b>	<b>72.92</b>	<b>71.35</b>
T <sub>7</sub>	Control (No clipping)	12.56 (3.68)	11.21 (3.49)	11.89 (3.59)	19.35 (4.51)	18.00 (4.36)	18.68 (4.44)	21.52 (4.75)	20.17 (4.60)	20.85 (4.67)	27.00 (5.29)	24.65 (5.16)	26.33 (5.23)	-	-	-	-	-	-
	S.E (m)	0.08	0.08	0.08	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-	-	-	-	-	-
	C.D at 5 %	0.24	0.24	0.25	0.14	0.15	0.14	0.14	0.14	0.14	0.15	0.16	0.16	-	-	-	-	-	-
	C.V	3.37	3.68	3.52	2.21	2.47	2.33	2.49	2.63	2.55	2.47	2.80	2.63	-	-	-	-	-	-

\*Mean of three replicates; DAC: Days after clipping, Figures in the parenthesis are  $\sqrt{x + 0.5}$  transformed values

clipping of *A. astur* at 500 eggs/palm (T<sub>5</sub>) with 41.69, 27.66 and 7.46 nymphs per leaflet (70.77 PR and 71.25 PR over control) was the next best treatment. The control palms (T<sub>8</sub>) recorded with maximum number of nymphs (84.58, 88.52 and 93.93 nymphs) per leaflet throughout the observational period. The release rates at 100 to 400 eggs/palm resulted in 57.99, 64.45, 69.16 and 70.11 PR over control (Table 3).

**Number of RSW pupae**

The pooled analysis data (2020-21 and 2021-22) revealed that, significant difference was observed among different treatments of field release of *A. astur* eggs against pupae. The clipping of *A. astur* at 600 eggs/palm (T<sub>6</sub>) recorded lowest number of pupae (15.84, 3.47 and 1.37 pupae per leaflet at 7, 14 and 21 DAC) with 75.81 PR in pupae and 82.26 PR over control and proved to be superior treatment. The clipping of *A. astur* at 500 eggs/palm (T<sub>5</sub>) with 16.63, 4.57 and 2.25 pupae per leaflet (70.67 PR and 79.86 PR over control) was the next best treatment. The control palms (T<sub>8</sub>) recorded with maximum number of pupae (31.83, 35.89 and 48.77 pupae) per leaflet throughout the observational period. The release

rates at 100 to 400 eggs/palm resulted in 59.36, 68.09, 75.97 and 77.65 PR over control (Table 4).

The identical results were obtained by Chalapathi *et al.* (2020) released a total number of 500 *A. astur* eggs and clipped them in five palms at 100 per palm randomly in the Godavari Ganga hybrid with 9-15 spirals per leaflet and the whitefly population was dwindled to low with less than 3 spirals/leaflet in the palms due to successful establishment of a predator. In further experimentation, it was observed that 80 per cent of RSW eggs were fed by predators on the palm by clipping 100 eggs of predator randomly on the leaflets in 6-year-old cross combination under high infestation levels (> 30 spirals per leaflet).

Similar results were obtained from Zade *et al.* (2007) reported that field releases of *M. boninensis* at 60 eggs and 50 eggs per tree led to successful suppression of citrus blackfly, *Aleurocanthus woglumi* and was significantly superior over that of unreleased control. Studies by Chen *et al.* (2014) reported that inundative releases of *M. basalis* at a rate of

**Table 3.** Efficacy of field release of *A. astur* against nymphs of RSW, *A. rugioperculatus*

S. No.	Treatments	Pre-Count*			Post-Count*									% Reduction over pre-count			% Reduction over control		
					7 DAC			14 DAC			21 DAC								
		2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results
T <sub>1</sub>	Clipping of 100 eggs per palm	72.75 (8.59)	71.40 (8.51)	72.08 (8.55)	52.65 (7.32)	51.30 (7.23)	51.98 (7.28)	39.65 (6.38)	38.30 (6.27)	38.98 (6.32)	21.92 (4.79)	20.57 (4.64)	21.25 (4.72)	47.67	48.57	48.11	57.55	58.44	57.99
T <sub>2</sub>	Clipping of 200 eggs per palm	76.56 (8.81)	75.21 (8.73)	75.89 (8.77)	48.25 (7.02)	46.90 (6.92)	47.58 (6.97)	32.25 (5.77)	30.90 (5.65)	31.58 (5.71)	16.46 (4.18)	15.11 (4.01)	15.79 (4.09)	57.78	58.82	58.29	63.97	64.95	64.45
T <sub>3</sub>	Clipping of 300 eggs per palm	82.25 (9.12)	80.90 (9.05)	81.58 (9.09)	44.25 (6.73)	42.90 (6.63)	43.58 (6.68)	29.25 (5.49)	27.90 (5.38)	28.58 (5.44)	12.88 (3.73)	7.53 (2.92)	10.21 (3.35)	64.99	67.73	66.34	67.90	70.45	69.16
T <sub>4</sub>	Clipping of 400 eggs per palm	85.12 (9.28)	83.77 (9.21)	84.45 (9.24)	43.41 (6.66)	42.06 (6.56)	42.74 (6.61)	29.05 (5.48)	27.70 (5.36)	28.38 (5.42)	10.38 (3.37)	7.03 (2.83)	8.71 (3.12)	67.56	68.99	68.49	69.22	70.61	70.11
T <sub>5</sub>	Clipping of 500 eggs per palm	88.25 (9.45)	86.90 (9.38)	87.58 (9.41)	42.36 (6.59)	41.01 (6.48)	41.69 (6.53)	28.33 (5.42)	26.98 (5.29)	27.66 (5.35)	8.58 (3.11)	6.23 (2.69)	7.46 (2.91)	70.06	71.53	70.77	70.55	71.99	71.25
T <sub>6</sub>	<b>Clipping of 600 eggs per palm</b>	<b>91.35 (9.61)</b>	<b>87.10 (9.39)</b>	<b>89.23 (9.49)</b>	<b>39.79 (6.39)</b>	<b>38.44 (6.28)</b>	<b>39.12 (6.33)</b>	<b>25.36 (5.13)</b>	<b>24.01 (5.00)</b>	<b>24.69 (5.07)</b>	<b>6.45 (2.73)</b>	<b>5.10 (2.46)</b>	<b>5.78 (2.59)</b>	<b>73.87</b>	<b>94.14</b>	<b>74.01</b>	<b>73.39</b>	<b>74.51</b>	<b>73.95</b>
T <sub>7</sub>	Control (No clipping)	79.56 (8.98)	78.21 (8.90)	78.89 (8.94)	85.25 (9.29)	83.90 (9.21)	84.58 (9.25)	89.36 (9.50)	87.90 (9.43)	88.52 (9.47)	94.60 (9.78)	93.25 (9.71)	93.93 (9.74)	-	-	-	-	-	-
S.E (m)		0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.04	-	-	-	-	-	-
C.D at 5 %		0.09	0.08	0.09	0.09	0.09	0.09	0.13	0.13	0.13	0.16	0.16	0.13	-	-	-	-	-	-
C.V		0.59	0.48	0.52	0.68	0.69	0.69	1.12	1.17	1.15	1.95	2.09	1.68	-	-	-	-	-	-

\*Mean of three replicates; DAC: Days after clipping, Figures in the parenthesis are  $\sqrt{x} + 0.5$  transformed values

**Table 4.** Efficacy of field release of *A. astur* against pupae of RSW, *A. rugioperculatus*

S. No.	Treatments	Pre-Count*			Post-Count*									% Reduction over pre-count			% Reduction over control		
					7 DAC			14 DAC			21 DAC								
		2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results	2020-21	2021-22	Pooled results
T <sub>1</sub>	Clipping of 100 eggs per palm	26.25 (5.22)	24.90 (5.09)	25.58 (5.16)	24.74 (5.07)	23.39 (4.94)	24.07 (5.01)	14.66 (3.96)	13.31 (3.78)	13.99 (3.87)	9.96 (3.31)	8.61 (3.09)	9.29 (3.21)	37.33	39.36	38.31	58.35	60.42	59.36
T <sub>2</sub>	Clipping of 200 eggs per palm	24.98 (5.09)	23.63 (4.96)	24.31 (5.03)	20.50 (4.64)	19.15 (4.49)	19.83 (4.56)	11.20 (3.49)	9.85 (3.29)	10.53 (3.39)	7.50 (2.91)	6.15 (2.67)	6.83 (2.79)	47.74	50.40	49.03	66.91	69.28	68.09
T <sub>3</sub>	Clipping of 300 eggs per palm	23.52 (4.95)	22.17 (4.81)	22.85 (4.88)	18.69 (4.44)	17.34 (4.28)	18.02 (4.36)	6.72 (2.78)	5.37 (2.52)	6.05 (2.65)	4.60 (2.36)	3.25 (2.05)	3.93 (2.21)	57.36	60.90	59.17	74.61	77.33	75.97
T <sub>4</sub>	Clipping of 400 eggs per palm	28.50 (5.43)	27.15 (5.31)	27.83 (5.37)	18.50 (4.42)	17.15 (4.26)	17.83 (4.34)	6.10 (2.66)	4.75 (2.39)	5.43 (2.53)	3.15 (2.03)	2.40 (1.83)	2.78 (1.93)	67.54	70.17	68.81	76.58	78.77	77.65
T <sub>5</sub>	Clipping of 500 eggs per palm	27.35 (5.32)	26.00 (5.19)	26.68 (5.26)	17.30 (4.28)	15.95 (4.12)	16.63 (4.19)	5.24 (2.49)	3.89 (2.20)	4.57 (2.35)	2.62 (1.89)	1.87 (1.68)	2.25 (1.79)	69.32	72.15	70.69	78.75	81.02	79.86
T <sub>6</sub>	<b>Clipping of 600 eggs per palm</b>	<b>29.15 (5.49)</b>	<b>27.80 (5.37)</b>	<b>28.48 (5.43)</b>	<b>16.51 (4.18)</b>	<b>15.16 (4.02)</b>	<b>15.84 (4.10)</b>	<b>4.14 (2.26)</b>	<b>2.79 (1.94)</b>	<b>3.47 (2.11)</b>	<b>1.73 (1.63)</b>	<b>0.99 (1.37)</b>	<b>1.37 (1.51)</b>	<b>74.41</b>	<b>77.30</b>	<b>75.81</b>	<b>81.11</b>	<b>83.46</b>	<b>82.26</b>
T <sub>7</sub>	Control (No clipping)	29.56 (5.53)	28.21 (5.40)	28.89 (5.47)	32.50 (5.79)	31.15 (5.67)	31.83 (5.73)	36.56 (6.13)	35.21 (6.02)	35.89 (6.07)	49.44 (7.10)	48.09 (7.01)	48.77 (7.06)	-	-	-	-	-	-
S.E (m)		0.06	0.06	0.06	0.07	0.07	0.07	0.11	0.12	0.11	0.14	0.16	0.15	-	-	-	-	-	-
C.D at 5 %		0.18	0.19	0.18	0.21	0.21	0.21	0.33	0.37	0.35	0.43	0.48	0.45	-	-	-	-	-	-
C.V		1.91	2.00	1.95	2.45	2.62	2.53	5.37	6.42	5.84	7.82	9.52	8.57	-	-	-	-	-	-

\*Mean of three replicates; DAC: Days after clipping, Figures in the parenthesis are  $\sqrt{x} + 0.5$  transformed value

100 to 200 eggs per plant, is an efficient biological means to control Kanzawa spider mite, *Tetranychus kanzawai* Kishida infesting papaya in screen houses.

The findings are supported by Chalapathi *et al.* (2021) who recorded a lesser number of RSW eggs (200.96), nymphs (19.96) and pupae (18.84) in generalist predator *A. astur* inoculated coconut palm on the 28<sup>th</sup> day of release than that of the control palm with 786.7 eggs, 158.50 nymphs and 84.50 pupae.

In the present study, it was observed that the RSW population (spirals, eggs, nymphs and pupae) was sufficient to sustain the progeny (grubs) of *A. astur* eggs clipped at a higher rate i.e., 600 eggs per palm. In all the treatments promising reduction of RSW stages was obtained as the hatching and survival percentage of the predator stages could be sustained due to abundant prey availability. As the predator-prey interaction is density-dependent, the high density of the predator could have more impact on all stages of RSW than at lower densities.

Similarly, Lesna *et al.* (2000) reported that a 3:1 release ratio of a predator, *Hypoaspis aculifer* against prey, *Rhizoglyphus robini* (Claparede) in greenhouse and field experiments gave promising results than when released at lower rates. Nachman and Zemak (2003) observed that higher release rates of predatory mite, *Phytoseiulus persimilis* were effective in suppressing spider mites, *Tetranychus urticae* significantly. Studies by Campbell and Lilley (1999) revealed that the highest Maximum per Capita net Population Growth (MCPG) of *T. urticae* was 4.4 when five female *P. persimilis* were released per plant, whereas the release of 10 and 20 predators per plant led to MCPG values of 2.71 and 1.66 respectively.

El-Din *et al.* (2013) reported that the release of adults and 3<sup>rd</sup> instar larvae of coccinellid, *H. convergens* (Geur.) at two different rates (80 and 120 individuals) against *Aphis gossypii* on squash plants in a screen house reduced the aphid population by 67.25, 72.45, 76.73 and 79.27 per cent over that of control. The highest reduction percentage (79.27 per cent) was obtained after releasing *H. convergens* at a rate of one adult predator per 73 prey individuals.

El-Arnaouty *et al.* (2000) studied the effect of releasing *Harmonia axyridis* (larvae and adults), for the biological control of the cowpea aphid *A. craccivora* (3<sup>rd</sup> instar predator larvae were released at 1/30 and 1/50 aphid individuals). Results showed that the predator *H. axyridis* was able to control the aphid species and the best rate of release was 1 predator / 30 aphids/faba bean plant.

## CONCLUSION

Evaluation of release rates of predator *A. astur* against RSW during 2020-21, 2021-22 and pooled results indicated that clipping of *A. astur* at 600 eggs/palm ( $T_0$ ) recorded the lowest number of RSW stages (spirals, nymphs and pupae).

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