Mass multiplication of *Micromus igorotus* Banks on sugarcanewolly aphid (SWA), *Ceratovacuna lanigera* Zehntner and field release to manage the SWA

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ABSTRACT

Sugarcane woolly aphid (SWA), *Ceratovacuna lanigera* Zehntner, appeared in an epidemic form in southern Maharashtra and Northern Karnataka, India during 2002 and biological control of pest with potential predator, *Micromus igorotus* Banks was found to be dependable remedy. So the predator was mass multiplied in laboratory on SWA, and then released in sugarcane ecosystem. The adults were reared using plastic container of 25 cm (ht.) X 11.25 cm (dia) size and were released @ 25 pairs per container. SWA was given as adult food and cotton thread [15 cm (length) and 0.155 cm (thick)] was used as ovipositional substrate. The larvae were reared in plastic box with ventilated lid [10.00 cm (ht.) X 25.50 cm (dia)] @ 100 larvae per box. At the time of pupation corrugated brown paper of 15.0 cm (l) X 12.0 cm (w)] was provided for pupation. The pupae of the predator were released in SWA infested sugarcane fields @ 500, 1000 and 1500 pupae/ha. Studies on predatory dosage, level of incidence and gestation period for suppression of SWA to desired level indicated that there exists choice in altering the dosage depending on the severity of aphid incidence, age of the crop and gestation period targeted for suppression of pest. Augmentation of 500 pupae/ha was adequate to suppress the pest in 90 days when it was prevalent at grade 2 – 3 on 6 – 7 month crop during June – November. To reduce the gestation period and thus to prevent growth and loss of cane, release of 1000 pupae/ha on 6 – 7 months crop infested with SWA at 3 – 4 grade ensured the suppression of the pest in 60 days after release (DAR) in June – November. A dosage of 1500 pupae/ha proved effective to lower the SWA incidence from sever state of grade 5 – 6 on crop of 6 – 7 months in 30 DAR during June to November. In all the field release studies, native population of SWA predator assisted the augmented population.

Key words: *Ceratovacuna lanigera, Hemerobius* spp*., Micromus igorotus*

INTRODUCTION

The members of Hemerobiidae are unfamiliar since they are rare in nearly all localities. The brown lacewings (BLW) are cosmopolitan neuropteran group comprising approximately 575 species worldwide. Hemerobiids, characteristics of low vegetation, include a number of species from widely distributed genera and most of the biological information available refers to *Micromus* Rambur and *Hemerobius* Linnaeus. Soft bodied and very fragile BLW have been regarded as "key predators" of aphids (Horne *et al.,* 2001). Persistence in the environment is likely during the period of low pest abundance when alternative food is available. They are regarded as "Lying in wait" and as "Insurance" against pest outbreaks (Chang and Kareiva, 1999). The number of *Micromus* species reported so far in the world is 42, of which two are encountered in India. *Micromus igorotus* was described for the first time by Banks in 1920, redescribed and illustrated by Monserrat (1993). This species was originally described from Philippines, and has since been reported from China, Indonesia, Malaysia, Taiwan and Thailand, whereas from India and elsewhere, it has been reported for the first time as predator of sugarcane woolly aphid, *C. lanigera* (Lingappa *et al.,* 2004). The species is widespread in oriental region.

Suppression of any pests by biological control is not only density dependent but also influenced by the rate of multiplication of pest versus predator, feeding potential, native predator population, climatic conditions favourable to predator and unfavourable to pest. In the exploitation of a predator, it becomes imperative to make indepth studies on release rate, time and frequency of natural enemy. In cognizance of this fact, mass multiplication and field release studies were undertaken to find out the effective dosage to suppress the pest within reasonably short time without affecting the quality and quantity of the produce.

MATERIALS AND METHODS

Mass rearing of *M. igorotus*

Nucleus culture of *M. igorotus* larvae and pupae were collected from the sugarcane field infested with SWA in Sunadholi village of Gokak taluk in Belgaum. The larvae were reared in round plastic box with ventilated lid. The pupae were kept for emergence in the ventilated plastic box. Freshly emerged adults were released for oviposition in round plastic container providing SWA infested sugarcane leaf bit. In the field oviposition was seen on abdoned spider webbing. So, to simulate the natural oviposition a substrate cotton thread string was provided for egg laying. The eggs were further used for mass multiplication studies.

Culture of aphids is essential for large scale production of *M. igorotus*. For multiplication of *M. igorotus*, either *Aphis gossypii* G., *Melanaphis sacchari* (Zehntner) and SWA can be used. But, considering the availability of the host throughout the year, *C.lanigera* being a naturally preferred host, gets an edge over all aphid species, for selection as ideal host for rearing in the insectary. The SWA required for mass multiplication was maintained on sugarcane crop by irrigating and providing nitrogen fertilizer at regular intervals that boost SWA population.

Materials required for mass rearing of *M. igorotus* are plastic container of 25 cm (height) x 11.25 cm for adult rearing, cotton thread of 15 cm (length) and 0.155 cm (thick)] as ovipositional substrate, thin nylon cloth for covering the container, plastic box with ventilated lid of 10.00 cm (height) X 25.50 cm (dia) for larval rearing, corrugated brown paper of 15 x 12 cm for pupation, plastic vials of 7.5 x 2.5 cm for adult collection, injection vials for keeping adult food, seizer, camel hair brushes and rubber bands .

Field establishment studies

Assessment on time delay in the suppression of SWA following *M. igorotus* release at different dosages was carried out in open field condition. In the first year, trials were conducted in two districts in North Karnataka (Belgaum and Bagalkot) and one district in South Karnataka (Mandya) from June to December, 2004 at varied pest intensity, natural enemy diversity and abundance and varied climatic conditions. Experimental crop selected for release of predator varied from six to ten months age. Assessment of SWA infestation (1-6 scale) (0% - grade 1; 1 -20% grade 2; 21 - 40% grade 3; 41 - 60% grade 4; 61 - 80% grade 5 and 81 - 100% grade 6) (Anon., 2005) and natural enemy population per clump were made before the release of predator from ten randomly selected clumps @ five leaves/clump in each field. Predator (*M. igorotus*) pupae were released @ 500, 1,000 and 1,500 per ha. Corrugated paper or sugarcane leaf bits containing pupae were inserted at 30 cm from ground in the tight leaf sheaths of severely SWA infected clumps. Care was taken to avoid direct sunlight and rainwater hitting the released pupae. Post treatment observations on SWA and natural enemy population were made at 30, 60, 90 and 120 days after release of predator as mentioned earlier. In the second year, studies were made from January 2005 to December 2005 in three districts of North Karnataka (Dharwad, Belgaum and Bagalkot) following the procedure outlined above.

RESULT AND DISCUSSION

Mass multiplication of *M. igorotus*

The adults were reared using plastic container. Before release of adults into container, SWA infested sugarcane leaf bit of 20 cm was given as adult food. The turgidity of leaf was maintained by inserting the lower end of bit in glass vial containing water plugged with cotton wad. Cotton thread string [15 cm (length) and 0.155 cm (thick)] was hanged from the container mouth @ of 20-25 numbers/container. Then the adults were released @ 25 pairs per container. Then the container mouth was covered with muslin cloth and fastened with rubber band. Adults were transferred to fresh container containing oviposition substrate and SWA as food everyday. The eggs were collected and kept for hatching in plastic box with ventilated lid.

Freshly hatched larvae were transferred to plastic box with ventilated lid @ 100 larvae per box. Larvae were reared on SWA by providing sugarcane leaf bit of 15 cm. The container was changed every day and fresh food was provided twice a day. While the larvae were transferred to fresh container every day, on 5th day when larvae were about to pupate, corrugated brown paper was provided for pupation. Pupae on corrugated paper were kept in plastic container for adult emergence. The adult emerged are used for further mass multiplication, whereas part of pupae obtained were used for field release studies.

Economics of production of *M.igorotus* are furnished in Table 1. Accordingly, the production cost per 1000 pupae comes to Rs. 100.00 or per pupa to 10 paise.

Field release studies of *M. igorotus*

During July – August, 2004-05, the predator was released at fourteen locations in Bagalkot, Belgaum and Dharwad districts @ 500pupae/ha (Table 2). Out of 14 places, greater success was met at 11 places. The woolly aphid, whose severity was in 3-5 grade before release was clinched to 2–4 grade at 30 DAR of predator. From then on 2 months time was needed to bring down the population to grade 1. Population of *M. igorotus* and *D. aphidivora,* which was 0.00 to 0.85 and

Table 1

Materials required and cost involved in production of *M. igorotus* @ 3000 pupae per day

Fixed cost

Particulars	Quantity	Unit cost (Rs.)	Cost (Rs.)
Room	1 (12' x 15')		Rental basis
Racks	3 (6.5' x 3' x 1')	3,000=00	9,000=00
Working table	1 (4' x 3')	1,000=00	1,000=00
Stools	4	100=00	400=00
Mesh top boxes	50	55=00	2,750=00
Jars	30	52=00	1,560=00
Adult vials	6	10=00	60=00
Glass vials	100		-
Scissors	2	40=00	80=00
	Total		**14,850**

Cost Economics of *Micromus* Production

Depreciation values in Rupees per month	**Cost (Rs.)**
a. Racks, table & stools	87=00
b. Mesh top boxes & Jars	180=00
Room Rent	500=00
Monthly ORC	8,270=00
Total costs per month for production of 90,000 pupae of predator	9,037=00
Cost of production 1000 predators	100.41=00
Cost per ha (Rs.) recommended @1000 pupae per ha	100=00

Consumables required and their cost for production of 3000 *Micromus* pupae per day per month

Operational costs

Particulars	Quantity	Unit cost (Rs.)	Cost /month (Rs.)
SWA infested leaves	100 /day		-
Labour Charges	3	2,500=00	7,500=00
White cloth	2 m	20=00	40=00
Thread	6 bundles	32=00	192=00
Corrugated Paper	1 Kg	25=00	25=00
Nose masks	12	5=00	60=00
Packing boxes	90	5=00	450=00
Total			**8,267**

0.07 – 1.80 larvae/clump before release, was increased to 1.85–4.75 and 0.13–2.13. Corresponding figures at the end of 90 DAR were 0.00–0.098 and 0.00 – 0.09. Decrease in predator population closely followed that of SWA population. Experiments met with failure at 3 locations.

Studies were taken up by release of 1,000 predators/ha in 20 fields during July–August, 2004-2005 and at 13 places (Table 3), confirmed success of *M. igorotus* in the suppression of SWA population within 60 DAR. Interestingly predator could not be noticed at 7 locations where the pest had declined drastically due to pesticide intervention soon after release. Though the SWA population was effectively controlled by

Table 2. Effect of release of *M. igorotus* pupae @ 500/ha on SWA activity (July–August 2004-05)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			Status of aphid control	Locality
			SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of			
				M. i +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		
1	1.0	500	3	0.00	1.22	2	1.85	0.93	1	0.71	0.15	1	0.00	0.00	Success	Mudhol
2	1.0	500	3	0.00	0.20	2	1.97	0.13	1	0.17	0.00	1	0.00	0.00	Success	Bilagi
3	0.4	200	3	0.00	0.07	3	0.41	0.11	4	0.89	1.02	4	1.08	0.85	Failure**	Saundatti
4	0.5	250	3	0.00	0.00	1*	0.00	0.00	2	0.00	0.00	2	1.18	0.00	Failure	Gokak
5	0.5	250	3	0.63	0.00	2	4.17	0.04	1	0.00	0.00	1	0.00	0.00	Success	Dharwad
6	1.0	500	3	0.18	0.00	2	3.53	0.00	1	0.00	0.00	1	0.00	0.00	Success	Dharwad
7	0.8	400	3	0.85	0.00	2	5.35	0.00	1	0.05	0.00	2	0.98	0.00	Success	Bailhongal
8	2.0	1000	4	0.00	0.35	2	4.75	0.54	1	0.03	0.10	1	0.00	0.00	Success	Mudhol
9	0.5	250	4	0.00	0.25	3	3.25	1.07	2	3.42	1.00	1	0.04	0.09	Success	Bilagi
10	0.5	250	4	0.00	0.54	3	4.33	0.95	2	5.07	1.26	1	0.00	0.00	Success	Bailhongal
11	0.4	200	4	0.00	0.75	1*	0.00	0.00	2	0.00	0.00	2	0.42	0.00	Failure	Khanapur
12	0.5	250	4	0.00	0.75	3	2.25	0.64	2	4.33	0.03	1	0.75	0.00	Success	Mudhol
13	1.0	500	4	0.65	0.07	2	4.45	0.29	1	0.75	0.00	1	0.00	0.00	Success	Saundatti
14	0.2	100	5	0.00	1.80	4	3.55	2.13	3	5.25	0.00	1	0.16	0.00	Success	Khanapur

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant

* Due to chemical intervention before 30 days of observation; ** Detrashing of crop the population build was very slow

chemical toxicant, resurgence was evident at 60 days where the incidence increased at 5 locations. At Gokak, success was due to *D. aphidivora* whose population increased by 222.08% at 30 DAR. While SWA population was contained at grade 1, where *M. igorotus* exerted biotic pressure, it increased in the remaining localities. It may be said that time gap from release to pest suppression was shorter than in earlier studies. At Bailhongal and Saundatti, SWA reappeared because of heavy irrigation. But with reappearance of SWA, *M. igorotus* also reappeared (0.95–1.09 larvae/clump) immediately and curtailed build up of the aphid.

Predator released at 1500/ha at 10 locations during July–August, 2004-2005 ensured pest suppression in 60 days at 8 locations and partial at one and failure in the remaining location (Table 4). The aphid population slide down from 3 and 6 grades to 2– grade in 30 days and to 1 grade in 60 days. Natural population of *M. igorotus* and *D. aphidivora* was 0.00 and up to 0.75 larvae/clump respectively before experimentation. Consequent to release of *M. igorotus,* the population exploded to 13.54 while *D. aphidivora* increased marginally at 30 DAR. BLW density ranged from 0.00 to 0.95 at 60 DAR and disappeared totally at 90 DAR consequent to decrease in SWA population. Release dosage of predator @ 500, 1000 and 1500 pupae ha^{-1} during September–November, 2004–20 05.

Results of the trial conducted during September–November, 2004-05 confirmed the efficacy of the predators where the complimentary action of native population of both the predators synergised the efficacy of augmented predator @ 500/ha (Table 5). Natural incidence of *M. igorotus* and *D. aphidivora* was fairly high (4.23-5.35 and 1.69-4.32 larvae/clump) at two location were success was witnessed in 30 days and time extension of 30 more days was needed in another two location where the initial predator density was 1.43 and 2.35 respectively. At K. R. Pet, SWA density increased from grade 5 to 6 at 30 DAR and then declined to 1 at 60 DAR partially. There was increase in *M. igorotus* and *D. aphidivora* population from 0.00 to 2.14 and 3.25 to 3.54 larvae/clump before vanishing from scene at 60 DAR. The farmer at this location had resorted to insecticidal spray to contain the pest, hence the deviation in findings from other locations.

Aphid was successfully contained at 12 out of 13 places where the release was undertaken @ 1000 pupae/ha (Table 6). The pest declined from 3–6 grade to 1 grade by 60 days and was

Table 3. Effect of release of *M. igorotus* pupae @ 1000/ha on SWA activity (July – August 2004-05)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			Status of aphid control	Locality
			SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of			
				M. i +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		
1	2.0	2000	3	0.00	0.00	1	1.32	0.00	1	0.00	0.00	1	0.00	0.00	Success	Dharwad
2	0.8	800	3	0.13	0.03	1	0.80	0.00	1	0.00	0.00	2	0.95	0.00	Success	Bailhongal
3	1.0	1000	3	0.00	0.09	1	0.14	0.00	1	0.00	0.00	2	1.09	0.00	Success	Saundatti
4	0.8	800	4	0.00	0.05	3	8.73	0.74	2	12.13	0.92	1	0.08	0.00	Success	Bailhongal
5	0.2	200	4	0.00	0.32	1*	0.00	0.00	2	0.00	0.00	3	1.14	0.00	Failure	Khanapur
6	0.4	400	4	0.00	1.43	1*	0.00	0.00	0.00	0.00	0.00	2	0.00	0.00	Failure	Bailhongal
7	0.8	800	4	0.00	0.83	1*	0.00	0.00	1	0.00	0.00	2	0.00	0.00	Failure	Bailhongal
8	1.0	1000	4	0.10	1.63	3	2.0	3.62	2	2.50	4.74	1	0.00	0.92	Success**	Gokak
9	1.0	1000	4	0.79	0.00	2	4.77	0.00	1	0.05	0.00	1	0.00	0.00	Success	Dharwad
10	0.8	800	4	0.75	0.00	2	5.53	0.05	1	0.00	0.00	1	0.00	0.00	Success	Dharwad
11	1.2	1200	4	0.26	0.01	2	9.83	0.00	1	0.00	0.00	1	0.00	0.00	Success	Saundatti
12	0.5	500	5	0.00	0.25	2	11.27	0.83	1	0.00	0.17	1	0.00	0.05	Success	Saundatti
13	1.0	1000	5	0.00	1.25	3	13.67	1.86	2	6.43	0.72	1	0.00	0.13	Success	Khanapur
14	1.6	1600	5	1.63	0.00	3	13.83	0.19	1	0.05	0.00	1	0.00	0.00	Success	Saundatti
15	0.4	400	5	0.00	0.80	1*	0.00	0.00	2	0.00	0.00	3	0.92	0.00	Failure	Khanapur
16	0.2	200	5	0.00	0.74	1*	0.00	0.00	2	0.00	0.00	3	0.00	0.00	Failure	Khanapur
17	0.2	200	5	0.00	1.69	1*	0.00	0.00	2	0.00	0.00	3	0.00	0.00	Failure	Bailhongal
18	1.0	1000	6	0.00	2.85	4	6.42	1.74	2	11.75	0.09	1	0.12	0.00	Success	Mudhol
19	2.0	2000	6	0.00	3.25	4	9.83	2.74	2	7.90	1.58	1	0.25	0.00	Success	Bilagi
20	0.2	200	6	0.00	2.72	1*	0.00	0.00	2	0.00	0.00	2	0.00	0.95	Failure	Bailhongal

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant
* Due to chemical intervention before 30 days of observation; ** Success due to *D. aphidivora* not by *M. igorotus* because of detrashing

Table 4. Effect of release of *M. igorotus* pupae @ 1500/ha on SWA activity (July – August 2004-05)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			Status of aphid control	Locality
			SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of			
				M. i +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		
1	0.8	1200	3	0.00	0.13	1	0.25	0.00	1	0.00	0.00	1	0.00	0.00	Success	Bailhongal
2	4.0	6000	4	0.00	0.00	2	11.43	0.07	1	0.24	0.27	1	0.00	0.00	Success	Bilagi
3	2.0	3000	4	0.00	0.15	2	13.54	0.74	1	0.95	0.62	1	0.00	0.00	Success	Khanapur
4	2.0	3000	4	1.00	0.00	2	10.85	0.25	1	0.07	0.03	1	0.00	0.00	Success	Dharwad
5	0.4	600	4	0.25	0.00	1	0.95	0.00	1	0.00	0.00	2	1.22	0.00	Success	Bailhongal
6	2.0	3000	5	0.00	0.75	3	9.32	0.92	1	0.00	0.25	1	0.00	0.00	Success	Mudhol
7	5.0	7500	5	0.00	0.00	3	10.64	0.93	1	0.17	0.03	1	0.00	0.00	Success	Bilagi
8	0.8	1200	5	1.25	0.23	2	12.65	0.07	1	0.03	0.00	2	1.32	0.27	Success	Saundatti
9	1.0	1500	6	0.00	1.32	1*	0.00	0.00	1	0.00	0.00	3	0.00	0.00	Failure	Khanapur
10	1.0	1500	6	0.00	0.98	5	0.48	1.76	4	0.95	1.79	3.50	1.10	2.01	Partial control**	Gokak

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant
* Due to chemical intervention before 30days of observation; ** Partial control because of detrashing of crop the population build up was very slow

contained thereafter till 90 days. Synchronously the population of *M. igorotus* rose from 0.00-6.56 larvae/clump to maximum of 14.75 larvae 30 DAR, which however, declined to 0.00–0.95 at 60 DAR as the host density dwindled to grade 1 and both the pest and predators stabilised there after. The results presented in Table 7 indicate that as the predatory population increased from 0.19–2.35 to 8.95–16.85, the pest incidence was lowered to 2–4 grade from 4–6 after 30 DAR. As the SWA reached grade 1 at 90 DAR, the predator number declined to minimum. Deviation of results at Gokak was once again due to insecticide application after 30 DAR. Release dosage of predator @ 500, 1000 and 1500 pupae ha^{-1} during January – February 2004 –20 05.

At the lowest augmentation dosage, failure of treatment was noticed at 2 out of 3 locations (Table 8). At the successful location, a time lapse of 120 days was required for the predators to bring down the pest incidence from grade 5 to 1 with the concurrent increase in *M. igorotus* population to reach maximum of 3.19 at 90 DAR before declining to 0.63 at 120 DAR. At Gokak and Saundatti experiment met with failure because of chemical spray by the impatient farmers.

Trials with higher dosage at 3 locations met with total success (Table 9). The aphid population was lowered from 4-5 grade to 3–4 grade in 30 days and to 2–3 grade and 1 in 90 and 120 DAR, respectively. Conversely *M. igorotus* and *D. aphidivora* population rose from 0.00 – 0.23 and 0.13 – 1.43 larvae/clump to 4.34 - 6.80 and 0.61 -1.78 larvae/clump and to 1.53–3.69 and 0.04–0.93 respectively at 60, 90 and120 DAR. Experiments with highest dosage revealed success at 2 out of 3 study locations (Table 10). Results of this study exhibited same trend of gradual decline in pest incidence *vis-à-vis* increase in predatory population till the SWA population was stablised at 1 grade after 120 days. Failure at Dharwad was due to rigorous killing of the predators at 60 DAR by pesticidal application.

Studies on period of release of *M. igorotus* revealed that early effect of the predator was apparent during July – August and September – November where the SWA incidence was lowered within 60 to 90 DAR as against 120 DAR during January – February. Predatory dosage, level of incidence and gestation period for suppression of SWA to desired level indicated that there exists choice in altering the dosage depending on severity of aphid incidence, age of the crop and gestation period targeted for suppression of pest. Augmentation of 500 pupae/ha was adequate to suppress the pest in 90 days when it is prevalent at grade 2–3 on 6–7 month crop during June – November. To reduce the gestation period and thus to prevent growth and loss of cane, release of 1000 pupae/ha on 6–7 months crop infested with SWA at 3–4 grade ensured the suppression of the pest in 60 DAR in June – November. A dosage of 1500 pupae/ha proved effective to lower the SWA incidence from sever state of grade 5–6 on crop of 6–7 months in 30 DAR during June to November. In all the field release studies, native population of SWA predator assisted the augmented population.

Table 5. Effect of release of *M. igorotus* pupae @ 500/ha on SWA activity (September-November 2004-05)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			Status of aphid control	Locality
			SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of			
				M. i +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		*M. i*+	*D. a* ++		
1	0.8	400	3	2.35	1.62	2	3.56	0.65	1	0.12	0.07	1	0.00	0.00	Success	Saundatti
2	1.0	500	3	5.35	1.69	1	0.94	0.79	1	0.00	0.00	2	0.61	0.17	Success	Bailhongal
3	0.2	100	4	1.43	2.25	2	3.49	1.73	1	0.00	0.54	1	0.00	0.00	Success	K. R. Pet
4	0.2	100	4	4.23	4.32	1	0.11	0.32	1	0.00	0.00	1	0.00	0.00	Success	K. R. Pet
5	0.4	200	4	3.85	2.65	2	4.65	4.99	2	3.21	3.31	1	0.07	0.79	Success	Dharwad
6	0.4	200	5	0.00	3.25	6	2.14	3.54	1*	0.00	0.00	2	0.00	0.00	Failure	K. R. Pet

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant
* Due to chemical intervention after 30days of release

Table 6. Effect of release of *M. igorotus* pupae @ 1000/ha on SWA activity (September-November 2004-05)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			Status of aphid control	Locality
			SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of			
				M. i +	*D. a* ++		*M. i* +	*D. a* ++		*M. i* +	*D. a* ++		*M. i*+	*D. a*++		
1	1.0	1000	3	0.00	0.00	2	7.15	0.07	1	0.95	0.00	1	0.00	0.00	Success	Saundatti
2	3.0	3000	3	0.00	1.72	2	8.28	1.93	1	0.08	0.04	1	0.00	0.00	Success	Saundatti
3	0.4	400	4	1.20	1.43	2	8.73	2.42	1	0.00	0.05	1	0.00	0.00	Success	Mandya
4	0.8	800	4	2.12	2.22	2	9.42	0.07	1	0.02	0.00	1	0.00	0.00	Success	Mandya
5	0.6	600	4	0.00	0.17	3	2.38	0.93	1*	0.00	0.00	2	0.00	0.00	Failure	Mandya
6	1.0	1000	4	1.00	0.15	2	12.56	0.73	1	0.01	0.05	1	0.00	0.00	Success	Saundatti
7	0.8	800	4	0.95	0.64	3	8.85	1.07	1	0.93	0.13	1	0.00	0.00	Success	Dharwad
8	0.8	800	4	5.38	2.04	1	0.35	0.06	1	0.00	0.00	2	1.07	0.00	Success	Dharwad
9	0.3	300	5	1.32	2.15	3	7.83	1.93	1	0.03	0.41	1	0.00	0.00	Success	Mandya
10	1.2	1200	5	4.38	1.94	2	12.94	2.05	1	0.73	0.34	1	0.00	0.00	Success	Bailhongal
11	1.0	1000	6	1.04	2.42	4	13.75	1.54	1	0.11	0.13	1	0.00	0.00	Success	K. R. Pet
12	1.0	1000	6	2.13	1.86	2	14.13	2.67	1	0.00	0.92	1	0.00	0.00	Success	K. R. Pet
13	1.6	1600	6	6.56	2.64	3	14.75	3.69	1	0.85	0.17	1	0.00	0.00	Success	Bailhongal

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant
* Due to chemical intervention after 30days release

Hemerobiids have not been attempted either for inoculative or inundative release for biological control (Eilenberg *et al.,* 2001). Thus the work on field establishment of BLW, specifically *M. igorotus* is very meagre, to compare with the present findings. However, *Micromus timidus* was introduced for control of sugarcane and corn aphids (Williams, 1927) and later recovered in the field. Neuenschwander and Hagen (1980) released eggs of *Hemerobius pacificus* Banks @ 240 eggs per week. The aphid populations were reduced consistently and artichoke plume moth (APM), *Platyptilia carduidactyla* (Riley) infestation was lowered by 30%. Eggs of *Micromus tasmaniae* (Walker) were dispersed in sprays for the control of *Myzus persicae* (Sulzer). Aphids were reduced by 70% and potato tuber yield was increased by 38% compared to those in untreated plots (Hussein, 1983 and Hussein, 1984). Potemkina and Kovalenko (1990) released the first instar larvae of *Micromus angulatus* (Stephens), against *Aphis fragulae* Kaltenbach on cucumber. The combined use of *M. angulatus* and the fungus, *Verticillium lecanii* (Zimmerman) demonstrated to be effective against aphids.

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Table 7. Effect of release of *M. igorotus* pupae @ 1500/ha on SWA activity (September-November 2004-05)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			Status of aphid control	Locality
			SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade#	No. of			
				M. I +	*D. a*++		*M. i* +	*D. a*++		*M.i* +	*D. a* ++		*M. i*+	*D. a*++		
1	1.0	1500	4	0.98	1.05	2	10.85	1.35	1	0.05	0.19	1	0.00	0.00	Success	Saundatti
2	0.8	1200	4	0.24	0.35	2	12.93	0.69	1	0.04	0.07	1	0.00	0.00	Success	Dharwad
3	0.8	1200	4	1.65	0.74	2	11.39	0.09	1	0.13	0.00	1	0.00	0.00	Success	Dharwad
4	0.4	600	5	0.83	0.04	3	13.75	0.74	1	0.35	0.06	1	0.00	0.00	Success	Dharwad
5	0.4	600	5	1.74	0.72	3	14.15	0.98	1	1.24	0.00	1	0.00	0.00	Success	Dharwad
6	1.6	2400	5	0.42	0.15	3	15.64	0.53	1	0.26	0.10	1	0.00	0.00	Success	Dharwad
7	0.4	600	5	1.04	2.05	2	16.85	1.35	1	0.65	0.00	1	0.00	0.00	Success	Saundatti
8	0.4	600	5	2.35	1.32	3	8.95	2.62	1	1.24	0.74	1	0.00	0.00	Success	Bailhongal
9	0.8	1200	5	2.17	1.74	3	9.76	3.18	1	0.56	0.12	1	0.00	0.00	Success	Bailhongal
10	0.5	750	6	0.19	0.25	4	12.43	1.13	2	20.86	0.10	1	0.03	0.00	Success	Mandya
11	2.0	3000	6	1.25	0.96	5	5.34	2.01	1*	0.00	0.00	1	0.00	0.00	Failure	Gokak

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant

* Due to chemical intervention after 30 days of release

Table 8. Effect of release of *M. igorotus* pupae @ 500/ha on SWA activity (January – February 2004-05)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			120 Days After Release			Status of aphid control	Locality
			SWA severity in grade #	No. of		SWA severity in grade #	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of			
				M i +	*D. a*++		*M i*+	*D. a*++		*M i*+	*D. a*++		*M i*+	*D. a*++		*M i*+	*D. a*++		
1	1.0	500	4	0.00	0.25	4	1.02	1.45	1*	0.00	0.00	1	0.00	0.00	1	0.00	0.00	Failure	Saundatti
2	0.4	200	4	0.43	2.53	1*	0.00	0.00	1	0.00	0.00	1	0.00	0.00	1	0.00	0.00	Failure	Gokak
3	0.8	400	5	0.00	0.76	5	1.65	1.89	4	2.42	2.00	3	3.19	1.93	1	0.63	0.22	Success	Saundatti

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant

* Due to chemical intervention before and after 30 days of observation

Table 9. Effect of release of *M. igorotus* pupae @ 1000/ha on SWA activity (January – February 2005)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			120 Days After Release			Status of aphid control	Locality
			SWA severity in grade#	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of			
				M. i+	*D. a*++		*M. i*+	*D. a*++		*M. i*+	*D. a*++		*M. i*+	*D. a*++		*M. i*+	*D. a*++		
1	0.4	400	5	0.23	0.65	4	2.74	0.85	4	4.34	0.61	3	2.04	0.93	1	0.92	0.00	Success	Dharwad
2	0.8	800	4	0.00	0.13	3	2.18	0.63	3	4.74	0.71	3	3.69	0.16	1	1.12	0.00	Success	Dharwad
3	0.4	400	4	0.00	1.43	4	3.05	0.95	3	6.80	1.78	2	1.53	0.04	1	0.98	0.00	Success	Saundatti

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant

Table 10. Effect of release of *M. igorotus* pupae @ 1500/ha on SWA activity (January – February 2005)

Sl No.	Area (ha)	No. of pupae released/ha	Before Release			30 Days After Release			60 Days After Release			90 Days After Release			120 Days After Release			Status of aphid control	Locality
			SWA severity in grade#	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of		SWA severity in grade#	No. of			
				M. i+	*D. a*++		*M. i*+	*D. a*++		*M. i*+	*D. a*++		*M. i*+	*D. a*++		*M. i*+	*D. a*++		
1	3.0	4500	5	0.00	0.89	4	4.64	0.96	3	5.94	0.63	2	2.04	0.93	1	0.98	0.00	Success	Saundatti
2	2.0	3000	4	0.00	0.63	3	3.74	0.17	3	4.74	0.21	2	0.35	0.04	1	0.18	0.00	Success	Saundatti
3	1.5	2250	6	0.23	0.14	5	4.01	0.22	1*	0.00	0.00	1	0.00	0.00	1	0.00	0.00	Success	Dharwad

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* per plant; ++ = No. of *Dipha aphidivora* per plant
* Due to chemical intervention after 30 days of release

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