Research Paper :

Field evaluation of *Micromus igorotus* banks (Neuroptera: Hemerobiidae) for the management of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner

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SUMMARY

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 the potential predator, *Micromus igorotus* Banks was found to be dependable remedy. Preliminary studies were conducted under confinement in sugarcane crop from January to December, 2004-05 by erecting the nylon net of 5 x 5 x 4 m. Severity of SWA was reduced to grade one within 30 DAR of predator during June – August and October – December. On the contrary, further 30 days were required to reduce to same level during January – March. Under open field condition, predator (*M. igorotus*) pupae were released @ 500, 1,000 and 1,500 per 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 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 severe 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 : Biological control, *Ceratovacuna lanigera*, *Micromus* spp., *Micromus igorotus*

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Natural enemies are key mortality factors of insect pests devouring field crops, much before the invention of artificial measures of pest control, specially chemical toxicants. Use of toxicants, while providing temporary relief from insect pests, disrupted the ecological balance by killing natural enemies. In situations, where this interaction is disrupted, potential insect pests are relieved from the constraints imposed by their natural enemies and therefore, unhindered population growth lead to pest outbreak.

Insects also become enemies when dissociated from their natural enemies due to habitat modification that differentially favour the pest, egg., habitat simplification. Use of natural enemies in pest management is mainly concerned with redressing the imbalance that has occurred through this disassociation, either by reintroducing natural enemies into the system or by trying to recreate conditions where an association can occur.

In sugarcane, biological control occupies a pivotal position in insect pest management. Similarly for the management of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner, which appeared suddenly in an epidemic form in Southern Maharashtra and Northern Karnataka during 2002, biological control appears to be the potential and dependable remedy. Solitory and the first report of *Micromus igorotus* Banks in India by Lingappa *et al.* (2004) as a most potent and amenable predator for mass production and utilization in SWA management paved way for undertaking this investigation in an effort to provide effective and sustainable biocontrol technology. This neuropteran belonging to family Hemerobiidae was encountered commonly in SWA infested fields in Northern Karnataka.

MATERIALS AND METHODS

Under confined condition:

Preliminary studies were conducted to know the impact of *M. igorotus* release on SWA suppression under confinment. In the first year, trials were conducted in sugarcane crop of six to seven months old under differential pest intensity, natural enemy population and climatic conditions in two districts in North Karnataka (Belgaum and Dharwad) from June to December, 2004. Natural population of *M. igorotus* and *D. aphidivora* were removed and then the nylon net of 5 x 5 x 4 m was erected with the support of bamboo poles. Assessment of SWA infestation was on the basis of 1 – 6 scale (detailed below) (Anonymous, 2005) on five clumps selected randomly @ five leaves per clump before release of adult predator @ one pair per clump. Post treatment observations on both SWA and *M. igorotus* pupae per clump were made from each clump within the cage at 30, 60 and 90 days after release of predator. The studies were repeated in the second year from January to December 2005 in the same districts but at different locations.

Scale	Per cent leaf infestation
1 grade	0.00
2 grade	1 - 20
3 grade	21 - 40
4 grade	41 - 60
5 grade	61 - 80
6 grade	81 - 100

Under open field condition:

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) 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.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been presented under following heads:

Confined condition:

Severity of SWA was reduced to grade one from 4 - 6 within 30 DAR of predator during June – August and October – December (Table 1). On the contrary, further 30 days were required to reduce to same level from 4 –5 grade during January – March. This could mean that rate of predator multiplication was low and climatic factors prevailing during the period were obviously not congenial for predatory action and multiplication.

Open condition:

Suppression of any pests by biological control is not only density dependent but also influenced by 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, 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.

Time delay in the suppression of SWA at varying intensities:

Data on field release of predator for suppression of SWA was pooled and analysed according to pest intensity, dosage of predator irrespective of season of release to extract the influence of dosages on SWA suppression at different grades.

When the pest incidence was at 3 grade (Fig. 1a), release of predator @ 1500 pupae/ha suppressed the pest effectively within 30 days of predator release (DAR). While at lower dosages of 1000 and 500 pupae/ha, though the extent of reduction of SWA was low and in accordance with dosage at 30 DAR, time requirement to achieve the same effect was extended by 30 days more. However, all the three dosages were found equally effective in lowering SWA incidence to grade 1, which is tolerated by the 6 months old crop and more at 60 DAR. Increase in SWA severity after 60 days in lower dosage trials was mainly because of heavy irrigation and high nitrogenous fertilization. These two causes, though not experimentally proved and placed on record, were frequently associated with increase in SWA during two years of survey and field investigation. With the reappearance of the pest, *M.*

Table 1 : Establishment of under confinement during different periods

Sr. No.	Before release		30 Days after release		60 Days after release		90 Days after release	
	SWA severity # (in grade)	Number of *M. i* +	SWA severity # (in grade)	Number of *M. i* +	SWA severity # (in grade)	Number of *M. i* +	SWA severity # (in grade)	Number of *M. i* +
January – March 2004-05								
1	5	0.00	3	18.10	1	25.68	1	0.00
2	4	0.00	2	17.42	1	21.43	1	0.00
Mean	4.5	0.00	2.5	17.76	1	23.56	1	0.00
June– August 2004-05								
1	5	0.00	1	30.14	1	0.00	1	0.00
2	6	0.00	1	28.19	1	0.00	1	0.00
3	4	0.00	1	27.25	1	0.00	1	0.00
Mean	5	0.00	1	28.52	1	0.00	1	0.00
October- December 2004-05								
1	6	0.00	1	28.39	1	0.00	1	0.00
2	6	0.00	1	27.10	1	0.00	1	0.00
3	5	0.00	1	26.47	1	0.00	1	0.00
Mean	5.67	0.00	1	27.32	1	0.00	1	0.00

= Grading on 1 –6 scale; + = No. of *Micromus igorotus* pupae per clump

igorotus population also developed to exert pressure on pest buildup (Fig. 2a) but not *D. aphidivora* (Fig. 2e).

At grade 4 of SWA incidence (Fig. 1b), release of 500, 1000 and 1500 required around 60 days to bring down the incidence below grade 2. Better suppression of SWA @ 500 pupae/ha was mainly because of higher native population of *M. igorotus* (Fig. 2b) and *D.aphidivora* (Fig. 2f) *vis-a-vis* other two dosages. While the highest dosage could lower down the pest incidence to tolerable level of grade 1 at 60 DAR, it remained slightly above at

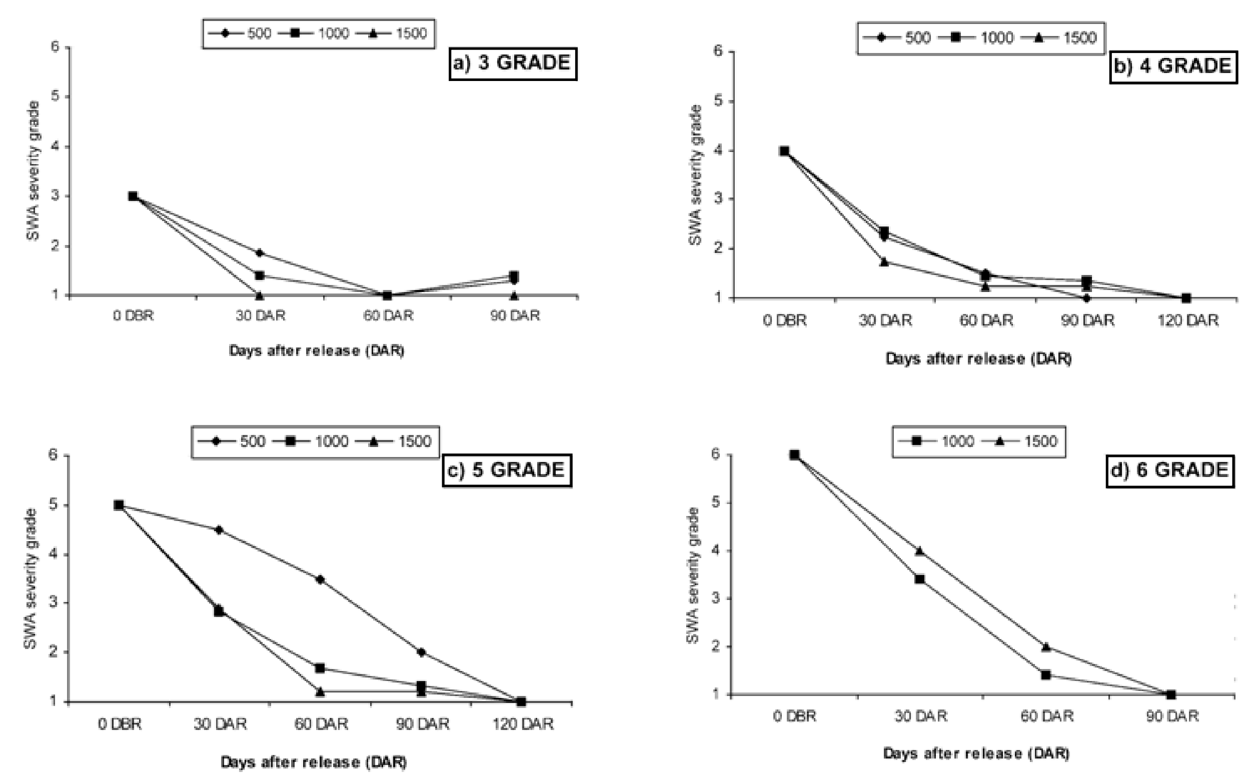

Fig. 1 : Time delay in suppression of SWA at different grades following *M. igoratus* release at various dosages

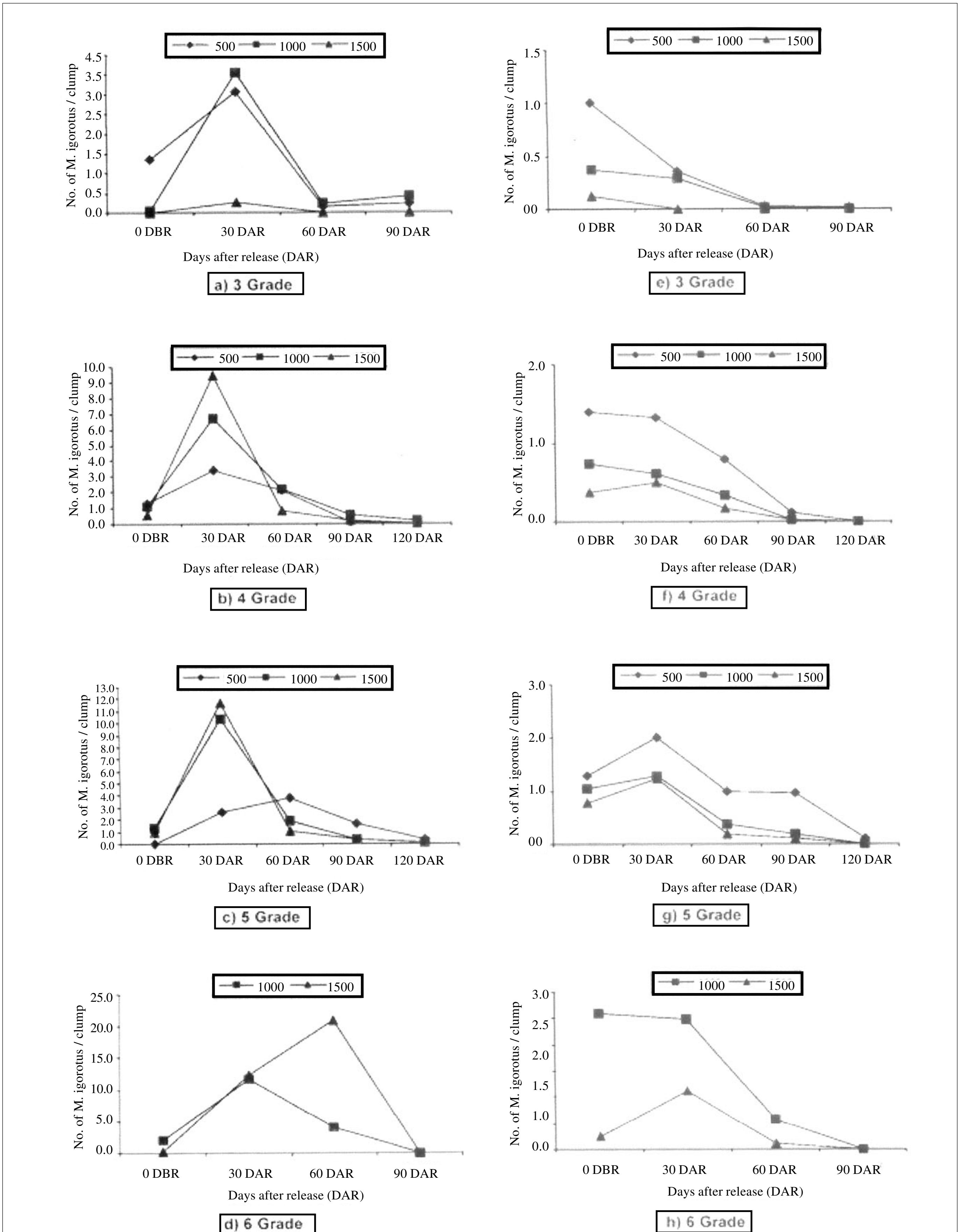

Fig. 2 : Influence on the population fluctuation of predators following release of *M. igorotus*

500 and 1000 pupae. Which, however, was subsequently lowered to 1 at 90 DAR. These facts highlight that time delay for suppression of aphid would be more when the aphid incidence is bit high (grade 4).

At pest intensity of 5 grade (Fig. 1c), release of 1500 and 1000 pupae/ha brought down the pest population to less than 2 grade within 60 DAR, while lowest dosage lagged far behind and required 90 days to cause the same effect because of higher native population of predators (Fig. 2c and 2g). Once again a time lag of 120 days was required to trim the population to 1 grade.

Under severely infested condition (grade 6) (Fig. 1d), release at higher dosages (1000 and 1500) were also required 90 days to bring the SWA population to grade one. Reduction in SWA infestation was at faster rate at 1000 pupae/ha was mainly because of higher natural population of *M. igorotus* (Fig. 2d) and *D.aphidivora* (Fig. 2h) compared to higher dosage of 1500. Impact of both higher dosages were visible only at 90 DAR.

Data on varying dosages of *M. igorotus* over 2 years on SWA suppression was pooled and analysed for impact of dosage level. Pictorial presentation of impact revealed that reduction in SWA incidence was 2.64, 2.63 and 2.58 grade after 30 days of release @ 500, 1000 and 1500 pupae/ha (Fig. 3a), was further tapered to 1.52, 1.44 and 1.30 grade, respectively, at 90 DAR.

It took four months to clear the sugarcane field from SWA regardless of dosage level. Superimposition of Fig. 1 and Fig. 2 suggest that reduction in aphid infestation was reciprocal to increase in density of predator (natural and augmented). Population build of the predator under study was in accordance with dosage and in opposition to the SWA reduction (Fig. 3b). Variable natural population of *D. aphidivora* (Fig. 3c) did cause additive effect to the differential levels of *M. igorotus* released.

Reduction in SWA was faster at dosage of 1500 pupae/ha followed by 1000 and 500. These findings suggest that release of predator at 1000 and 1500 pupae/ ha was effective for lowerdown the population of SWA within 90 days of release depending on the initial infestation level of SWA.

Seasonal influence on efficacy of *M. igorotus:*

Weather conditions may induce contrasting effect on the host and predator multiplication and succession. To have an insight into this, the data on field release of *M. igorotus* was pooled and analysed according to pest intensity, season of release irrespective of dosage, to extract the influence of season on SWA suppression.

When severity of the pest incidence was grade 3 (Fig. 4a), release of predator suppressed the aphids effectively within 60 days of release during July-August and September-November. Heavy irrigation and nitrogen application to crop caused the re-appearance of the pest subsequently, but *M. igorotus* also reestablished (Fig. 5a) but lagged behind the aphid build up. However, *D. aphidivora* failed to reestablish (Fig. 5e) with pest.

Under moderate and high infestation (4, 5 and 6 grades), the predator clinched down the pest population to grade one within 90 DAR during July-August and

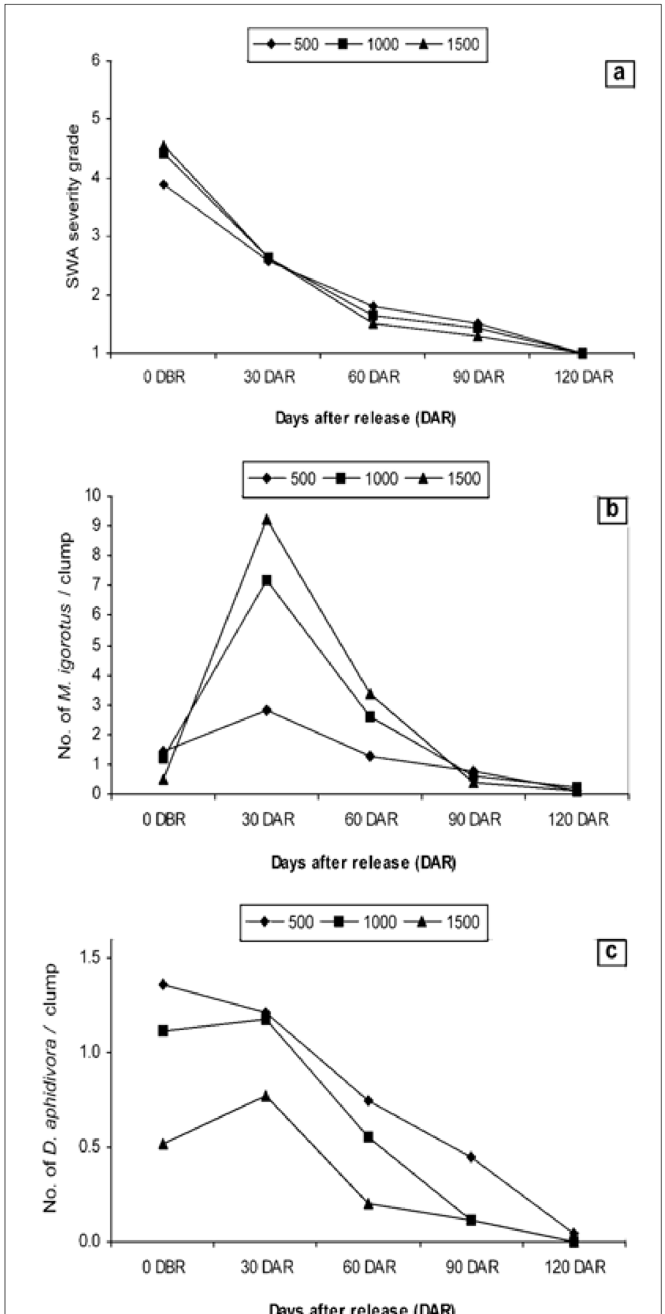

Fig. 3 : Influence of *M. igorotus* dogasge on SWA suppression (irrespective of SWA grade) and population buildup of predators following *M. igorotus* release

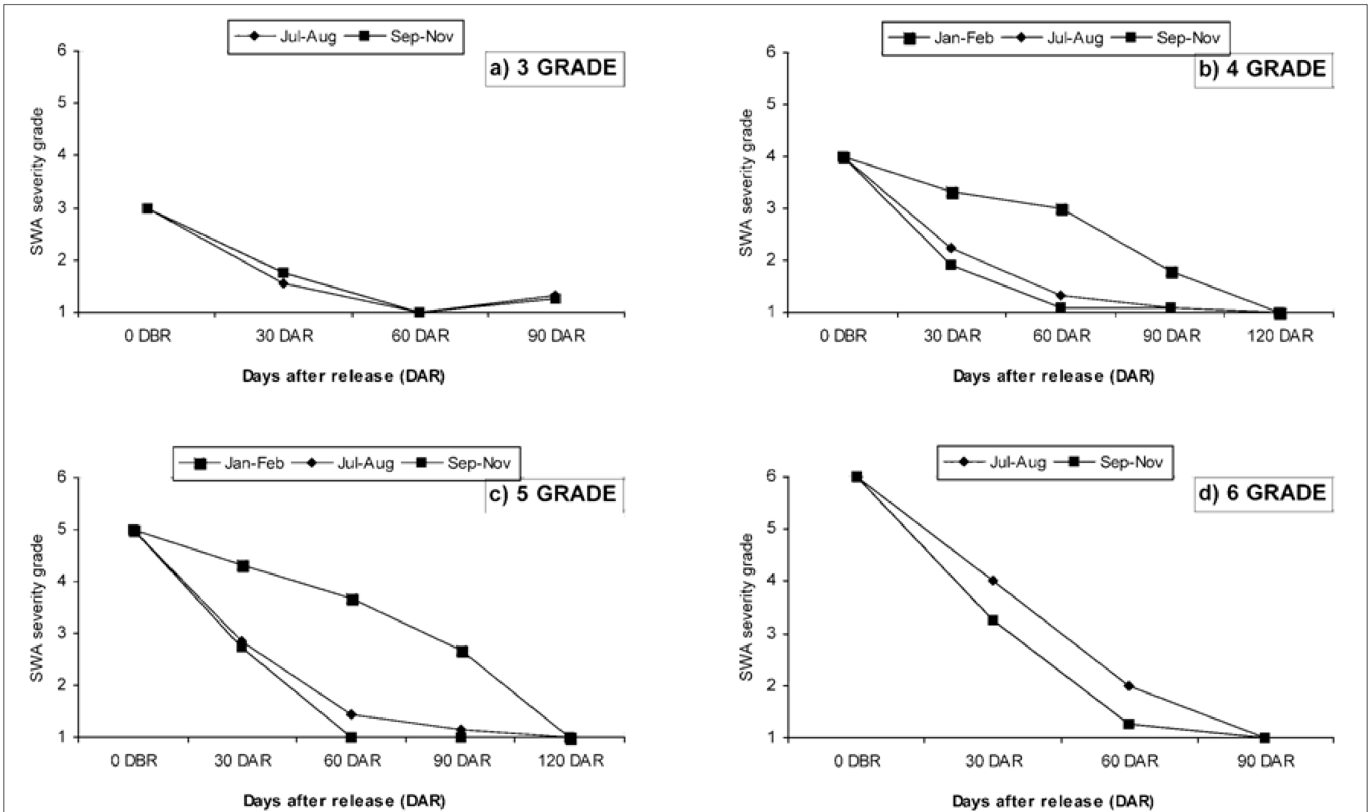

Fig. 4 : Influence of season on SWA suppression at different grades following *M. igoratus* release

September-November (Fig. 4b, 4c and 4d), but required 30 days more during January-February. The delayed action during January-February could be due to slow rate of predator multiplication, lower fecundity and slightly higher temperature during the period. However, between July-August and September-November, pest reduction was faster during the later period which was attributed to complimentary action of higher native population of *M. igorotus* (Fig. 5a, 5b, 5c and 5d) and *D. aphidivora* (Fig. 5e, 5f, 5g and 5h). But both periods of study were congenial to the predator to lower down the aphid severity in 90 DAR.

The data from field study over two years during different periods regardless of pest and release rate of predator was pooled to assess the seasonal influence on SWA suppression and predator build up following the release. The trend in the reduction of SWA incidence during different periods of the year varied. Release of predator during July-August and September-November enabled early suppression of the aphid followed by January-March (Fig. 6a) due to complimentary action of higher native population of *M. igorotus* (Fig. 6b) and *D. aphidivora* (Fig. 6c). Incidence of SWA was reduced from 4.05 in July-August and 4.37 in September-November to 1.10 and 1.17, respectively in 90 DAR *vis-a-vis* 120 days required to cause similar effect during January-March. Biological parameters studied in the insectary during three study periods lend support to the effect that reproductive capacity was lowered in January – March by nearly 29.1 and 44.8 % of June - August and October – December, respectively, besides lowering adult longevity and feeding potential. As such, these traits obviously caused low population buildup and lower consumption of aphids enforcing longer gestation period in October – December than in other two periods.

From this study it can be concluded that June to December were the ideal months for *M. igorotus* release to control the pest within reasonably short time compared to January-February.

Influence of *M. igorotus* release on *D. aphidivora:*

Data on field release of predator at different dosages were pooled and analysed according to *D. aphidivora* population per clump *viz.,* 0 to 1, 1 to 2 and 2 to 5, to assess the influence of *M. igorotus* release on *D. aphidivora* population. Though the study was conducted at unequal number of locations for each variable, data from single location for all variable were considered to draw dependable inference. Graphical presentation of facts in Fig. 7a, 7b, 7c reveal that after release of *M.*

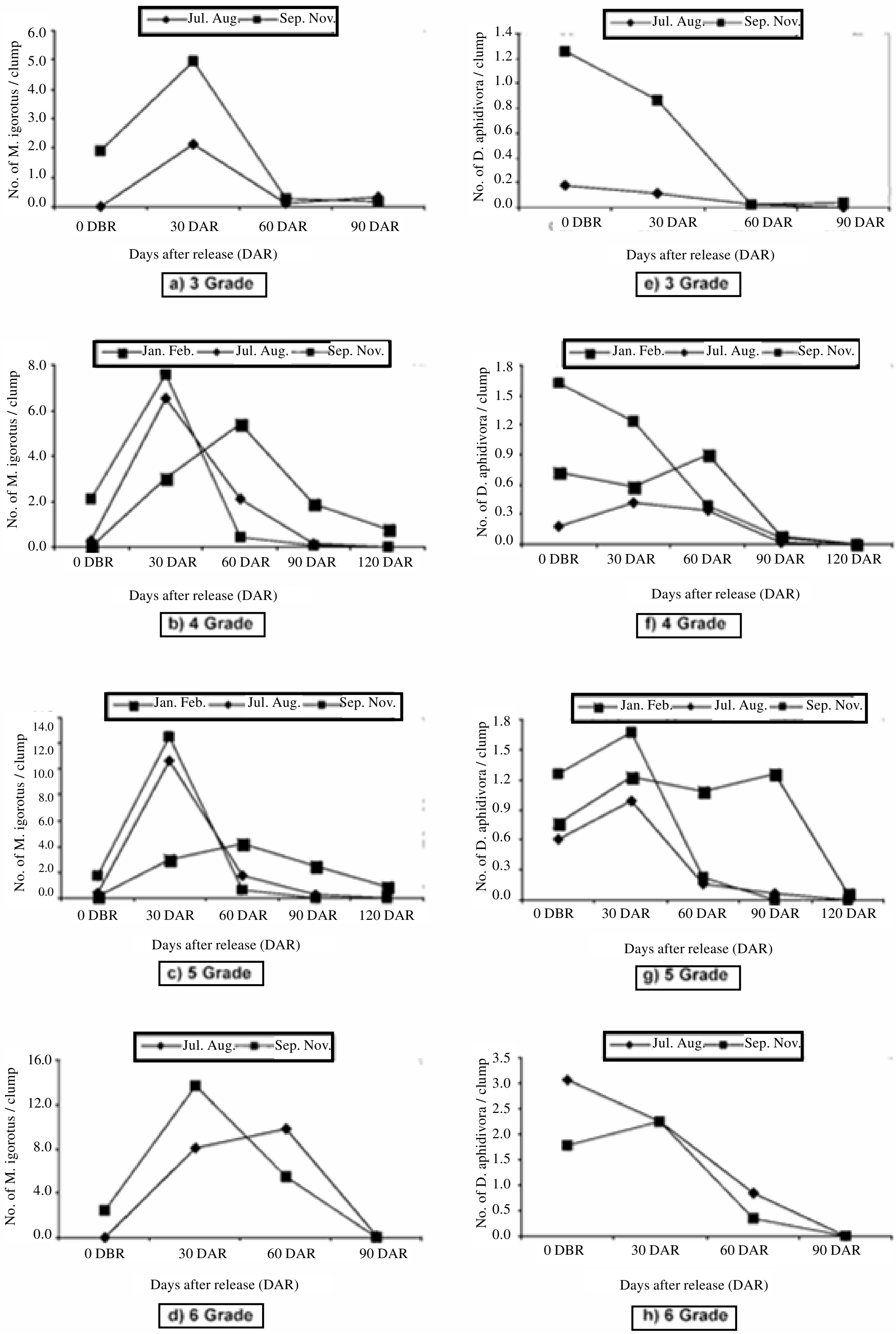

Fig. 5 : Influence of season on the population build up of predators following release of *M. igorotus*

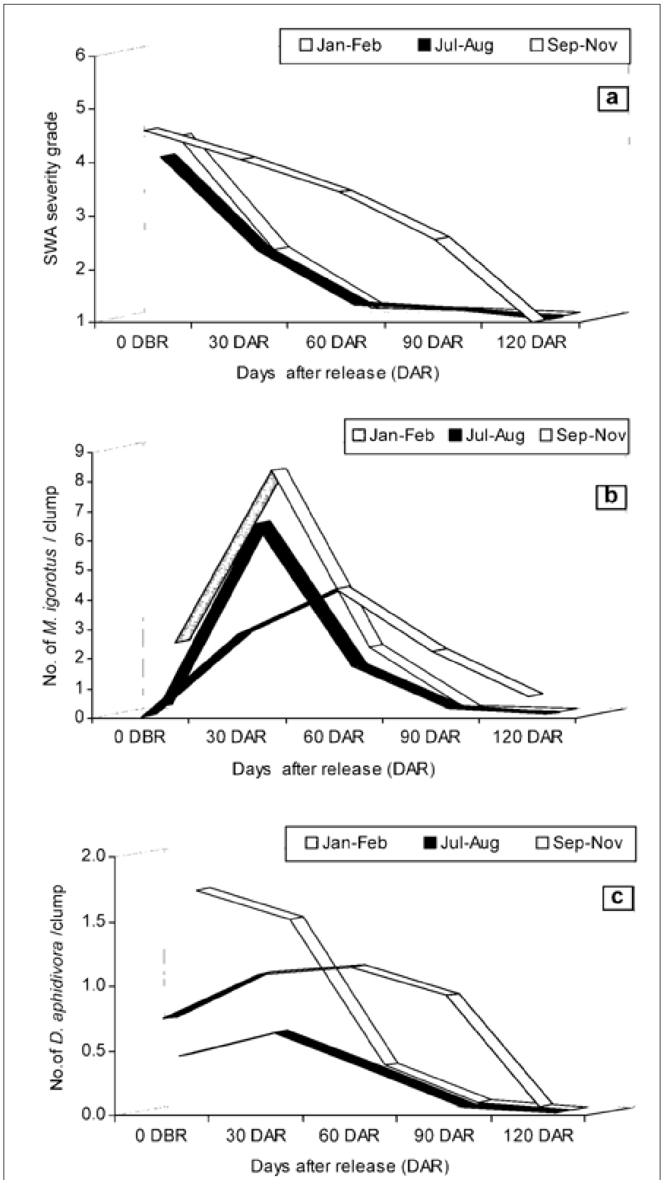

Fig. 6 : Influence of season on SWA suppression (irrespective of SWA grade) and population buildup of predators following *M. igorotus* release

igorotus at varied dosage, per cent increase in native population of *D. aphidivora* on each clump was 44.82, 33.88 and 36.32 at low (0 – 1), medium (1 – 2) and high (2 – 5) population of the latter predator after 30 DAR. A slight variation in build-up of *D. aphidivora* reveals non interference of augmented population of *M. igorotus* with the lepidopteran predator irrespective of its native density. The findings also suggest that both the predators can be exploited jointly for quicker and effective suppression of SWA. In all the three situations of differential density of *D. aphidivora*, lepidopteran predator density was reduced drastically from 30 to 60 DAR mainly because of shortage of natural food as SWA incidence declined steeply during the corresponding period due to predation by *M. igorotus*. Similar effect was also noticed on *M. igorotus.* Non interference between the two predators in the open field studies concurred the earlier laboratory findings under free choice condition. Co-existence of both the predators as equi-efficient enemies of SWA could be due to the differential behaviour. *Dipha aphidivora* larvae feed on aphids by constructing gallery, gluing flat eggs on leaf surface amidst SWA colony. Strikingly different behaviour is of egg laying by *M. igorotus* on abandoned spider web and active mobile larvae. *Dipha aphidivora* pupates in well secured compact and tightly woven cocoon galleries, while *M. igorotus* pupates in double layered cocoon at base of the sugarcane clump. These behavoural adaptations have led them spare each other in order to share the same niche.

Studies on period of release of *M. igorotus* in a year 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. 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 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 DAR in June – November. A dosage of 1500 pupae/ ha proved effective to lower the SWA incidence from severe 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.

Hemerobiids have not been attempted either for inoculative or inundative release for biological control (Eilenberg *et al.,* 2001). Thus, the review on field establishment of brown lacewings, specifically *M. igorotus* is very meagre, to compare with the present findings. However, *Micromus timidus* Hagen 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

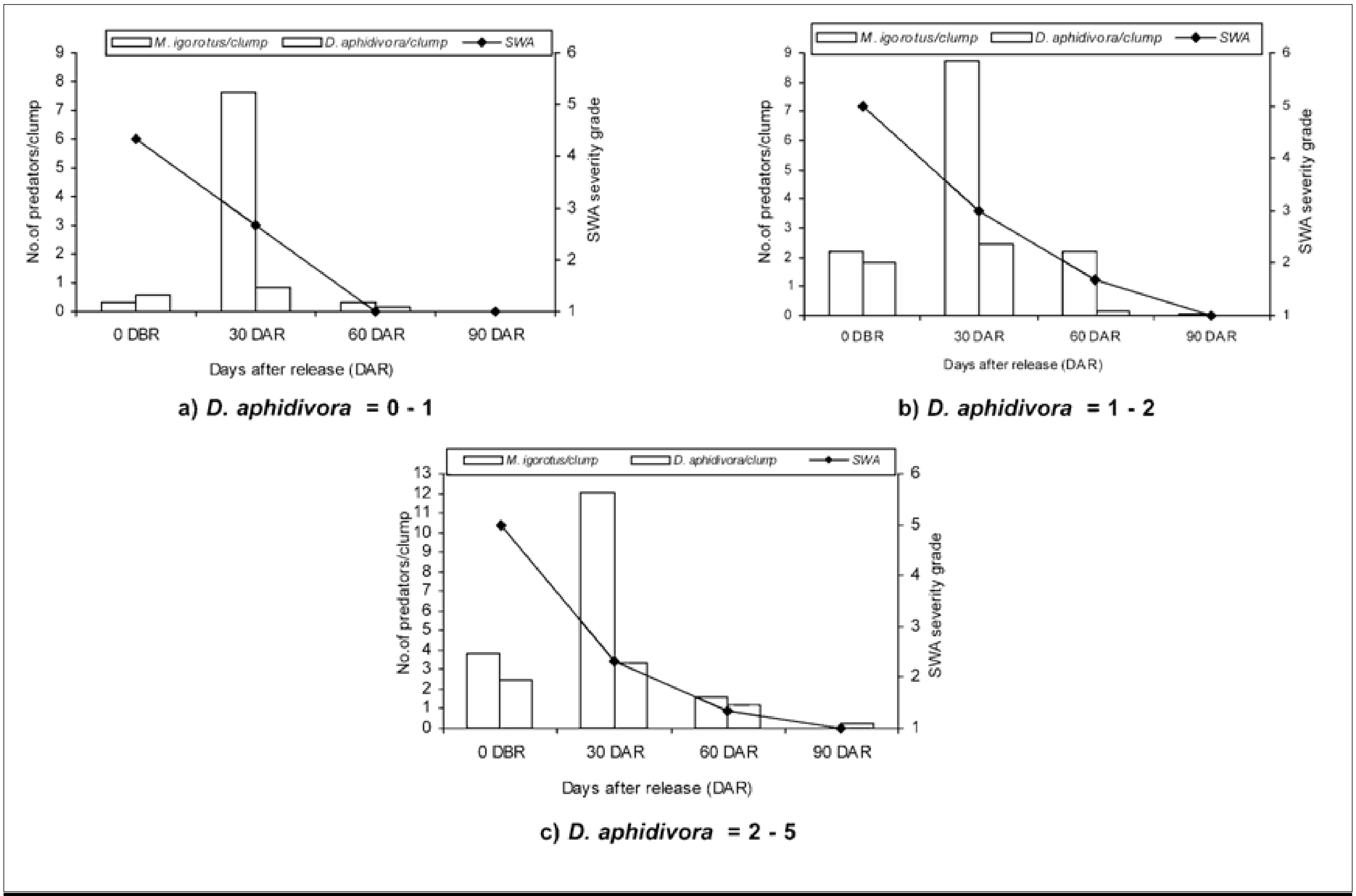

Fig. 7 : Influence of release of *M. igoratus* on population of *D. aphidivora*

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 1984). Potemkina and Kovalenko (1990) released the first instar larvae of *M. angulatus* against *A. fragulae* on cucumber. The combined use of *M. angulatus* and the fungus, *Verticillium lecanii* (Zimmerman) demonstrated to be effective against aphids.

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