Contents list available http://www.kinnaird.edu.pk/

Journal of Natural and Applied Sciences Pakistan

Journal homepage: http://jnasp.kinnaird.edu.pk/

NATURAL ENEMIES USED FOR BIOLOGICAL CONTROL OF MEALYBUGS *DROSICHA STEBBINGI GREEN* ON MULBERRY PLANTS

Khaliq Aman[1], Abdul Razaq[1], Saif-Ud-Din[1,2*], Maisoor Ahmed Nafees[1]
[1]Department of Biological Sciences, Karakoram International University Gilgit-Baltistan, Pakistan.
[2]Department of Environmental Sciences, Karakoram International University Gilgit-Baltistan, Pakistan.

Article Info

*Corresponding Author
Email: gltsaifuddin@gmail.com

Abstract

The present study was conducted in six selected areas of district Gilgit. During the survey, 350 mulberry plants were observed, out of which 329 (94%) were infected with Mealybugs. The highest prevalence of Mealybugs was recorded in Nagral (100%). For the Integrated Pest Management of mealybugs, biological control was used. Three biological agents (parasitoids) including the Lady Bird beetle (*Sumnius renardi* Weise), Common House Spider (*Parasteatoda tepidariorum*) and Wasp (*Anagyrus kamali*) were used. The highest mortality rate was recorded by using Ladybird beetle (*S. renardi weise*) with 93.17% *in vitro* and 84.32% in the field against mealy bugs. In the field, mortality ranged between 78.13-88.96% when exposed to Ladybird beetle, while the mortality rate for the common house spider ranged from 74.76 - 87.90%, whereas the wasp is accountable for a mortality rate from 69.73-81.60%. It is concluded the ladybird beetle is most effective. The integration of biological control methods, keeping in view the pest complex and the intensity of the damage in the research areas, show considerable mitigation of the pest population, coupled with fewer environmental hazards.

Keywords
Biological Control, Ladybird Beetle, Mealybugs, Parasitoids, Spider

1. Introduction

The mealybugs have an extended history as a significant insect pest type, taking attacked countless states of the biosphere. The genus *Maconellicoccus* has three designated species in southern Asia, well known as the area from the Indian section to Malaysia (Williams, 1996; Williams, 2004). Mealybugs are polyphagous insect pests, which nourishes on a wide diversity of significant plants species comprising but not limited to; coffee, guava, grape, peanuts, rose, beans, maize, sugar cane, soybean, cotton, and further fibre crops (Ranjan, 2006; Ujjan & Shahzad, 2007; Reddy *et al.*, 2009). The nourishing of *M. hirsutus* affects deformity of shoots and leaves supposed to be triggered by the inoculation of poisonous saliva. In addition to dropping the aesthetic vision of the plant, this distortion can also affect dropped crop yields and heavy invasions cause plant loss (Kairo *et al*., 2000; Chong *et al*. 2008). To overcome these pests natural control is a vital element of the natural base of IPM, and functional biological control is between the pest-control tools accessible to farmers. In this circumstance, the safeguarding of the natural opponents of plant pests gives meaningfully to dropping insecticide practice and decreasing environmental impact; consequently, the balance of the soybean agroecosystem is improved
(Bueno *et al.,* 2009; Carmo *et al.,* 2010).

Biological control is the practice of the usage of a living creature to condense the population thickness of another biological control provided by these living creatures (jointly entitled as natural enemies) is particularly significant for decreasing the number of pest insects and mites. Biological control is an ecologically sound and operative worth of decreasing or eliminating pests and pest invasion through the practice of natural opponents (Van Driesche, 2008).

In addition, the practice of further carefully selection of products to defend natural opponents and helpful insects through the integration of IPM, the further applicable practice of insecticides was pragmatic; farmers initiated considering the economic verges for pest control, which express the actual necessity for control (Stern *et al.,* 1959; Kogan *et al.,* 1977). Concern in biological control has augmented over recent years for various motives (Bailey *et al.,* 2009). Initially, better gratitude for environmental stewardship between regulators, farmers, and the community has endorsed the improvement of further sustainable farming practices. Second, quantities of arthropod pests have established resistance to one or more pesticides parting farmers to exploration for marginal controlling approaches (McCaffery, 1998).

2. Material and Methods

2.1 Research Site

The current research on Mealybug (*D. stebbingi)* was conducted at six locations of district Gilgit. The area was split into the different patches keeping in view the potential growth in the areas of major host plants i.e Mulberry. The partial work in vitro conditions was carried out at the Biological Sciences laboratory Karakorum International University Gilgit, Pakistan.

2.2 Research Design

Samples were collected seasonally from different Mulberry plants of six selected sites in Baseen village, Sonikote, Nagral, Sakarkoie, Danyore and Kashrote from District Gilgit Pakistan. Adult's samples of mealybugs were collected from the field from different host plants by cutting infected twig of 15 cm host plants with scissors and plant cutter. Mealybugs are collected directly from host plants with the help of a fine brush with care by avoiding damaging the soft body. These samples were placed in a cool box and the vial of alcohol or gathered samples into a dry container and labelled date, locality of sample and name of the host plants. Total 2012 samples were carried to the laboratory of Biological Sciences, Department Karakorum International University Gilgit, Pakistan for further study. In the laboratory, potatoes and honey were provided to mealybugs as a source of nutrients in a separate chamber. Rearing of adult insect was done in glass Petri dishes of 9 cm diameter containing fresh leaves of Mulberry. (Dreves & Walton, 2010)

2.3 Biological Control In In Vitro Environment

In this research wasp (*A. kamali*) ,Common House Spider *(P. tepidariorum)* and Ladybird beetle (*S. renardi weise*) were used as biological agents against Mealybugs (*D. stebbingi).* These biological agents were collected from the field by using a mosquito net very carefully. The numbers of mealybugs were noted before exposing in glass and Petrie dish cage by keeping a lid of the cage open and the mortality rate is regularly monitored. (Tanwar e*t al.,* 2007; Tanwar e*t al.,* 2008; Hajer & Hruba, 2007).

2.4 Biological Control in Field

In our study, biological agents were carried up to different patches of selected plants of the field. Before the ladybird beetle, common house spider, and wasp were exposed. To prevent further movement and mixing of meal bugs from other parts of the plant. The trunk and small twigs of Mulberry plants were labelled with engine oil up to one to two metres depending on plant height to determine the exact number of mealybugs in a specific region, and the number of mealybugs in a specific part of the plant was counted. Mulberry plants were divided into different patches, which were, not exposed to any insecticide was selected and exposed to 300 ladybird beetle, wasp and common house spider each. Biological control is the most insatiable phase on the field and is easily operated and familiarised in apple orchards. (Arnoldi *et al.,* 1992; Brodeur *et al.,* 1999; Chouinard *et al.,* 1999).

3. Results and Discussions

During the field survey 350 plants were observed from different locations of District Gilgit, and also observed that 329 plants of Mulberry were infected from mealybugs and the percentage prevalence of mealy bugs on the Mulberry plant is 94% in District Gilgit (Figure 1). During observation in filed, it was noticed that in biological control of mealybugs, ladybird beetle is more effective among common house spider and wasp. Ladybird beetle decreases the infestation rate was ranged between 78.13-88.96%, the highest

was recorded at Sonikote and the lowest was perceived at Syedano Mahla, Danyore, while common house spider provides the mortality varied between 74.76-87.90%, the uppermost mortality was recorded at Warzaie Baseen and lowermost was observed at Paltani Mahla, Kashrote, whereas wasp is responsible for the mortality fluctuated among 69.73-81.60% (Figure 2). The maximum mortality was recorded at Syedano Mahla, Danyore and the minimum was observed at Napure, Baseen.

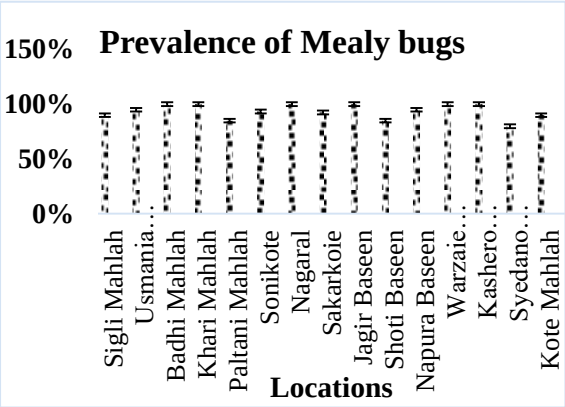

Figure 1: Prevalence of Mealybugs in Different Areas of District Gilgit on Mulberry Plants

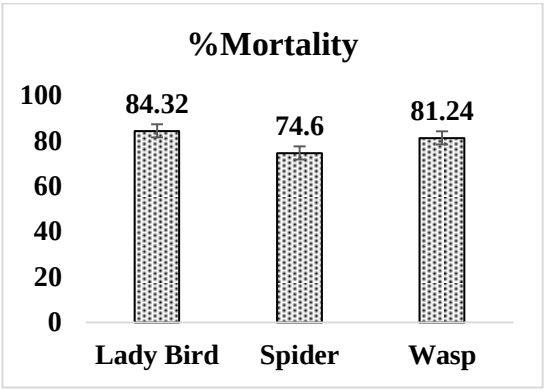

Figure 2: Comparative Mortality of Studied Pest In Mulberry Plant

Table 1: Biological Control of Mealy Bugs in Vitro Condition

Name of Biological Agent	Cage 1		Cage 2		Cage 3		Total BE	Total AE	% Mortality
	BE	AE	BE	AE	BE	AE			
Lady Bird Beetle	230	18	192	10	267	19	689	47	93.17
House Spider	223	33	176	28	240	35	639	96	84.97
Wasp	245	27	204	18	235	24	684	69	89.91
Total	698	78	572	56	742	78	2012	212	89.35

BE-Before Exposure, **AE**- After Exposure

Lady bird beetle was exposed to a total of 689 mealy bugs and achieved a mortality rate of 93.17%, common house spiders were exposed to 639 mealy bugs and achieved a mortality rate of 84.97% and wasp were exposed to 684 mealy bugs and achieved mortality rate of 89.91% (Table 1). All these mealybugs were reared in three different glass cages in vitro conditions. In an earlier study Hajer & Hruba, (2007) performed their research work on the biological control of mealybugs *Planococcuscitri* by using spider *A. tepidariorum* in Tokyo Japan (Table 3). They performed their research work in both green House and laboratories, have a common selection of Vitro and Vivo conditions for the IPM of mealy bugs.

Table 2: Biological Control Of Mealybugs in Field Though Ladybird Beetle (*S. Renardi Weise*)

Location		Mealybugs Before Exposure					Total	Mealybugs After Exposure					Total	% Mortality
		MP 1	MP 2	MP 3	MP 4	MP 5		MP 1	MP 2	MP3	MP 4	MP 5		
Sakarkoie		33	67	32	64	61	257	8	11	6	9	10	44	82.88
Danyore	**Kashero Mahla**	38	69	72	45	29	253	9	9	13	14	5	50	80.24
	Syedano Mahla	63	81	31	23	26	224	13	19	7	6	4	49	78.13
Kashrote	**Kote**	28	34	51	64	29	206	4	7	10	15	1	37	82.04
	Khari Mahla	26	28	38	49	50	191	0	5	7	12	6	30	84.29
	Usmania Mahla	60	91	37	16	22	226	9	19	6	0	5	39	82.74
	Sigli Mahla	27	34	49	17	37	164	4	6	7	2	5	24	85.37
	Paltani Mahla	19	17	34	26	29	125	0	1	4	5	0	10	92
Nargal		37	64	41	47	34	223	5	8	5	5	7	30	86.55
Sonikote		29	47	43	16	28	163	4	6	5	0	3	18	88.96
Total		360	532	428	367	345	2032	56	91	70	68	46	331	84.32

MP-Mulberry Plants

Table 3: Biological Control of Mealybugs In The Field Though Common House Spider (*P. Tepidariorum*)

Location		Mealybugs Before Exposure					Total	Mealybugs After Exposure					Total	% Mortality
		MP 1	MP 2	MP 3	MP 4	MP 5		MP1	MP 2	MP 3	MP 4	MP 5		
Baseen	**Warzaie**	46	28	56	46	34	210	11	7	16	8	11	53	74.76
	Shoti	28	29	43	58	40	198	6	7	11	14	10	48	75.75
	Kote	19	41	53	62	10	185	4	9	13	16	0	42	77.29
	Napure	74	58	14	38	20	204	18	11	0	13	2	44	78.43
Sakarkoie		39	85	61	42	34	261	6	17	11	7	4	45	82.75
Sonikote		24	15	27	46	44	156	3	6	5	9	8	31	80.12
Nagral		63	58	49	37	29	236	11	10	8	9	6	44	81.35
Kashrote	**Sigli Mahla**	40	28	19	37	46	170	6	4	4	2	5	21	87.64
	Khari Mahla	40	39	37	48	49	213	4	5	5	7	8	29	86.38
	Paltani Mahla	38	14	19	16	37	124	5	0	2	3	5	15	87.90
Total		411	395	378	430	343	1957	74	76	75	88	59	372	81.24

MP-Mulberry Plants

Table 4: Biological Control Of Mealybugs In The Field Though Wasp (*A. Kamali*)

Location		No of Mealybugs Before Exposure					Total	No of Mealybugs After Exposure					Total	% Mortality
		MP1	MP 2	MP 3	MP 4	MP 5		MP 1	MP 2	MP 3	MP 4	MP 5		
Danyore	Syedano Mahla	32	19	66	34	34	185	11	6	20	10	9	56	69.73
	Kashero Mahla	31	42	61	71	11	216	9	13	16	18	6	62	71.29
	Kote	23	36	19	28	17	123	6	8	4	6	9	33	73.17
Kashrote	Sigli Mahla	47	64	34	26	28	199	12	14	7	6	9	48	75.87
	Khari Mahla	66	39	28	41	25	199	14	8	9	8	7	46	76.9
	Paltani Mahla	29	37	67	51	27	211	7	9	14	11	8	49	76.8
	Usmania Mahla	54	27	29	26	37	173	14	11	7	6	7	45	74
Baseen	Warzaie	24	19	46	37	39	165	5	8	11	9	12	45	72.7
	Shoti	50	32	39	51	48	220	16	11	8	13	10	58	73.6
	Napure	39	48	13	27	36	163	5	11	0	5	9	30	81.6
Total		395	363	402	392	302	1854	99	99	96	92	86	472	74.6

MP-Mulberry Plants

Integrated pest management is an operative technique for handling pests (Abrol, 2013). Fortunately, there is increased responsiveness of the significance of biological control as a substitute to chemical control in crop production (Bompard *et al.,* 2013; Desneux *et al.,* 2010; Kleespies *et al.,* 2013; Ragsdale *et al.,* 2012). In the current study, 300 ladybird beetle (*S. renardi weise*) were exposed to the infected plants with mealybugs in different patches of Mulberry plants (Table 2). Before exposure, there were a total of 2032 mealybugs on Mulberry plants, but after exposure, the mealybugs decreased to 331 with a mortality rate of 84.32 per cent. In an earlier investigation, two species of ladybird *H. axyridis* and *C. septempunctata* was exposed to cope predominantly *A. gossypii* on strawberry plants. The practice of eliminating ancient leaves from plants was valuable in handling little bulk populations. At great bulks, *H. axyridis* or *C. septempunctata* was free on leaves, flowers, and fruit (Valerio, 2007a). In an acquaintance investigation, the investigators exposed *C. septempunctata* to destroy *A. gossypii* and *Aphis craccivora* Koch on sweet pepper. (Valerio, 2007b)

Walton and Pringle, (2004) performed their research work on the survey of Mealybugs and Related Usual Enemies in Wineries in the Western Cape Province of South Africa. They also found the natural enemy of Anagyrus species along with many other species of natural enemies in the vineyard. They investigate parasitism among mealy bugs and different

species of Anagyrus. In the existing study used 300 common house spiders (*P. tepidariorum*) were exposed to the infected plants with mealybugs in different patches of Mulberry plants aged greater than 30 to 40 years. Before exposing a total of 1957 mealybugs were present on Mulberry plants and after exposing the mealybugs decreases up to 372 with a mortality rate of 81.24%. A nearly similar study was conducted on Mealybugs and associated natural enemies on 3 to 10 year-old Mulberry plants in the Nile Delta of Egypt. They recorded two arthropod classes i.e, Arachnida and Insecta both were very effective to control pests (Hendawy *et*. al., 2013). Another related study of biological control of cotton mealy bugs by *A. tepidariorum* at different locations of Sindh province of Pakistan. They observed 25 plants randomly from 5 locations of the site. They reported predator was effective to control mealybugs (Sahito *et al.,* 2011).

The use of *Anagyrus kamali* is a suitable biological controlling method of mealybugs. In summer the population of *Anagyrus kamali* is high almost in all locations of the studied area (Table 4). William., *et al* (2006) investigate a classical biological control of mealybugs in southern California by using the same biological agent. They monitored parasitism in Mulberry plants among mealy bugs and *A. kamali* for about five years. Their control finding is approximately 95% within five years. They release 100–300 parasitoids at different locations with infested Mulberry plants in the Imperial Valley of California. In the current exploration, 300 samples of Wasp (*A. kamali*) were exposed to the infected plants of mealy bugs in different patches of Mulberry plants. Before exposing a total of 1854 mealybugs were present on Mulberry plants and after exposing the mealybugs decreases up to 472 with a mortality rate of 74.6% within three weeks. A similar approach of biological control on mealybugs was initiated by Mani, (1989) in India on Vineyard. The target host was different but the basics to disseminate the predatory *A. kamali* was in closer agreement with the current biological control with a controlling a rate of 60-100% population of mealy bugs. Another familiar study was conducted by Sagarra. *et.al* .2000 in Canada. They used *A. kamali*as Biological agents against mealy bugs. They reared mealybugs in a Nylon Mesh cage and provided sprouted potato supported in a steel wireframe. They investigated larval and adult stages of mealybugs in a cage. They exposed three-week-old population mealybugs species present in a cage to 100 *A. kamali*.

4. Conclusion

The present study also showed that all biological agents could eliminate mealy bugs. Based on the current study it is concluded that the most commonly effective biological agent against mealybugs *(D. stebbingi)* is lady Bird (*S. renardi weise*) which more efficiently decreases the infestation of mealybugs 84.24% in the field and 93.17% in in-vitro conditions. Among all other fruit plants, the mealybugs are mostly the

destruction of Mulberry plants in Gilgit. Needed further studies to explore other natural enemies and to control the mealybugs infestation on mulberry plants.

5. References

Abrol, D. (2013). Integrated Pest Management: Current Concepts and Ecological Perspective.

Arnoldi, D., R.K. Stewart, and Boivin, G. (1992). Predatory mirids of the green apple aphid Aphis pomi, the two-spotted spider mite Tetranychus urticae and the european red mite Panonychus ulmi in apple orchards in Quebec. Entomophaga, 37:283–292.

Bailey, A. S., M. Bertaglia, I. Fraser, M.A. Sharma, and Douarin (2009). Integrated Pest Management portfolios in UK arable farming: results of farmers survey. Pest Management Science, 65:1030-1039.

Bompard, A., C.C, Jaworski, P. Bearez, and N. Desneux (2013). Sharing a predator: can an invasive alien pest affect the predation on a local pest. Population Ecology, 55:433-440.

Brodeur, C., G. Chouinard, G. Laplante, and Y. Morin (1999). Preliminary studies on the activation and efficacy of indigenous predator Hyaliodes vitripennis (Heteroptera: Miridae) for biological control of mites in apple orchards in Quebec. Annals of the Entomological Society of France, 35:458–462.

Bueno, R.C.O.F., J.R.P. Parra, and A.F. Bueno (2009). Biological characteristics and thermal requirements of a Brazilian strain of the parasitoid Trichogramma pretiosum reared on eggs of Pseudoplusia includens and Anticarsia gemmatalis. Biological Control, 51:355-361.

Carmo, E.L., A.F. Bueno, and R.C.O.F. Bueno (2010). Pesticide selectivity for the insect egg parasitoid Telenomus remus. Biological Control, 55:455-464.

Chong, J.H., A.L. Roda, and C.M. Mannion (2008). Life history of the mealy bug, *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae), at constant temperatures. Environmental Entomology, 37(2):323-332.

Chouinard, G., A. Firlej, F. Vanhoosthuyse, and C. Vincent (2000). Guide to identifying apple pests and their natural enemies. Council of Productions of Vegetables of Quebec, Quebec.

Desneux, N., E. Wajnberg, K.A.G. Wyckhuys, G. Burgio, and S. Arpaia (2010). Biological invasion of European tomato crops by *Tuta absoluta*: ecology, geographic expansion and prospects for biological control. Journal of Pest Science, 83:197-215.

Dreves A. J., and V. M. Walton **(**2010). Trapping and Identifying Mealy bugs in Oregon Vineyards. EM 8998, Oregon state University Catalog:

https://catalog.extension.oregonstate.edu/em8998

Hajer, J., and L. Hruba (2007). Wrap attack of the spider *Achaearanea tepidariorum* (Araneae: Theridiidae) by preying on mealy bugs *Planococcus citri* (Homoptera: Pseudococcidae). Journal of Ethology, 25:9–20.

Hendawy, A. S., I. A. I. Saad and H.T. Rehab (2013). Survey of Scale Insects, Mealy Bugs and Associated Natural Enemies on Mulberry Trees in the Nile Delta, Egypt. J. Agric. Res., 91(4).

Kairo, M.T.K., G.V. Pollard, D.D. Peterkin, and V.F. Lopez (2000). Biological control of the hibiscus mealybug, *Maconellicoccus hirsutus* Green (Hemiptera: Pseudococcidae) in the Caribbean. Integrated Pest Management Reviews, *5:*241–254.

Kleespies, R.G., C. Ritter, G. Zimmermann, F. Burghause, S. Feiertag, and A. Leclerque (2013). A survey of microbial antagonists of *Agriotes* wireworms from Germany and Italy. Journal of Pest Science, 86:99-106.

Kogan, M., S.G. Turnipseed, M. Shepard, E.B. Oliveira, and A. Borgo (1977). Pilot insect pest management program for soybean in Southern Brazil. J. Econ. Entomol., 5:659-663.

Mani, M**.** (1989). A review of the pink mealy bug – *Maconellicoccus hirsutus Green*. Insect Sci. Applic., 10(2): 157-167.

McCaffery, A.R. (1998). Resistance to insecticides in heliothine Lepidoptera: a global view. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences, 353:1735–1750.

Ranjan, R. (2006). Economic impacts of the pink hibiscus mealy bug in Florida and the United States. Stochastic Environmental Research and Risk Assessment, 20:353-362.

Ragsdale, D.W., D.A. Landis, J. Brodeur, G.E. Heimpel, and N. Desneux (2011). Ecology and management of the soybean Aphid in North America. Annual Review of Entomology, 56:375-399.

Reddy, G.V.P., R. Muniappan, Z.T. Cruz, F. Naz, J.P. Bamba, and J. Tenorio (2009). Present status of *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae) in the Mariana Islands and its control by two fortuitously introduced natural enemies. Journal of Economic Entomology, 102(4):1431-1439.

Sagarra, L.A., C. Vincent and R.K. Stewart (2000). "Fecundity and survival of *Anagyrus* kamali under different feeding and storage temperature condition. European Journal of Entomology, 97:177-181.

Sahito, H. A., G.H. Abro, R. Mahmood, and A.Q. Malik (2011). Survey of Mealy bug, *Phenacoccus Solenopsis (Tinsley)* and Effect of Bio-Ecological Factors On

its Population in Different Ecological Zones of Sindh. Pakistan Journal of Agriculture, 1:51-65.

Stern, V.M., R.F. Smith, R. Van Den Bosch and K.S. Hagen (1959). The integrated control concept. Hilgardia 29, 81e101, 617–28.

Tanwar, R.K., P. Jeyakumar, and D. Monga (2007). Mealy bugs and their management. Technical Bulletin, 19, NCIPM, New Delhi.

Tanwar, R.K., V.K. Bhamare, V.V. Ramamurthy, M. Hayat, P. Jeyakumar, A. Singh, and O.M. Bambawale (2008). Record of newparasitoids on mealybug, Phenacoccus solenopsis. Ind. J. Entomol., 70:404-405.

Ujjan, A.A., and S. Shahzad (2007). Pathogenicity of *Metarhizium anisopliae* var *acridum* strains on pink hibiscus mealy bug (*Maconellicoccus hirsutus*) affecting cotton crop. Pakistan Journal of Botany, *39(3):*967-973.

Valerio, E., A. Cecílio, and A. Mexia (2007a). Population dynamics of aphids (Homoptera: Aphididae) and beneficial organisms on protected strawberry crops. Boletín Sanidad Vegetal Plagas., 33:153–161.

Valerio, E., A. Cecílio, and A. Mexia (2007b). Interactions between aphid species and beneficial organisms in sweet pepper protected crop. Bol. Sanid. Veg. Plagas., 33:143–152.

Van Driesche, R.G., S. Lyon, J.P. Sanderson, K.C. Bennett, E.J. Stanek and R.T. Zhang (2008). Green house trials of Aphidius Colemani (Hymenoptera: Braconidae) banker plants for control of aphids (Hemiptera: Aphididae) in greenhouse spring floral crops. Florida Entomologist, 91:583–591.

Walton, V.M., and K.L. Pringle (2004). Survey of Mealybugs and Associated Natural Enemies in Vineyards in the Western Cape Province :South Africa. South African Journal for Enology and Viticulture, 25.

Williams, D.J. (1996). A brief account of the hibiscus mealy bug *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae), a pest of agriculture and horticulture, with descriptions of two related species from southern Asia. Bulletin of Entomological Research, 86:617–628

Williams, D.J. (2004). Mealy bugs of southern Asia. The Natural History Museum, London. 896 pp.

William J. R., D. E. Meyerdirk , R. Warkentin, E. R. Andress and K. Carrera (2006). Classical biological control of the pink hibiscus mealy bug, *Maconellicoccus hirsutus* (Green), in southern California. Biological Control, 37:155–166.