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Potential of Predatory Natural Enemies for Biological Control of Sap-Sucking Insect Pests in Paraguay

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Abstract

Bionomics of some predators attacking aphids and spider mites of vegetables was investigated in Paraguay. Ladybirds, *Eriopis connexa*, *Coleomegilla maculata*, *C. quadrifasciata*, and *Olla v-nigrum,* were successfully reared on a drone honeybee powder diet. Total development time was 18.9 days in *E. connexa*, 21.2 days in *C. maculata*, 20.0 days in *C. quadrifasciata*, and 18.9 days in *O. v-nigrum* at 25ºC when they fed on the drone powder diet. Mean adult body weight of each species was 11.7 mg in *E. connexa*, 18.9 mg in *C. maculata*, 24.4 mg in *C. quadrifasciata*, and 16.2 mg in *O. v-nigrum*. Adult of *E. connexa* consumed 31.0 *Aphis gossypii* individuals or 22.1 *Lipaphis erysimi* individuals per day at 25ºC, while *C. maculata* consumed 34.5 *A. gossypii* individuals or 6.6 *L. erysimi* individuals per day. Predatory mites, *Phytoseiulus macropilis*, *P. fragariae*, and *Amblyseius idaeus* were collected in strawberry fields in Caacupé and Itá. The development time was 5.0 days in *P. macropilis* and 7.0 days in *A. idaeus* at 25ºC. Female of *P. macropilis* consumed 27.0 eggs of *Tetranychus urticae* per day and deposited 3.1 eggs, while *A. idaeus* consumed 18.0 eggs of *T. urticae* per day and deposited 3.2 eggs at 25ºC.

Discipline: Insect pest / Horticulture
Additional key words: coccinellid, predatory mite, aphid, spider mite

Introduction

Since Paraguay is located in the subtropical zone of South America, it is possible to produce vegetables all the year round. Recently the production of fresh vegetables and fruits such as tomato, green pepper, melon, and strawberry has increased in Paraguay along with the changes in the eating habits. On the other hand, the rapid increase of vegetable production is causing serious pest problems. Accordingly, The Ministry of Agriculture and Stock Raising of Paraguay (MAG) and the Japan International Cooperation Agency (JICA) initiated a joint project for the improvement of vegetable production techniques for small-scale farmers in Paraguay in 1997. Main research site of the project was the National Institute of Agriculture (Instituto Agronómico Nacional; IAN), which is located at Caacupé about 50 km east from Asuncion. Although chemical insecticides were applied mainly to control insect pests in this project, biological control methods have also attracted a great deal of attention in Paraguay in terms of cost, insecticide resistance, and environmental safety. In the production of vegetables such as tomato, green pepper, melon, and strawberry, aphids and spider mites are the major pests. As a part of the project, therefore, we investigated the bionomics of some predators attacking aphids and spider mites infecting vegetables to evaluate their potential to control pests.

In this paper, we report the results of experiments on artificial rearing of ladybirds, development and predation ability of ladybirds and predatory mites, and effects of some insecticides on predatory mites.

Materials and methods

1) Insects

Adults of ladybirds, *Eriopis connexa* (Germer), *Coleomegilla maculata* (De Geer), and *Coleomegilla quadrifasciata* Schönh., were collected from a strawberry field at IAN on October 12, 2000. Another species of

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ladybird, *Olla v-nigrum* (Mulsant), was collected in a Chinese cabbage field at IAN on October 18, 2000. Predatory mites, *Phytoseiulus macropilis* (Banks) and *Amblyseius idaeus* (Denmark and Muma), were collected in the same strawberry field as the above on October 12, 2000. These natural enemy species were reared separately for the following experiments. In addition, *Phytoseiulus fragariae* Denmark and Schicha was also recorded from a strawberry field at Itá, Paraguay, but was not used for the experiments.

2) Development time and body weight of ladybirds

Adults of each ladybird species were reared in a group on an artificial diet in a small plastic cage (18 × 12 × 7 cm) at 25ºC under natural long-day photoperiod (approximately 13–14 L). The artificial diet (drone powder) contained freeze-dried drone brood, hydrolyzed animal protein, and sucrose with a proportion of 6:3:1. The drone powder was supplied on a sheet of paraffin paper and changed when it became moldy. Water was supplied separately as a moistened cotton piece. Newly deposited eggs were reared on the drone powder and water in a petri dish at 25ºC under natural long-day photoperiod. Body weight of the adults was recorded within 24 h after emergence.

3) Predation ability of ladybirds

Cotton aphid, *Aphis gossypii* Glover, and turnip aphid, *Lipaphis erysimi* (Kaltenbach), were used as prey species. Seventy *A. gossypii* and 30 *L. erysimi* adults were each presented to a ladybird adult in a petri dish for 24 h and the number of aphids consumed was counted. For *L. erysimi*, experiments were continued for 5 successive days.

4) Predation ability of predatory mites

Females of *P. macropilis* and *A. idaeus* were singly reared on a leaf of kidney bean placed on a moistened sponge at 25ºC. To determine the potential for predation of predatory mites, more than 50 eggs of the spider mite, *Tetranychus urticae* Koch, were presented daily to a female and the number of eggs that remained after 24 h was counted. The number of eggs deposited by predators was also counted daily.

5) Development time of predatory mites

The eggs of the predatory mites obtained from the previous experiment were used for determining the development time. Ten newly deposited eggs of predatory mites were placed on a kidney bean leaf infested with *T. urticae* at 25ºC. The development of the predatory mites was checked daily until adult emergence.

6) Effects of insecticide application

Side-effects of 3 insecticides generally used in Paraguay, diafenthiuron (Polo®), hexythiazox + DDVP (Nissorun plus®), and abamectin (Vertimec®) were investigated by using a rotary insecticide spray apparatus (Mizuho Rika Co., Ltd.). Diluted insecticides were sprayed on 30 adults of predatory mites placed on a leaf of kidney bean at a dose of 4 mg active ingredient per cm^2. The survival of the predatory mites was checked 24, 48 and 96 h after the treatment at 25ºC.

Results and discussion

1) Development of ladybirds

Table 1 shows the development time and adult body weight of the ladybirds. The development time from egg to adult of *E. connexa* on the drone powder was 18.9 days at 25ºC and did not differ significantly from 17.9 days when the ladybird fed on frozen aphid, *L. erysimi*. Although the body size and weight of wild *E. connexa* were not measured, the body size of the adults that emerged in this study was apparently identical with that of the wild adults. Survival rates from egg to adult of *E.*

Table 1. Development time and adult body weight of ladybirds that fed on the drone powder diet and frozen aphids

	Diet	No. of insects	Development time (day)[3] Egg	Larva	Pupa	Total	Mean body weight (mg)
Eriopis connexa	DP[1]	40	2.9 ± 0.2a	12.1 ± 0.2c	3.9 ± 0.2ab	18.9 ± 0.3c	11.7 ± 0.4d
	Aphid[2]	19	2.4 ± 0.1b	11.9 ± 0.2c	3.4 ± 0.1b	17.9 ± 0.2c	13.1 ± 0.6cd
Coleomegilla maculata	DP	35	3.0 ± 0.0a	14.4 ± 0.3a	3.8 ± 0.1ab	21.2 ± 0.4a	18.9 ± 0.5b
C. quadrifasciata	DP	44	3.0 ± 0.0a	13.2 ± 0.1b	3.7 ± 0.1b	20.0 ± 0.1b	24.4 ± 1.1a
Olla v-nigrum	DP	25	2.0 ± 0.0b	12.6 ± 0.2bc	4.3 ± 0.2a	18.9 ± 0.3c	16.2 ± 0.5c

1): Drone powder diet. 2): Frozen *Lipaphis erysimi* nymphs and adults.
3): Mean ± S. E. Means followed by the same letter in the same column did not differ significantly by Tukey-Kramer's test at p=0.05 level.

Table 2. Predatory potential of ladybirds for aphids

	No. of aphids consumed by an adult for 24h*	
	Aphis gossypii	*Lipaphis erysimi*
Eriopis connexa	31.0 ± 18.4a	22.1 ± 12.1a
Coleomegilla maculata	34.5 ± 26.2a	6.6 ± 3.8b

*Means followed by the same letter in the same column did not differ significantly by t-test at p=0.05 level.

connexa were 54.3% on the drone diet and 100% on aphids. *E. connexa* is originally distributed in South America[16]. This ladybird has been recently introduced into the United States from South America for possible release against the Russian wheat aphid, *Diuraphis noxia*[16]. Miller and Paustian[13] reported that the development time from first instar to adult of *E. connexa* was 11.2 days at 26ºC when the ladybird fed on *D. noxia* and *Rhopalosiphum padi*. They suggested that *E. connexa* is active and grows at cooler temperatures than other aphidophagous coccinellids.

Coleomegilla maculata is also widely distributed in North and South America[7,12,15,17], and is known to be an egg predator of the European corn borer, *Ostrinia nubilalis*[1], Colorado potato beetle, *Leptinotarsa decemlineata*[6–8,10,11,14], and corn earworm, *Helicoverpa zea*[5,18]. Accordingly, *C. maculata* is obviously less aphidophagous than the other coccinellid species. It has been reported that the larval development time of *C. maculata* was 10.8–11.1 days when the ladybird fed on pea aphid, *Acyrthosiphon pisum*, and 13.9–15.0 days when it fed on *L. decemlineata* eggs[14]. The development time of *C. maculata* in the current study was 14.4 days at 25ºC. Body weight of emerged *C. maculata* adults in this study (18.9 mg) was much heavier than that previously reported (7.5–8.9 mg in the female) in the U.S.[14]. These results suggest that the difference in prey species and/or geographical strains may affect the duration of development and adult body size in *C. maculata*. Survival rate of *C. maculata* was 78.9% on the drone diet.

C. quadrifasciata and *Olla v-nigrum* were also successfully reared on the drone powder diet. Survival rate was 76.9% in *C. quadrifasciata* and 59.3% in *O. v-nigrum*. Although these species appeared to be widely distributed in South America, no detailed reports on their bionomics had been available.

2) Predation by ladybirds

Predation efficiency of ladybird adults is shown in Table 2. An *E. connexa* adult consumed 31.0 *A. gossypii* individuals or 22.1 *L. erysimi* individuals per day, while a *C. maculata* adult consumed 34.5 *A. gossypii* individuals or 6.6 *L. erysimi* individuals per day. The difference in the consumption rates of *L. erysimi* between the 2 ladybird species may be due to the difference in host preference because *C. maculata* was scarcely found on Chinese cabbage which is a host plant of *L. erysimi* in the field.

3) Development of predatory mites

The development time from egg to adult of *P. macropilis* was 5.0 days at 25ºC. It was almost the same as the reported development time of *P. persimilis*[2]. The development time from egg to adult of *A. idaeus* was 7.0 days at 25ºC. The reported development time from egg to adult of the prey species, *Tetranychus urticae*, is ca. 10 days at 25ºC[3]. Since both species can grow faster than their prey species, they could become effective natural enemies in the field.

4) Predation by predatory mites

A *P. macropilis* adult consumed 27.0 eggs of *T. urticae* and deposited 3.1 eggs per day at 25ºC (Table 3). This performance was equivalent to that of *P. persimilis*, which consumed 28.1 eggs of *T. urticae* and deposited

Table 3. Predatory potential and fecundity of predatory mites*

	No. of host eggs consumed per day	No. of eggs laid per day
Phytoseiulus macropilis	27.0 ± 3.9	3.1 ± 0.3
Amblyseius idaeus	18.0 ± 3.0	3.2 ± 0.6

*Means (± S. E.) of 10 females when eggs of *Tetranychus urticae* were supplied. Means in the same column did not differ significantly by t-test at p=0.05 level.

Table 4. Effect of insecticides on survival rates of adults of predatory mites

	Insecticide compound	No. of mites sprayed	No. of predatory mites that survived		
			24 h after[a)]	48 h after[a)]	96 h after[a)]
P. macropilis	diafenthiuron	30	1 (3.3)	1 (3.3)	0
A. idaeus	diafenthiuron	30	19 (63.3)	19 (63.3)	5 (16.7)
	hexythiazox+DDVP	30	0		
	abamectin	25	0		

a): No. of predatory mites that survived 24, 48 and 96 h after insecticide application.
Percentage of survival is indicated in the parentheses.

4.5 eggs per day[2)], while an *A. idaeus* adult consumed 18.0 eggs and laid 3.2 eggs per day at 25ºC. This performance was higher than that of *A. longispinosus*, which consumed 15.7 eggs of *T. urticae* and deposited 2.2 eggs per day[9)].

5) Effects of insecticides on predators

The determination of the side-effects of insecticide application is important to evaluate the natural enemy potential for biological control under conventional cropping systems. In this study, the effects of 3 insecticides commonly used in Paraguay were investigated on the survival of 2 predatory mites. Data are shown in Table 4. Diafenthiuron (Polo®) is known to be an effective compound on caterpillars, aphids, and thrips. In this study, it was toxic to both predatory mite species. Although hexythiazox itself is known to be a selective insecticide which is not toxic to predatory mites[4)], Nissorun plus® used in this study was highly toxic to *A. idaeus,* probably because it contains DDVP as an accessory ingredient. Although it was reported that abamectin did not affect the survival of *Phytoseiulus persimilis* at 1–16 ppm[19)], in the current study, it affected significantly the survival of *A. idaeus*. This observation suggests that the mode of action of abamectin may differ between *Phytoseiulus* and *Amblyseius*.

Because commercial production of natural enemies is very costly, it can not be realistically recommended in developing countries such as Paraguay. On the other hand, the warm winter in Paraguay is conducive to the hibernation and continuous interaction of natural enemies as well as pest species. Therefore, it might be possible to keep pest species at a low population density throughout the year by natural biological control. To develop effective biological control methods by using native natural enemies, it is essential to carry out further basic studies on the fauna of natural enemies and the evaluation of their potential for control. Since ladybirds and predatory mites have both been considered to be effective natural enemies worldwide, the results obtained in the current study may contribute to the development of future pest control programs in Paraguay.

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