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1. FINAL REPORT

For the Period

September 1, 1990 - October 30, 1993

Including the Annual Report for the period September 1, 1992 through October 30, 1993

Submitted to the Office of the Sciences Advisor
U.S. Agency for International Development

Title: "IPM of Scarlet Mite on Tea Using Genetically Improved Predaceous Mites"

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3. EXECUTIVE SUMMARY
Period: September 1, 1990 - October 30, 1993

Indigenous, beneficial, predatory mites, and a pesticidal chemical from the Javanese Neem tree in Indonesia, were investigated for use as two (2) elements in the practice of Integrated Pest Management (IPM) of Scarlet mite infestations on Tea. Predatory mites are the principal objects of the investigations. In the practice of IPM, the predatory mites were scheduled for release according to a computer model developed in the Project on predator mite/prey mite behavior and for assessment of damage to Tea by the Scarlet mite. It was planned that the predatory mites would be used with the additional elements of pest management for reducing damage to Tea, including pesticidal chemicals, microbial agents for control of phytophagous insects, and use of Tea varieties tolerant to damage by insects, mites and diseases of Tea.

For the thirty-six month reporting period, we have: 1) Created, developed, and validated an index of damage to Tea which is correlated with the density of Scarlet mite populations; 2) Detected, identified, and developed rearing methods for two (2) beneficial predatory mites employing indigenous plant pollens and substitute prey mites in addition to the Scarlet mite; 3) Evaluated and ranked the predatory efficacy and the efficiency of rearing predatory mites for field use; 4) Adopted a protocol for selection of pesticide resistance in populations of predaceous mites; 5) Trained Indonesian technical support personnel in the detection and identification of predaceous mites with Project funds and with supplementary international funds; and, 6) Initiated the screening of predatory mite populations for selection of resistance to pesticidal seed extracts of the Neem tree.

Five (5) short-term consultants and the Co-PI (Sastrodihardjo), in the collaborating laboratories at the Research Institute for Tea and Cinchona (RITC), Gambung (Java), and in the Institute of Technology, (ITB), Bandung (Java), have investigated and developed all research protocols for the Project. The results of investigations have been presented in national and international meetings in Indonesia and abroad. Four (4) manuscripts have been completed, two (2) accepted for publication in refereed journals, one (1) published as a separate report, and one (1) published in the unedited Proceedings of the International Congress of Entomology (Beijing, 1992).

A series of small plot field investigations of predatory mites to measure their efficacy and efficiency were planned for October, 1992, through May, 1993, at the RITC. A predictive computer model for release of predaceous mite and their efficacy was planned to be tested, validated, and modified. The results of the 1992-93 small plot field investigations were intended to be the basis for multiple field investigations, weather permitting, beginning in May, 1993.

4. RESEARCH OBJECTIVES

The Project to use genetically improved predaceous mites in the IPM of Scarlet mite in Indonesia was developed as one element in the effort to reduce the dependency of Tea producers on conventional chemical pesticides, particularly acaracides. Species of beneficial predaceous mites are lost due to the use of conventional chemical pesticides. An investigation of alternatives to pest control practices continues to be necessary. Further, agricultural workers in Tea production are exposed to all pesticide application residues on Tea plants, and pesticide residues can be present on the harvested leaves of Tea. The Indonesian national effort to increase IPM for both domestically consumed and exported agricultural crops provided an imperative for the successful development of the Project and the application of the results of the Project. Researchers in Indonesia and abroad for several decades have investigated the activity of beneficial predaceous mites on many different crops; and have investigated the impact of pesticidal applications on non-target beneficial predaceous mites (Bakker et al., 1992). The current Project identifies the most effective beneficial predaceous mites, and documents methods to train persons in the agricultural industry for development of the predaceous mites for improving the safe production of Tea in Indonesia.

The results of the Project include the establishment of the laboratory procedures and methods for selecting effective beneficial predaceous mites. The glasshouse production of the effective predaceous mites serve as an innovative agricultural industrial development for the commercial availability of the predaceous mites for field release as a biological control agent.

In addition to the research on isolation and selection of the most effective predaceous mites, the mass propagation and maintenance of predaceous mites was investigated for mass release in the field for reduction of Scarlet mites on Tea. Production methods established the use of living prey for predaceous mites, and the use of pollens from indigenous plants as protein dietary supplements for successful mass rearing of the biological control agents. These lines of investigation, on the identification and selection of beneficial mites and their maintenance were supplemented by the initiation of a series of training workshops for agricultural managers and investigators. The initial annual workshop was supported cooperatively by the USAID and the Australian International Development Assistance Bureau (AIDAB).

5. METHODS AND RESULTS

Laboratory Investigations

Based on references to recent research (Oomen, 1982), in advance of this Project, the recommendations of consultants to the Project, and the results of laboratory, greenhouse, and field observations, the predaceous beneficial mites Amblyseius deleoni and Phytoseus crinitus were the focus for the investigations. The predators were investigated using different life forms of each species (eggs, immatures, and adult males and females) provided different sources of nutrition. The sources of nutrition were:

a) Pollen of Vicia vaba (Broad Bean).
b) Pollen of Hibiscus rosasinensis (Hibiscus).
c) Pollen of Camellia sinensis (Tea).
d) Pollen of Euphorbia pulcherrima (Poinsetta).
e) Eggs of Tetranychus urticae (Two-spotted Spider mite).
f) Eggs of Brevipalpus phoenicis (Scarlet mite).
g) Mobile life forms of phytophagous mites (see **e** and **f** above).

Amblyseius deleoni (predator).

Investigations were directed to the biology of the two (2) principal predators; specifically, the length of the life cycles, the survival of predators, the fecundity, and the effects of different sources of nutrition on the predators. All laboratory investigations were conducted using a conventional glass rearing plate (10 cm X 10 cm) in water barrier rearing units (20 cm X 30 cm X 5 cm). Ambient air temperature was 21° - 23° C. and an ambient relative humidity of approximately 70%.

Life Cycle

It is concluded that the life cycle of A. deleoni from egg hatch to the emergence of the adult stage, ranged from 8 - 16 days on the pollen of Broad Bean to the longest period of development from 12 - 19 days on the pollen of Hibiscus. The pollen of Tea supported

5. METHODS AND RESULTS (Continued)

the rapid development of the life cycle, essentially equal to the time completed by the predator on the pollen of Broad Bean. The data is presented in **Table 1.**

Survivalship, and Female : Male Ratio

The survival of adult female A. deleoni on a majority of the seven nutrition sources was ranked according to the percentages of adults surviving and the eggs produced by the females which resulted in the observed sex ratios. The highest percentage of survival (85%) was found to occur on the pollen of Tea, the pollen Poinsetta, and the eggs of the Scarlet mite. The most favorable female : male sex ratio (4.6 : 1) occurred with the pollen of Poinsetta. The data is presented in **Table 2.**

Fecundity

The largest total number of eggs produced by eleven (11) female A. deleoni on the available sources of nutrition, for a period of 32 days, occurred with the pollen of Tea. The second most productive nutritional source was the pollen of Broad Bean. No eggs were produced by female A. deleoni which were provided the eggs of the Two-spotted Spider mite. The results are presented in **Table 3.**

Predatory Behavior

Individual female A. deleoni were exposed to groups of adults, eggs, and three forms of immature Scarlet mites to investigate the preferences of predators. It can be concluded that female predators exhibit preferences for the protonymph, larvae, and eggs of the Scarlet mite, rather than the deutonymph or adult forms of the prey Scarlet mites. The results of daily predation of adult A. deleoni are presented in **Table 4.**

5. METHODS AND RESULTS (Continued)

Effects of Azadirachta indica (Neem) Seed Extract on Development of Predator Populations

The effects of the exposure to Neem, of adult A. deleoni, the effects on the hatching on A. deleoni eggs, and the number of eggs produced daily by A. deleoni females are provided in **Tables 5, 6, and 7.** A direct dosage/mortality effect resulted from the exposure of adult A. deleoni to Neem residues. The residues did not effect the viability of eggs exposed to Neem; and there was no effect on Neem on the fecundity of A. deleoni.

Phytoseius crinitus (predator).

Life Cycle and Survivalship

The results of the investigation of 7 sources of nutrition were the same for P. crinitus as was observed in the investigation of A. deleoni.

Hatching Ability, Fecundity, and Prey Preference

The results of the investigation of 7 sources of nutrition were the same for P. crinitus as was observed in the investigation of A. deleoni.

Greenhouse Investigations

The location and design of greenhouse investigations planned for use of Amblyseius deleoni for reduction of the populations of Brevipalpus phoenicus (Scarlet mite) and Polyphagotarsonemus latus (Yellow mite) on Tea plants are provided in **Appendix A.**

5. METHODS AND RESULTS (Continued)

Tea Plantation Investigations

The location and design of Tea Plantation investigations planned for use of Amblyseius deleoni for reduction of the populations of Brevipalpus phoenicus (Scarlet mite) on Tea plants are provided in **Appendix B.**

The Greenhouse investigations and Tea Plantation investigations were delayed due to weather. Results have been provided to the Co-Principal Investigators, on computer disk, however, the analysis of the data has not been completed.

Conclusions

The principal beneficial predatory mite which selectively attacks Scarlet mite on Tea is Amblyseius deleoni. The second, and less common beneficial predatory mite attacking all forms of the Scarlet mite on Tea is Phytoseius crinitus. Adults and immature forms of both beneficial predaceous mites are able to complete their life cycles, maintain their fecundity, and selectively attack all life forms of the Scarlet mite on Tea when provided with pollen and life forms of additional phytophagous mites in the absence of the preferred Scarlet mite.

6. IMPACT, RELEVANCE AND TECHNOLOGY TRANSFER

The utility of the results of the Project are important for Indonesian agriculture, technology development, and industrial development. The results of the Project show that the facilities exist now that can be used for mass propagation of beneficial predaceous mites. The faculty and staff of the institutions of higher education and research in Indonesia can train their staff to implement the technology already available in Indonesia and that which is available abroad. When Indonesian IPM interests implement the use of predaceous mites on Tea, the development of small local or regional businesses for the production of predaceous mites will be a source of income not now available.

Through the services of consultants for the Project, and the development of Workshops in applied acarology, existing useful skills among individuals in faculty and staff, have been identified and developed. The facilities necessary for predaceous mite production have been identified in universities and institutes. It is evident from the results of the Project, that techniques and procedures developed in the Project can be transferred from research institutions to their application in the field.

As a result of the utility of the skills in Indonesian institutions, and the usefulness of existing facilities, the Republic can benefit from the lack of dependency on external supplies of pesticides, particularly acaracides for the control of the Scarlet mite on Tea. As a result of the opportunity to transfer Indonesian laboratory technology to the field, and to anticipate the development of local or regional industries, the results of the Project are useful. Further, the technical staffs in research institutions appreciate the value of developing hypotheses as a basis for investigations in order to assess the use of predaceous mites. The validity of the approaches to research, and the results of laboratory and greenhouse investigations, can be established for field studies using computer software introduced by consultants. Scientific self sufficiency and economic independence from pesticide imports, are two useful and important results of the Project.

7. PROJECT ACTIVITIES / OUTPUTS

(Publications, Presentations, Posters, Workshops, and Consultants)

Period: September 1, 1991 - October 30, 1993

Publications:

1992. Applied Acarology Workshop, A Report. Gerrit van de Klashorst. Australian International Development Assistance Bureau. Institute of Technology, Bandung (Java), Indonesia. May 19 - June 5, 1992.

1992. Prospects for Biological Control of Scarlet Mites on Tea using Mass-reared Predatory Mites; Section XVIIS4, p.661a; Proceedings XIX International Congress of Entomology, Beijing, China. June 28 - July 4, 1992.

1993. IPM in Tea: The Case of Predators Against Scarlet Mites. Gerrit van de Klashorst & Dana L. Wrensch. Proceedings of Experimental & Applied Entomology, 4:235-236.

1994. Sampling Population Density of Scarlet Mite (Brevipalpus phonecius) and Assessment of Feeding Damage on Indonesian Tea. Sydney S.Y. Young, Donald .M Yehling, Soelaksono Sastrodihardjo, and Dana L. Wrensch. Journal of Economic Entomology. In Press.

Invited Presentations:

1992. USAID/NRC - BOSTID Networking Meeting on Forestry - Tree Crops. "IPM of scarlet mite using predaceous mites." E.A.R.T.H., Limon, Costa Rica (3/31-4/8). (D. L. Wrensch).

1992. International Congress of Entomology, Beijing, China; Program Symposium Speaker, Acarology Section: "Introduction to Symposium: Population and Quantitative Approaches to the Use of Natural Enemies." (D. L. Wrensch)

1992. International Congress of Entomology, Beijing, China; Program Symposium Presentation, Acarology Section: "Mite pest management and modes of reproduction". In Acarology Symposium: Population and Quantitative Approaches to the Use of Natural Enemies." (D. L. Wrensch and G. van de Klasthorst)

1992. International Congress of Entomology, Beijing, China; Program Symposium Presentation, Acarology Section: "Sampling scarlet mite densities and damage scores on tea". In Acarology Symposium: Population and Quantitative Approaches to the Use of Natural Enemies." (S.S.Y. Young and D.M. Yehling).

Invited Presentations (continued):

1992. International Congress of Entomology, Beijing, China; Program Symposium Presentation, Acarology Section: "Sampling scarlet mite densities and damage scores on tea". In Acarology Symposium: Population and Quantitative Approaches to the Use of Natural Enemies." (G. van de Klasthorst and S. Sastrodihardjo).

1992. University of Amsterdam, Amsterdam, The Netherlands; Seminar: "Scarlet mite densities and leaf damage on Tea". (G. van de Klasthorst).

1993. Malaysian Agricultural Research and Development Institute (MARDI) Research Station, Klang, Selangor, Malaysia. "Injurious and beneficial mites in Tea". (G. van de Klasthorst).

1993. University of Queensland, Brisbane, Australia; "Propagation and selection of predaceous beneficial mites on Tea". (G. van de Klasthorst).

Conferences (Organized and/or Co-Moderated):

1992. International Congress of Entomology, Beijing, China; Program Symposium Organizer, Acarology Section: "Population and Quantitative Approaches to the Use of Natural Enemies". (June 28 - July 4).

Posters (Professional Meetings):

1991. "Sampling Strategies for Scarlet Mite on Tea in Indonesia". (D.M. Yehling, S.S.Y. Young, and A. Dharmadi). Entomological Society of America Annual Meeting, Reno Nevada, USA.

1991. "Sampling Strategies for Scarlet Mite on Tea in Indonesia". (D.M. Yehling, S.S.Y. Young, and A. Dharmadi). International Sustainable Agriculture Conference, Columbus, Ohio, USA.

1992. "Scarlet mite densities and leaf damage on Tea". (G. van de Klasthorst). Netherlands Entomological Society Annual Applied Entomology Meeting, Wageningen, The Netherlands.

Workshops:

1992. Applied Acarology Workshop. May 19 - June 5. Bandung, (Java) Indonesia. Co-sponsored by the Australian International Development Assistance Bureau and the USAID.

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8. PROJECT PRODUCTIVITY

Two of the four proposed goals for the Project were not completed. One goal included the genetic improvement of beneficial predaceous mites for increased frequency of genotypes resistant to conventional chemical pesticides. The second goal to initiate field trials was not completed in time to be reported. The trials are to compare, blocks of commercial Tea subject to mass release of predaceous mites, in contrast to conventional control methods. Completion of this goal was delayed due to the limitations of bad weather. The locations for the field trials were committed in Tea estates and on the Research Institute properties. The trials are expected to be completed in 1994, after the end of the current Project in 1993.

With respect to the genetic improvement of predaceous mites for pesticidal resistance, the review of a single pesticide was completed using the two principal predaceous species available in the field on Tea. The pesticidal "azadiractin", an extract of the seeds of the Neem tree *Azadirachta indica*, was found to not adversely affect the growth, development, maturity, or reproductive qualities of the beneficial predaceous mites. The facilities and methodologies are available to continue the pesticidal screening of beneficial mites and the selection of resistant genotypes. The procedures adopted are those developed in Indonesia by Bakker et al. (1992).

The productivity of the Project depended largely on the availability of trained and skilled laboratory and agricultural field workers for investigations of beneficial mites. The administrative division of resources in research institutions in Indonesia has heretofore not included greenhouse space for the production of injurious or beneficial mites. The educational process of leadership personnel for integrated pest management (IPM) was satisfied in part by the initiation of annual Workshops for applied acarology. The scope of botanical and entomological activities necessary in greenhouses, and the intensity of this activity can only be appreciated by individuals who have practical experience in mentored exercises. This experience has been and will continue to be provided through the annual workshops for predaceous mite investigations as part of IPM in Indonesia.

9. FUTURE WORK

The Project has provided a model for all other agricultural crops subject to investigations of both destructive and useful mites. Because developing nations must continue to exercise independence in research and development, the substitutions of indigenous resources, e.g., predaceous mites and other beneficial arthropods, will assure reduction in the loss of foreign exchange as the need to import pesticidal materials is eliminated. Further, the Project has demonstrated the value of establishing economic thresholds for agricultural crops, e.g., damage indices for agricultural commodities as these are correlated with populations of injurious arthropods.

As noted in **Item 6** (p. 7), the revelation through the Project of the existing and useful skills for isolation, propagation, nutrition, and field-use of beneficial insects, the continued investment of these skills will generate additional funds for investigations. Tea, as with all other agricultural commodities subject to damage by injurious mites, will be the basis for local or regional industries to supply continuously those beneficial arthropods which are specifically selected for use for the commodities in question.

10. LITERATURE CITED

Bakker, F., A. Grove, S. Blumel, J. Calis, and P. Oomen (1992) - Side-effect tests for phytoseiids and their rearing methods. IOBC/WPRS Bulletin XV:61-82.

van de Klashorst, G., and D. L. Wrensch (1993) - IPM in Tea: The Case of Predators Against Scarlet Mites. Proceedings of Experimental & Applied Entomology, 4:235-236.

Oomen, P. A. (1982) - Studies on population dynamics of the scarlet mite, *Brevipalpus phoenicis*, a pest of tea in Indonesia. Meded. Landb. Hogeschool Wageningen No. 82-1.

Young, S. S. Y., D. M. Yehling, S. Sastrodihardjo, and D. L. Wrensch (1994). Sampling Population Density of Scarlet Mite (Brevipalpus phonecius) and Assessment of Feeding Damage on Indonesian Tea. Journal of Economic Entomology. *In Press*.

TABLE 1

Life cycle of Amblyseius deleoni on six different alternative food (in days).

Stages	Pollen of Vicia vaba	Pollen of Hibiscus rosa-sinensis	Pollen of Camellia sinensis	Pollen of Euphorbia pulcherrima	Eggs of Tetranychus	Eggs of Brevipalpus phoenicis
1. Egg	2-3	2-3	2-3	2-3	2-3	2-3
2. Larva	2-4	2-4	3-4	3	3	2-3
3. Protonymph	3-4	3-6	1-4	1-3	3	3-4
4. Deutonymph	1-5	5-6	2-6	5-6	4	4-6
5. Eggs to adult	8-16	12-19	8-17	11-15	12-13	11-16
6. Adult Prae oviposition	4-6	3-4	2-5	1	-	5-8

TABLE 2

Survivalship of tea scarlet mite predator Amblyseius deleoni on six different alternative food, indicated by number of adult

Replication	Initial number of eggs	Pollen of Vicia vaba	Pollen of Hibiscus rosasinensis	Pollen of Camellia sinensis	Pollen of Euphorbia pulcherrima	Eggs of Tetranychus	Eggs of Brevipalpus phoenicis
1	5	3	3	5	4	0	3
2	5	4	5	5	5	0	5
3	5	4	3	4	4	4	4
4	5	2	5	3	4	0	5
		13	16	17	17	4	17
% to adult		65	80	85	85	20	85
Ratio female : male		3.3 : 1	1 : 1	1.8 : 1	4.6 : 1	4 male	2.4 : 1

TABLE 3

Total number of eggs produced on six different kind alternative food in 32 days observation

Replication	Pollen of Vicia veba		Pollen of Hibiscus rosasinensis		Pollen of Carthamus tinctorius		Pollen of Euphorbia pulcherima		Eggs of Tetranychus		Eggs of Brevipalpus phoenicis	
	x/f	x/f	x/f	x/f	x/f	x/f	x/f	x/f	x/f	x/f	x/f	x/f
1	55/2	27.5	7/2	3.5	61/3	20.3	0/2	0	0/0	0	35/2	17.5
2	72/3	24.0	10/2	5.0	100/4	25	2/4	0.5	0/0	0	19/3	6.3
3	2/4	0.5	12/1	12.0	99/3	33	23/4	5.75	0/0	0	24/3	8.0
4	22/1	22.0	16/3	5.3	9/1	9	53/4	13.25	0/0	0	25/4	6.25
Total number egg/total female	151/10 female		45/8 female		369/11 female		78/14 female		0		102/12 female	
Average egg produced per female	12.5		6.5		21.8		4.9		0		9.5	
Days of observation	32		32		32		32		32		32	
Number of egg produced/ female/day	0.6		0.2		0.7		0.2		0		0.3	

f = female

TABLE 4

Average number of tea scarlet mite Brevipalpus phoenicis consumed by predator Amblyseius deleoni to each particular stage in every day consumption

Treatment	Replication I	II	III	IV	V	Total Ex	Average x	F .05
Adult	1.5	2.625	2.5	2.5	2.0	11.125	2.225	c
Deutonymph	7.25	9.375	8.0	10.75	12.375	47.75	9.55	b
Protonymph	13.375	10.5	12.5	12.75	14.375	63.5	12.7	a
Larva	10.5	13.0	9.75	13.375	14.125	60.75	12.15	a
Eggs	10.0	14.375	9.75	8.375	13.25	55.75	11.15	ab

Note : Means followed by the same letter are not significantly different by Duncan's Multiple Range Test at 5 % level.

TABLE 5

Effect of seed extract of Azadirachta indica on the hatching ability of eggs predator, Amblyseius deleoni.

Concentration of Seed Extract A. indica	Day of observation 1	2	3	4	5	6	7		Total hatching (%)
	I II III IV	I II III IV	I II III IV	I II III IV	I II III IV	I II III IV	I II III IV	I II III IV	
1. 0.0001 %			10	10 10	10				100
2. 0.001 %				10 10	10 10				100
3. 0.01 %				10 10 10		10			100
4. 0.1 %				10 10 10				10	100
5. 1.0 %				10 10 10 10					100
6. 2.0 %		10 10 10		9					97.5
7. 3.0 %	10			10 10 10					100
8. 4.0 %				10 10 10 10					100
9. 5.0 %	10	10 10 10							100
10. Untreated				10 10 10			8		95
Total number eggs hatching	20	70	249	30	10	8	10		397
% eggs hatching	5	17.5	62.25	7.5	2.5	2.0	2.0		

TABLE 6

Effect of seed extract of Azadirachta indica on the mortality of predator Amblyseius deleoni.

Consentration of seed extract A. indica	Replication I	II	III	IV	$\bar{x}$	F .05
1. 0.0001 %	4.36	7.14	6.78	6.86	6.28	bcd
2. 0.001 %	6.07	3.28	3.64	3.93	4.23	d
3. 0.01 %	3.64	3.28	8.78	9.07	6.04	cd
4. 0.1 %	8.43	9.21	9.36	5.36	8.09	abc
5. 1.0 %	7.07	8.86	6.07	6.14	7.04	bc
6. 2.0 %	8.07	6.57	9.93	6.71	7.82	abc
7. 3.0 %	9.78	10.0	10.0	10.0	9.95	a
8. 4.0 %	8.93	9.64	7.64	9.93	9.04	ab
9. 5.0 %	7.50	7.50	9.71	8.14	8.21	abc
10. Untreated	3.28	5.93	8.21	8.71	6.71	bcd

Note : Means followed by the same letter are not significantly different according to Duncan Multiple Range Test at 5 % level.

TABLE 7

Average number of oviposited eggs per day by each adult female after treated by seed extract of Azadirachta indica.

Concentration of seed extract A. indica	Replication I	II	III	IV	$\bar{x}$	F .05
1. 0.0001 %	2.73	0.91	0.18	1.1	1.23	bc
2. 0.001 %	2.27	3.6	4.0	2.5	3.09	a
3. 0.01 %	3.27	3.1	0.09	0	1.62	b
4. 0.1 %	0.91	0	0	1.45	0.59	bc
5. 1.0 %	0.82	0	1.45	0.64	0.73	bc
6. 2.0 %	0.36	1.27	0	0.36	0.49	bc
7. 3.0 %	0.09	0	0	0	0.02	c
8. 4.0 %	0.45	0.09	1.0	0	0.38	bc
9. 5.0 %	0	0.18	0	0.27	0.11	c
10. Untreated	2.91	2.18	1.45	0.18	1.68	b

Note : Means followed by the same letter are not significantly different according to Duncan Multiple Range Test at 5 % level.

APPENDIX A

METHOD OF THE EXPERIMENT

EFFECTIVENESS OF AMBLYSEIUS DELEONI ON BREVIPALPUS PHOENICIS AND POLYPHAGOTARSONEMUS LATUS ON TEA PLANT IN GREEN HOUSE

1. Location :

   This experiment was conducted in the condition of Green House (Screen House)

2. Time and Location
   Location : Green House (Screen House) of Entomology Department of RITC in Gambung
   Time : February - June 1993

3. Material and method :

   3.1. Material

   3.1.1 Cultivar
   The tea variety on this experiment was tea clone of TRI 2025, growth on plastic pot with 60 cm height, 35 cm diameter.

   3.1.2 Condition of the tea bush
   The tea plant was the productive plant of two years of production after pruning, and heavily invested by tea scarlet mite Brevipalpus phoenicis and yellow mite Polyphagotarsonemus latus.

   3.1.3 Maintenance :
   The maintenance of the tea plant was carried out in order to keep plant growing, but there's no spraying of insecticide or acaricide also fungicide, to prevent contamination to the predator.

   3.2. Method :

   3.2.1 The experiment based on completely randomized design, with 4 treatment and 4 replication.

   3.2.2 The treatment were :

No.	Treatment	number of predator per tea bush
1.	Amblyseius deleoni	20
2.	A. deleoni	10
3.	A. deleoni	5
4.	Untreated	-

Note : release of the predator will be every 2 weeks.

3.2.3 Number of replication : 4 times.

3.2.4 Data analyses :
Analyses data will be accordingly with the experimental design involved and at 5 and 1 % level of confidence.

3.2.5 Unit of tea pot and distance :
The distance of every tea plant on the pot was 75 cm.

3.2.6 Lay out of the experiment :
The distribution of the plot was such a way, so the distribution of the target pest and the predator were evenly distributed.

3.2.7 Way of application :
The predator A. deleoni were put on the maintenance leaves on every tea bush and accordingly with the tested treatments, except on the plot untreated as control.

3.2.8 Frequency and time of application.

3.2.8.1 First application.
After the number of tea scarlet mite B. phoenicis was observed and counted per leaf by taking sample of tea leaves (10 leaves). The number of predator accordingly with the treatments were released in each plot. The first release of the predator was on February 24, 1993.

3.2.8.2 Interval of application.
Release of the predator accordingly with the treatment will be every 2 weeks, and depending on the target pest population. Sampling for monitoring tea pest will be every 2 weeks.

3.2.8.3 Time of application : 8 X.

3.2.9 Criteria of the predator distribution :
Application or release of the predator based on the number of scarlet mite population or investation on every plot.

3.2.10 Observation :

3.2.10.1 Number of leaves for monitoring samples : 10 old leaves (maintenance leaves) for observing and counting the number of tea scarlet mite B. phoenicis, and 10 young leaves for observation and counting the yellow mite P. latus from each plot.

3.2.10.2 Method of sampling technique:
The tea leaves samples were originally from one tea plant taken by random from each plot. From each tea plant was taken 10 old leaves and 10 young leaves.

3.2.10.3 Counting the number of population of B. phoenicis, P. latus were carried out in the laboratory from leaf to leaf.

3.2.10.4 Time of observation :
The observation of the target pest B. phoenicis and P. latus will be every two weeks.

3.2.10.5 Data observation and additional observation.
Number the predator at before treatment. other pest and diseses. plant production. temperature and relative humidity. will be recorded.

APPENDIX B

METHOD OF FIELD EXPERIMENT
EFFECTIVENESS OF AMBLYSEIUS DELEONI ON BREVIPALPUS PHOENICIS IN TEA PLANTATION

1. **Location :**
   This experiment was conducted in tea plantation in form of field experiment.

2. **Time and location :**
   Location : Experimental garden of Research Institute for Tea and Cinchona Gambung.
   Field plot : Panarikan - B3 - Gambung.
   Time : March - June 1993.

3. **Material and Method :**

   3.1. Material

   3.1.1. Cultivar
   The tea variety on this field experiment was seedling tea with 3 years after pruning.

   3.1.2. Condition of the tea bush :
   The tea plant was the productive plant of three years of production after pruning. and heavily infested by tea scarlet mite B. phoenicis.

   3.1.3. Maintenance :
   The maintenance of the tea plant was carried out in order to keep plant growing. but there is no spraying of insecticide or acaricide. fungicide and herbicide. to prevent contamination to the predator.

   3.2. Method :

   3.2.1. The experiment was arranged on randomized block design with 11 treatments and 3 replication.

   3.2.2. The treatments were :

No.	Treatment	number of predator per tea bush
1.	Amblyseius deleoni	50
2.	-.-	45
3.	-.-	40
4.	-.-	35
5.	-.-	30
6.	-.-	25
7.	-.-	20
8.	-.-	15
9.	-.-	10
10.	-.-	5
11.	Untreated	

3.2.3. Number of replication : 3 times

3.2.4. Data analyses :
Analyses data will be carried out accordingly with experimental design involved and at 5 and 1 % level of confidence.

3.2.5. Plot size and planting distance :
The size of a plot was 10 X 10 meter, with ± 80 tea bushes and planting distance was 120 X 90 cm.

3.2.6. Lay out of the experiment :
The distribution of tea bushes were such a way in every plot,so target pest were naturally distributed.

3.2.7. Way of release or application :
The predator A. deleoni were put on the maintenance leaves on every tea bush randomly, and accordingly with the tested treatments, except on the plot of untreated as control or check.

3.2.8. Frequency and time of release or application :

3.2.8.1. First application
After the number of B. phoenicis was observed and counted per leaf sample out of total sample of 50 tea leaves taken randomly from each plot. The number of predator accordingly with treatments were released to each plot. The first release of this predator will be March 30, 1993.

3.2.8.2. Interval of application
Release of the predator accordingly with the treatment will be every two weeks.

3.2.8.3. Time of application : 8 times.

3.2.9. Criteria of predator distribution :
Application or release of predator based on the number of scarlet mite population on investation on every plot 1993.

3.2.10. Observation :

3.2.10.1. Number of leaves samples were 50 old leaves (maintenance leaves) for observing and counting the number of tea scarlet mite B. phoenicis, and also predator of tea scarlet mite, either the released predator Amblyseius deleoni, A. quadridens, Phytoseius crinitus or other scarlet mite predator.

3.2.10.2. Method of sampling technique :
The 50 tea leaves samples were originally from one plot, consisting of 80 tea bushes. The samples were taken at random from the whole bushes.

3.2.10.3. Counting the number of population of target pest B. phoenicis and the predator will be carried out in the laboratory. from leaf to leaf by using brushing mite machine.

3.2.10.4. Time of observation :
The observation of the target pest and its predator will be carried out every two weeks.

3.2.10.5. Data of additional observation :
Number of B. phoenicis and A. deleoni and also other naturally occuring predator will be observed before the treatments started. including the tea leaves production. as well as temperature and relative humidity and rainfall will be recorded.
The plucking of tea leaves production will be every 7 days.