CONTRIBUTIONS TO THE DEVELOPMENT OF INTEGRATED RICE PEST CONTROL IN THAILAND

January, 1981

Japan International Cooperation Agency

ERRATA

Page	Line	For	Read
13	13 from the bottom	Phinophoridae	Rhinophoridae
36	In Table 9, P means	*Paracentrobia* sp.	
44 (Table 10)	7 from the bottom	*pygmaea*	*femina*

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PREFACE

In response to a request of the Government of the Kingdom of Thailand, the Government of Japan decided to take up a study on the integrated rice pest control and entrusted the Japan International Cooperation Agency (JICA) with the work. The JICA dispatched one long-term expert, Dr. Keizo YASUMATSU to Thailand from March 17, 1976 to March 18, 1980.

The expert conducted field research trips in almost all the areas in Thailand and studied the foodchain relationship between rice pests and their enemies in collaboration with the counterparts of the Department of Agriculture of the Government of Thailand. Based on many years of field observations, the expert pointed out-factors to be considered in the development of integated rice pest control program. And after deep studies made in Japan, the expert compiled this report.

I hope this report will greatly contribute to the integrated rice pest control in Thailand and to the enhancement of the friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned in Thailand for their close cooperation extended to the expert.

March 1981

Keisuke Arita

Keisuke ARITA
President
Japan International Cooperation Agency

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INTRODUCTION

Many years have been passed since some agronomists and applied entomologists felt the importance of integrated rice pest control.

The integrated rice pest control should utilize all suitable techniques and methods in as compatible a manner as possible and maintains the rice pest populations at levels below those causing economic injury. In the developed countries where the rice ecosystem has already been destroyed by chemicals including fertilizers and pesticides in order to expand rice production without taking any ecological considerations in former days.

Fortunately in Thailand, the rice environment still remains healthy, receiving less chemical fertilizers and pesticides and keeping tremendous numbers and species of natural enemies of rice pests.

For the past fifteen years Yasumatsu has been engaged in the study of natural enemies of rice pests in Asia. The authorities of the Department of Agriculture of the Government of Thailand has paid great attention to the importance of natural enemies of rice pests and asked Yasumatsu to start a joint work on the integrated rice pest control with the entomologists of Entomology and Zoology Division. Thus, in 1972 through 1974 Yasumatsu have been in service as an Agricultural Officer of FAO and from 1976 to 1980 as a Colombo Plan Expert attached to the Japan International Cooperation Agency.

In developing the integrated rice pest control, the fundamental problem is the survey of natural enemies of rice pests. Based upon the sound knowledge on the natural enemy fauna of rice pests we can establish a rational integrated rice pest control program. Therefore, we have focused our research on the quantitative and qualitative studies of natural enemies of rice pests. Now, it can be said that our current knowledge of the natural enemies of rice pests in Thailand has become only the most complete one throughout the world.

In this report we present results of our studies which may be of great interest to the workers in the area of integrated rice pest control and of great help to the practical application of its control program.

Keizo Yasumatsu

Tanongchit WONGSIRI

Chalermwong TIRAWAT

Nualsri WONGSIRI

and

Angoon LEWVANICH

ACKNOWLEDGEMENTS

We are very much indebted to the authorities of the Department of Agriculture, Ministry of Agriculture and Cooperatives and the Department of Technical and Economic Cooperation of the Government of Thailand and the Japan International Cooperation Agency.

We are deeply thankful for Dr. Sala Dasananda, Dr. Bhakdi Lusanandana and Dr. Prakob Kanjanasoon, the former and the present Director-Generals of the Department of Agriculture, Mr. K. Kuwabara and Mr. Y. Kitano, the former and the present Directors of the Bangkok Office of the Japan International Cooperation Agency and their staff members for their constant encouragement, advice and assistance.

Our thanks are also due to all the staff members of the Entomology and Zoology Division of the Department of Agriculture and Prof. T. Nishida of the University of Hawaii for their kind cooperation during the course of this work. Special technical assistances were done by Mrs. Vichuda Nitiuthai and Mrs. Sommai Chunram.

Further, we cannot forget the very kind encouragement rendered to us by the authorities of Japan Embassy to Thailand, especially the secretaries Messrs. H. Tsuchiya, H. Imafuji, S. Igarashi, N. Ueno and H. Takei.

Our thanks are due to Drs. S. Hatta, H. Inoue, T. Igarashi, T. Hidaka, M. Kobayashi, T. Morinaka and S. Takaya of the Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fisheries, Japanese Government for their assistance in many ways.

Finally, we express our sincere thanks to the following entomologists for their kind assistance in promptly identifying the material concerned and in sending us reprints or xerox copies of some important literature which were not accessible to us in Bangkok: Dr. S. Asahina of the National Institute of Health, Japan; Dr. A. Habu of the National Institute of Agricultural Sciences, Japan; Dr. C. Watanabe of Hokkaido University, Japan; Prof. Y. Hirashima, Associate Professors M. Chujo and K. Morimoto and Miss C. Okuma of Kyushu University, Japan; Prof. T. Kifune of Fukuoka University; Japan; Associate Prof. T. Tachikawa of Ehime University, Japan; Prof. M. Chujo of Meijo University, Japan; Dr. T. Yamasaki of the National Science Museum, Japan; Dr. K. Nohara of Hagi Citrus Experiment Station, Japan; Mr. K. Haga of the University of Tsukuba, Japan; Prof. H. Hashimoto of Shizuoka University, Japan; Prof. H. Sasaji of Fukui University, Japan; Prof. Banpot Napompeth of Kasetsart University, Thailand; Drs. B.R. Subba Rao and Z. Bouček of the Commonwealth Institute of Entomology, England; Drs. C.W. Sabrosky, G.C. Steyskal, W.W. Wirth and C.F.W. Muesebeck of the U.S. National Museum, U.S.A.; Dr. J. van der Vecht, the Netherlands; Dr. Sudha Nagarkatti and Dr. H. Nagaraja of the Commonwealth Institute of Biological Control, Indian Station, India; Dr. L.P. Mesnil of the Commonwealth Institute of Biological Control, European Station, Switzerland. Without their kind assistance it would have been impossible to carry out this study.

The manuscript was completed and printed in a mimeographed form in March, 1980, and submitted to the Department of Agriculture, Ministry of Agriculture and Cooperatives and the Department of Technical and Economic Cooperation of Thailand and the Japan International Cooperation Agency as our Final Report. Later, some additions and corrections were made to the original manuscript in order to make the report as complete as possible. Special thanks are due to Messrs. A. Kawanishi, H. Endo, M. Esaki, K. Ono, T. Takeda, T. Kato and Miss K. Kuwajima of the Japan International Cooperation Agecy for their invaluable aid in various aspects of publishing this Revised Final Report.

FIELD RESEARCH TRIPS, AND COLLECTING AND STUDY METHOD

One of the most convenient and fastest ways of determining the abundance of and species of natural enemies present in a given locality is by sweeping. Of course to use this procedure effectively a knowledge of the taxonomy and biology of natural enemies in question is necessary. In fact it is a very troublesome work to separate the insects captured into taxonomic order for identification. The insects captured in the 50 sweep nets were placed into cyanid killing jars. From the jars the dead insects including pests, natural enemies and some debris were placed immediately in 70% alcohol vials. Preservation the material in alcohol was extremely necessary to sort out a very tiny egg-parasites of insect pests without destruction. The relative abundance of various species in the collections gives an indication of their relative predominance in a given area, although the effects of behavioral differences of species and the stage of growth of the crop should be borne in mind. Sometimes, the eggs and larvae of the pest insects were also taken and brought back to the laboratory for future checking of the emergence of parasites from them.

During Yasumatsu's stay in Thailand, 1976-1979, we made many research trips to the nearby areas of Bangkok. Our research trips to the upcountry were as follows:

<u>1976</u>

April 20. Ban Pasao, Wang Kra Pi, Ban Pan Kloea, Phrae Province.

April 21. Phrae Rice Experiment Station, Phrae Province.

April 22. Amphoe Ko Kha, Lampang Province.

June 22.	Phrae Rice Experiment Station, Phrae Province.
June 23.	Den Chai, Ban Pong Pa Wai, Ban Den Chumphon, Phrae Province.
June 24.	Ban Dok Kam Tai, Amphoe Ngao, Phayao Province.
	Phan Rice Experiment Station, Chiang Rai Province.
June 25.	Ban Nam Cham, Ban Chon, Ban Paktong Sobkam, Ban Pa Huai Plu, Chiang Rai Province.
June 26.	Ban Mae Pong, Lampang Province.
June 27.	Ko Kha, Lampang Province.
Sept. 15.	Phrae Rice Experiment Station, Phrae Province.
Sept. 16.	Ban Rong Kard, Phrae Province.
Sept. 17.	Phayao, Phayao Province, Phan Rice Experiment Station, Chiang Rai Province.
Sept. 19.	San Pa Tong Rice Experiment Station, Chiang Mai Province.
Sept. 20.	Doi Inthanon, Amphoe Hang Dong, Chiang Mai Province.
Oct. 26.	Ban Nong Sang, Amphoe Cumpae, Khon Kaen Province.
	Ban Na Kam Hai, Amphoe Nong Bua Lampoo, Udon Thani Province.
Oct. 27.	Ban Srang Kaeo, Amphoe Chiang Yun, Maha Sarakham Province.
	Ban Puey, Amphoe Yang Talat, Kalasin Province.
Oct. 28.	Ban Non Sa ard, Amphoe Muang, Maha Sarakham Province.
	Ban Non Yang, Amphoe Muang, Roi Et Province.
	Ban Selaphoon, Roi Et Province.
	Ban Yo, Amphoe Kam Khuan Kaeo, Roi Et Province.
	Amphoe Yasothon, Ubol Ratchathani Province.
	Ban Yan Kee Nok, Amphoe Khuang Nai, Ubol Ratchathani Province.
Oct. 29.	Ubol Rice Experiment Station, Ubol Ratchathani Province.
	Amphoe Phibun Mangsahan, Ubol Ratchathani Province.

Oct. 30.	Ban Nong Bua, Amphoe Khanthararom, Si Sa Ket Province.
	Ban Kra Sang, Amphoe Muang, Si Sa Ket Province.
	Ban Toom Noi, Amphoe Kantharalak, Si Sa Ket Province.
	Ban Nong Tha, Amphoe Kantharalak, Si Sa Ket Province.
	Ban Ta Muan, Amphoe Khun Han, Si Sa Ket Province.
Oct. 31.	Ban Si Ko, Amphoe Prasat, Surin Province.
	Ban Hua Woa, Amphoe Muang, Buri Ram Province.
Nov. 1.	Ban Bu, Amphoe Muang, Nakhon Ratchasima Province.
	Ban Krok, Amphoe Prathai, Nakhon Ratchasima Province.
	Ban Bo Ta Khlong, Amphoe Phon, Khon Kaen Province.
	Ban Non Sila, Amphoe Ban Phai, Khon Kaen Province.
Nov. 8.	Ban Nong Dam, Amphoe Muang, Prachin Buri Province.
	Ban Muang, Amphoe Muang, Prachin Buri Province.
	Ban Hong Hua Chang, Amphoe Kabin Buri, Prachin Buri Province.
	Ban Nong Ka Poa, Amphoe Sa Kaeo, Prachin Buri Province.
	Ban Huai Dyua, Amphoe Watthana Nakhon, Prachin Buri Province.
Nov. 9.	Ban Khao Noi, Amphoe Aranyaprathet, Prachin Buri Province.
	Ban Phommanea, Amphoe Muang, Nakhon Nayok Province.
	Ban Pa Ka, Amphoe Muang, Saraburi Province.
Nov. 10.	Ban Bang Kra Pee, Amphoe Ban Mi, Lop Buri Province.
Nov. 11.	Amphoe Muang, Uthai Thani Province.
	Tambol Ban Luang, Amphoe Sanphaya, Chai Nat Province.
	Tambol Bang Kra Bue, Amphoe Muang, Sing Buri Province.
	Amphoe Muang, Ang Thong Province.
	Ban Tha Chang, Amphoe Muang, Suphan Buri Province.

Nov. 12.	Ban Ta Kram Enn, Tambol Tha Rua, Amphoe Tha Maka, Kanchanaburi Province.
Dec. 7.	Ban Yang, Amphoe Fang, Chiang Mai Province.
Dec. 8.	Amphoe Muang, Mae Hong Son Province.
Dec. 9.	Doi Tao, Chiang Mai Province.

1977

June 20.	Chaiyaphum Province.
June 21.	Phu Khieo, Chaiyaphum Province.
June 22.	Phu Luang, Loei Province.
June 23.	Ban Kud Khae, Ban Nong Bua, Khon Kaen Province.
Nov. 19.	Ban Muad, Amphoe Kantharalak, Si Sa Ket Province.
	Ban Thang Sai, Ubol Ratchathani Province.
Nov. 20.	Ban Don Chi, Amphoe Phibun Mangsahan, Ubol Ratchathani Province.

1978

March 13.	Ban Song Kwae, Amphoe Chom Thong, Chiang Mai Province.
	Ban Tung Pang, Tambol San Khlang, Amphoe San Pa Tong, Chiang Mai Province.
	Ban Khlang, Tambol Ban Khlang, Amphoe San Pa Tong, Chiang Mai Province.
	Ban Nam Prae, Tambol Hang Dong, Amphoe Hang Dong, Chiang Mai Province.
March 15.	Ban Mae Ka, Tambol Mae Ngon, Amphoe Fang, Chiang Mai Province.
March 16.	Ban Bo Hin, Tambol Talad Kwan, Amphoe Doi Saket, Chiang Mai Province.

March 26.	Nakhon Si Thammarat Rice Experiment Station, Nakhon Si Thammarat Province.
March 29.	Phatthalung Rice Experiment Station, Phatthalung Province.
March 31.	Prachuap Khiri Khan Province.
Apr. 1.	Hua Hin, Prachuap Khiri Khan Province.
May 3.	Amphoe Phayuha Khiri, Nakhon Sawan Province.
	Amphoe Khlong Khlong, Kamphaeng Phet Province.
May 4.	Amphoe Muang, Lamphun Province.
	Ban San Kab Tong Nua, Amphoe Saraphi, Chiang Mai Province.
May 5.	Amphoe Mae Sariang, Mae Hong Son Province.
May 6.	Ban Pang Mu, Amphoe Muang, Mae Hong Son Province.
	Ban Pa Bong, Amphoe Muang, Mae Hong Son Province.
May 7.	Ban Wang Nam Yard, Amphoe Chom Thong, Chiang Mai Province.
May 8.	Ban Huai Dib, Amphoe Chom Thong, Chiang Mai Province.
	Ban Yu Wha, Amphoe San Pa Tong, Chiang Mai Province.
Aug. 7.	Pimai Rice Experiment Station, Nakhon Ratchasima Province.
Aug. 8.	Ban Nong Kiang, Amphoe Phen, Udon Thani Province.
Aug. 9.	Sakhon Nakhon Rice Experiment Station, Sakhon Nakhon Province.
Aug. 10.	Ban Pone Thong, Amphoe Renunakorn, Nakhon Phanom Province.
	Ban None Nam Tang, Amphoe Amnarcharoen, Ubol Ratchathani Province.
Sept. 5.	Doi Pa-Morn, Doi Inthanon, Chiang Mai Province.
Sept. 6.	Ban Thung Ka La, Amphoe Chiang Dao, Chiang Mai Province.
	Ban Sob Kab, Amphoe Chiang Dao, Chiang Mai Province.
	Mae Jo, Chiang Mai Province.
Nov. 17.	Doi Pa-Morn, Doi Inthanon, Chiang Mai Province.

Nov. 18.	Sam Muang, Chiang Mai Province.
	Ban Pong Yong Nok, Mae Rim, Chiang Mai Province.
Nov. 19.	Doi Pa-Morn, Doi Inthanon, Chiang Mai Province.

<u>1979</u>

Feb. 19.	San Pa Tong Rice Experiment Station, Chiang Mai Province.
Feb. 20.	Ban Suk Sawadee, Amphoe Muang, Lampang Province.
Feb. 21.	Ban Mae Kachiang, Amphoe Wiang Pa Pao, Chiang Rai Province.
Feb. 22.	Ban Den, Amphoe Muang, Chiang Rai Province.
	Ban Mae Khao Tom, Amphoe Muang, Chiang Rai Province.
	Ban Teen Doi, Amphoe Muang, Chiang Rai Province.
March 27.	Ban Thau Sieo, Amphoe San Pa Tong, Chiang Mai Province.
	Ban Rong Ku, Amphoe Hang Dong, Chiang Mai Province.
	Ban Teen Doi, Chiang Rai Province.
March 28.	Ban Kua Tae, Amphoe Muang, Chiang Rai Province.
	Ban Mae Khao Tom, Amphoe Muang, Chiang Rai Province.
	Ban Teen Doi, Amphoe Mae Suai, Chiang Rai Province.
June 24.	Ban Mae Kachiang, Amphoe Wiang Pa Pao, Chiang Rai Province.
	Ban Mae Yoi, Amphoe San Sai, Chiang Mai Province.

Beside the material collected in our trips mentioned above, we have also examined the vast number of material which were collected in 1972 through 1974. The localities of the collected material are as follows :

<u>1972</u>

Nov. 17.	Amphoe Non Sung, Nakhon Ratchasima Province.
Nov. 18.	Maha Sarakham, Roi Et, and Ubol Ratchathani Provinces.

Nov. 19.	Ban Tepa, Amphoe Muang, Ubol Ratchathani Province.
	Amphoe Warin Chamrap, Ubol Ratchathani Province.
	Ban Don Chi, Amphoe Phibun Mangsahan, Ubol Ratchathani Province.
Nov. 26.	Phan Rice Experiment Station, Chiang Rai Province.
Nov. 28.	Ban Sam Lung and Ban Tung Theo, Amphoe San Pa Tong, Chiang Mai Province.
Nov. 29.	Ban San Sailong, Chiang Mai Province.
Nov. 30.	Ban Kilek, Ban Rintai, Ban Boukrock and Ban Nong Koung, Chiang Mai Province.
Dec. 12.	Ban Pakong, Chachoengsao Province.
Dec. 13.	Ban Wang Khla Thum and Ban Chondura, Lop Buri Province.
Dec. 14.	Amphoe Wiset Chai Chan and Amphoe Muang, Ang Thong Province.

<u>1973</u>

Jan. 15.	Phatthalung Rice Experiment Station, Phatthalung Province.
Jan. 16.	Amphoe Rata Phum, Songkhla Province.
Jan. 17.	Amphoe Muang, Satun Province.
Jan. 18.	Amphoe Muang, Songkhla Province.
	Amphoe Khok Pho, Pattani Province.
Jan. 19.	Amphoe Muang, Pattani Province.
	Amphoe Yi ngo and Amphoe Sungai Padi, Narathiwat Province.
Apr. 11.	Amphoe Khlong Yai, Trat Province.
April 19.	Amphoe Sam Phran, Nakhon Pathom Province.
May 21-24.	Trat Province.
Aug. 7.	Chiang Mai and Lamphun Provinces.
Oct. 5.	San Pa Tong Rice Experiment Station, Chiang Mai Province.

1974

Jan. 15.	Amphoe Sam Chuk, Suphan Buri Province.
Feb.	Amphoe Muang, Kanchanaburi Province.
	Tambol Takhum-are, Amphoe Tha Maka, Kanchanaburi Province.
	Tambol Phanom Thuan, Amphoe Phanom Thuan, Kanchanaburi Province.
March 12.	Amphoe Khlong Yai, Trat Province.
March 18.	Tambol Tha Maka, Kanchanaburi Province.
	Tambol Nong Bua, Kanchanaburi Province.
March 22.	Tambol Yan Yaw, Amphoe Sam Chuk, Suphan Buri Province.
Apr. 22.	San Pa Tong Rice Experiment Station, Chiang Mai Province.
	Amphoe Mae Sariang, Mae Hong Son Province.
Apr. 24.	Ban Pa Bong, Amphoe Muang, Mae Hong Son Province.
Apr. 26.	Amphoe Hang Dong, Chiang Mai Province.

MAJOR PESTS OF RICE IN THAILAND

Nobody has ever made a complete catalogue of insects associated with rice plant in Thailand. Following list gives the names of common rice pests based upon the present state of our knowledge.

Table 1. A compilation of common rice pests in Thailand.

Species	Common Name	Family
	Major pests	
Chilo polychrysus (Meyrick)	Dark-headed rice borer	Pyralidae
Cnaphalocrocis medinalis (Guénée)	Rice leaf roller	Pyralidae
Hydronomidius molitor Faust	Rice weevil	Curculionidae
Nephotettix nigropictus (Stål)	Green leafhopper	Cicadellidae
Nephotettix virescens (Distant)	Green leafhopper	Cicadellidae
Nilaparvata lugens (Stål)	Brown planthopper Brown rice planthopper	Delphacidae
Nymphula depunctalis Guénée	Rice caseworm	Pyralidae
Orseolia oryzae (Wood-Mason)	Rice gall-midge	Cecidomyiidae
Pelopidas mathias (Fabricius)	Rice skipper	Hesperiidae
Scirpophaga gilviberbis Zeller	Small rice borer	Pyralidae
Scirpophaga nivella (Fabricius)	White rice borer	Pyralidae
Tryporyza incertulas (Walker)	Yellow rice borer	Pyralidae
	Minor pests	
Balclutha viridis (Matsumura)	Green splashed leafhopper	Cicadellidae
Chilo auricilius Dudgeon	Gold fringed borer	Pyralidae

Table 1. (Continued)

Species	Common Name	Family
Chilo suppressalis (Walker)	Asiatic rice borer Striped rice borer Rice stem-borer Rice stalk borer	Pyralidae
Chloethrips oryzae (Williams)	Rice thrips	Thripidae
Dicladispa armigera (Oliver)	Rice hispid	Hispidae
Heterococcus rehi (Lindinger)	Rice mealybug	Pseudococcidae
Hieroglyphus banian (Fabricius)	Rice grasshopper	Acrididae
Hydrellia philippina Ferino	Rice whorl maggot	Ephydridae
Leptocorisa acuta (Thunberg)	Rice bug Tropical rice bug	Coreidae
Leptocorisa oratoria (Fabricius)	Rice bug	Coreidae
Mythimna separata (Walker)	Rice armyworm Rice ear-cutting caterpillar	Noctuidae
Nezara viridula (Linné)	Green rice bug Green vegetable bug Southern green stink bug	Pentatomidae
Nisia atrovenosa Lethierry	White-striated planthopper Striated planthopper	Meenoplidae
Oxya chinensis (Thunberg)	Small rice grasshopper	Acrididae
Recilia dorsalis (Motschulsky)	Zigzag rice leafhopper Zigzag striped leafhopper	Cicadellidae
Scotinophara coarctata (Fabricius)	Malayan black rice bug	Pentatomidae
Scotinophara lurida (Burmeister)	Black rice bug	Pentatomidae
Sogatella furcifera Horváth	White-backed planthopper	Delphacidae

Table 1. (Continued)

Species	Common Name	Family
Spodoptera mauritia (Boisduval)	Rice swarming caterpillar Grass armyworm	Noctuidae
Sesamia inferens Walker		Noctuidae
Thaia oryzivora Ghauri	Orange head leafhopper	Cicadellidae

For the sake of practical convenience and importance we classified the major rice pests of Thailand as follows :

Defoliators: *Cnaphalocrocis medinalis, Nymphula depunctalis, Pelopidas mathias, Methimna separata,* etc.

Stem-borers: *Chilo polychrysus, Scirpophaga nivella, S. gilviberbis, Tryporyza incertulas, Sesamia inferens,* etc.

Hoppers: *Nephotettix* spp., *Nilaparvata lugens,* etc.

Gall-midge: *Orseolia oryzae*

Rice weevil: *Hydronomidius molitor*

Consulting all the available literature, we found a considerable lack of information to establish the integrated control of rice pests. Therefore, for the past ten years our study on rice pests has been specially focused on the field surveys to find a food-chain relationship between rice pests and their natural enemies. And at the same time our effort has been concentrated to the biological, ecological and quantitative analyses of natural enemies of rice pests.

The rice weevil incidence was for the first time encountered in 1979 in the provinces of Kanchanaburi and Lopburi. This rice weevil also occurs in India.

But, not a single detailed study has ever been made. This weevil seems to have a wide range of host plants, and the staff of the Entomology and Zoology Division has just started its study.

REVISED LIST OF NATURAL ENEMIES OF THE MAJOR RICE PESTS IN THAILAND

Defoliators

Egg parasites:

Trichogramma japonicum Ashmead (Trichogrammatidae)

Trichogramma spp. (Trichogrammatidae)

Larval parasites:

Argyrophylax nigrotibialis Baranov (Tachinidae) (Host: *Pelopidas mathias)*

Dolichocolon vicinum Mesnil (Tachinidae) (Host: *Mythimna separata*)

Eocarcalia illota Curran (Tachinidae) (Host : *Mythimna separata*)

Exorista xanthaspis Wiedemann (Tachinidae) (Host : *Mythimna separata)*

Halidaya luteipennis Walker (Phinophoridae) (Host : *Pelopidas mathias)*

Charops bicolor (Szêpligeti) (Ichneumonidae) (Host : *Pelopidas mathias)*

Apanteles baoris Wilkinson (Braconidae) (Hosts : *Parnara guttata, Pelopidas mathias*)

Brachymeria lasus (Walker) (Chalcididae) (Host : *Pelopidas mathias*)

Brachymeria excarinata Gahan (Chalcididae) (Host : *Cnaphalocrocis medinalis*)

Brachymeria spp. (Chalcididae)

Anthrocephalus spp. (Chalcididae)

Dirhinus spp. (Chalcididae)

Elasmus 5 spp. (Elasmidae)

Tentatively identified as: *Elasmus hyblaeae, brevicornis, luteus, claripennis, zehntneri.*

Litomastix sp. (Encyrtidae) (Hosts: Noctuid larvae)

Parsierola sp. (Bethylidae)

Platyscelio abnormis Crawford (Scelionidae)

The following Tachinids have been recorded as parasites of *Mythimna separata*. It needs further confirmation. *Carcelia kockiana* Townsend, *Dolichocolon paradoxum* B, B., *Eutachina civiloidea* Baranoff, *Alsomyia anomala* Villeneuve, *Pseudogonia jacobsoni* (Townsend) (Tachinidae).

Egg predators:

Conocephalus longipennis (de Haan) (Tettigoniidae)

Conocephalus maculatus (Le Guillou) (Tettigoniidae)

Conocephalus sp. (Tettigoniidae)

Euscyrtus sp. (Encopteridae)

Anaxipha sp. (Trigoniidae)

Metioche vittaticolis Stål (Trigoniidae)

Ants

Larval or pupal predators:

Zicrona caerulea Linné (Pentatomidae)

Geocoris ochropterus (Fieber) (Lygaeidae)

Coranus sp. (Reduviidae)

Rhinocoris fuscipes Fabricius (Reduviidae)

Scipinia horrida Stål (Reduviidae)

Nabis capsiformis Germar (Nabidae)

Arbela nitidula Stål (Nabidae)

Orius tantilus (Motschulsky) (Anthocoridae)

Micraspis discolor (Fabricius) (Coccinellidae)

Micraspis vincta (Gorham) (Coccinellidae)

Harmonia octomaculata (Fabricius) (Coccinellidae)

Ophionea indica (Thunberg) (Carabidae)

Ophionea ishiii ishiii Habu (Carabidae)

Paederus fuscipes Curtis (Staphylinidae)

Formicomus braminus braminus La Ferté-Senectère (Anthicidae)

Hapalochrus rufofasciatus Pic (Malachiidae)

Ropalidia fasciata (Fabricius) (Vespidae)

Ropalidia marginata sundaica van der Vecht (Vespidae)

Ropalidia variegata jacobsoni (Buysson) (Vespidae)

Allorhynchium sp. (*argentata* group) (Eumenidae)

Antepipona sp. (Eumenidae)

Antepipona rufescens (Smith) (Eumenidae)

Empids

Ants

Adult predators:

Damselflies

Spiders

Birds

Bats

Stem-borers

Egg parasites of *Tryporyza* spp.:

Telenomus rowani (Gahan) (Scelionidae)

Telenomus sp. (Scelionidae)

Tetrastichus schoenobii Ferrière (Eulophidae)

Trichogramma japonicum Ashmead (Trichogrammatidae)

Trichogramma chilonis Ishii (Trichogrammatidae)

Egg parasites of *Chilo* spp.:

Telenomus dignus (Gahan) (Scelionidae)

Trichogramma japonicum Ashmead (Trichogrammatidae)

Trichogramma chilonis Ishii (Trichogrammatidae)

Trichogramma chilotraeae Nagaraja et Nagarkatti (Trichogrammatidae)

Larval or pupal parasites of *Tryporyza* spp.:

Temelucha stangli (Ashmead) (Ichneumonidae)

Temelucha philippinensis (Ashmead) (Ichneumonidae)

Amauromorpha accepta schoenobii (Viereck) (Ichneumonidae)

Ischnojoppa luteator (Fabricius) (Ichneumonidae)

Bracon chinensis Szépligeti (Braconidae)

Tropobracon schoenobii (Viereck) (Braconidae)

Nematode

Larval or pupal parasites of *Chilo* spp.:

Apanteles flavipes (Cameron) (Braconidae)

Bracon chinensis Szépligeti (Braconidae)

Tetrastichus ayyari Rohwer (Eulophidae)

Larval or pupal parasites of *Sesamia inferens:*

Apanteles flavipes (Cameron) (Braconidae)

Bracon chinensis Szépligeti (Braconidae)

Tetrastichus ayyari Rohwer (Eulophidae)

Egg predators:

Conocephalus longipennis (de Haan) (Tettigoniidae)

Conocephalus maculatus (Le Guillou) (Tettigoniidae)

Conocephalus sp. (Tettigoniidae)

Euscyrtus sp. (Encopteridae)

Anaxipha sp. (Trigoniidae)

Metioche vittaticolis Stål (Trigoniidae)

Micraspis discolor (Fabricius) (Coccinellidae)

Micraspis vincta (Gorham) (Coccinellidae)

Harmonia octomaculata (Fabricius) (Coccinellidae)

Formicomus braminus braminus La Ferté-Senectère (Anthicidae)

Ophionea indica (Thunberg) (Carabidae)

Ophionea ishii ishii Habu (Carabidae)

Paederus fuscipes Curtis (Staphylinidae)

Hapalochrus rufofasciatus Pic (Malachiidae)

Orius tantilus (Motschulsky) (Anthocoridae)

Larval predators:

Anatrichus pygmaeus Lamb (Chloropidae)

Poecilotraphera taeniata (Macquart) (Platysomatidae)

Orius tantilus (Motschulsky) (Anthocoridae)

Adult predators:

Lestes 2 spp.

Damselflies

Spiders

Ants

Birds

Bats

Plant- and Leaf-hoppers

Egg parasites:

Paracentrobia garuda Subba Rao (Trichogrammatidae) (Hosts : *Nilaparvata lugens, Nephotettix nigropictus*)

Paracentrobia yasumatsui Subba Rao (Trichogrammatidae) (Hosts : *Nilaparvata lugens, Nephotettix nigropictus)*

Oligosita brevicauda Girault (Trichogrammatidae)

Oligosita yasumatsui Viggiani et Subba Rao (Trichogrammatidae) (Hosts : *Nilaparvata lugens, Sogatella furcifera*)

Oligosita sp. (*collina* Walker group) (Trichogrammatidae)

Anagrus optabilis (Perkins) (Mymaridae) (Hosts : *Nilaparvata lugens, Sogatella furcifera, Nephotettix* spp.)

Anagrus spp. (Mymaridae)

Gonatocerus spp. (Mymaridae) (Hosts : *Nilaparvata lugens, Nephotettix nigropictus*)

Mymar taprobanicum Ward (Mymaridae) (Hosts : *Nilaparvata lugens, Sogatella furcifera*)

Polynema sp. (Mymaridae)

Tetrastichus formosanus (Timberlake) (Host : *Nilaparvata lugens*)

Nymphal or nymphal-adult parasites:

Elenchus yasumatsui Kifune et Hirashima (Elenchidae) (Hosts : *Nilaparvata lugens, Sogatella furcifera*)

Pipunculus mutillatus Loew (Pipunculidae) (Hosts : *Nephotettix nigropictus, Nephotettix virescens*)

Tomosvaryella oryzaetora Koizumi (Pipunculidae) (Hosts : *Nephotettix virescens, Nephotettix nigropictus*)

Tomosvaryella subvirescens (Loew) (Pipunculidae) (Hosts : *Nephotettix nigropictus, Nephotettix virescens*)

Haplogonatopus orientalis Rohwer (Dryinidae) (Hosts : *Nilaparvata lugens, Sogatella furcifera*)

Pseudogonatopus hospes Perkins (Dryinidae) (Hosts : *Nilaparvata lugens, Sogatella furcifera*)

Echthrodelphax fairchildii Perkins (Dryinidae) (Hosts : *Nilaparvata lugens, Sogatella furcifera*)

Nematode

Egg and first instar nymphal predator:

Cyrtorhinus lividipennis Reuter (Miridae)

Nymphal or adult predators:

Orius tantilus (Motschulsky) (Anthocoridae)

Geocoris ochropterus (Fieber) (Lygaeidae)

Nabis capsiformis Germar (Nabidae)

Arbela nitidula Stål (Nabidae)

Microvelia douglasi Scott (Veliidae)

Gerris adelaidis Dohn (Gerridae)

Neogerris parvula (Stål) (Gerridae)

Ochthera brevitibialis de Meijere (Ephydridae)

Empids ca. 2 species (Empidae)

Paederus fuscipes Curtis (Staphylinidae)

Micraspis discolor (Fabricius) (Coccinellidae)

Micraspis vincta (Gorham) (Coccinellidae)

Harmonia octomaculata (Fabricius) (Coccinellidae)

Ophionea indica (Thunberg) (Carabidae)

Ophionea ishiii ishiii Habu (Carabidae)

Hapalochrus rufofasciatus Pic (Malachiidae)

Bembicinus sp. (Sphecidae)

Psen sp. (Sphecidae)

Ants

Damselflies

Spiders

Fishes

Birds

Bats

Gall-midge

Egg parasites:

Platygaster oryzae Cameron (Platygasteridae) (Primary egg-larval parasite)

Platygaster foersteri (Gahan) (Platygasteridae) (Primary egg-larval parasite)

Larval parasites:

Obtusiclava oryzae Subba Rao (Pteromalidae) (Mainly secondary, rarely primary parasite)

Eurytoma sp. (Eurytomidae)

Pupal parasites:

Neanastatus oryzae Ferrière (Eupelmidae) (Sometimes primary, sometimes secondary parasite)

Neanastatus cinctiventris Girault (Eupelmidae) (Primary parasite, sometimes secondary parasite).

Egg predators:

Amblyseius imbricatus Corpuz et Rimando (Phytoseiidae)

Ants

Larval or pupal predators:

Ophionea indica (Thunberg) (Carabidae)

Ophionea ishiii ishiii Habu (Carabidae)

Adult predators:

Nabis capsiformis Germar (Nabidae)

Arbela nitidula Stål (Nabidae)

Ochthera brevitibialis de Meijere (Ephydridae)

Empid 2 spp. (Empidae)

Damselflies

Spiders

Fishes

The food chain relationships among the four major groups of rice pests and their natural enemies originally described in 1975 was revised as shown in Figures 1-4.

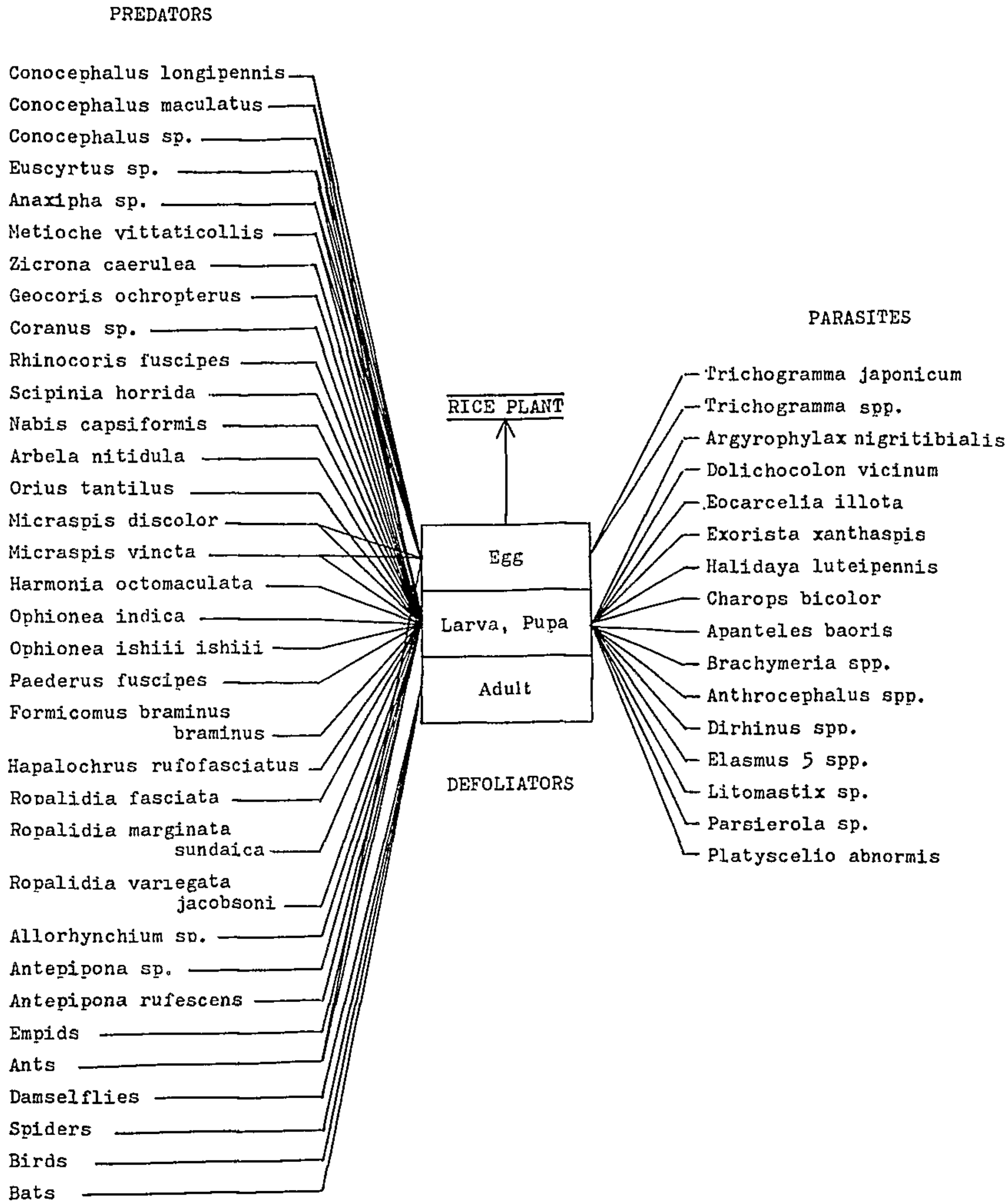

Figure 1. Food-chain relationship between the defoliators of rice and their natural enemies observed in Thailand (1972 - 1979).

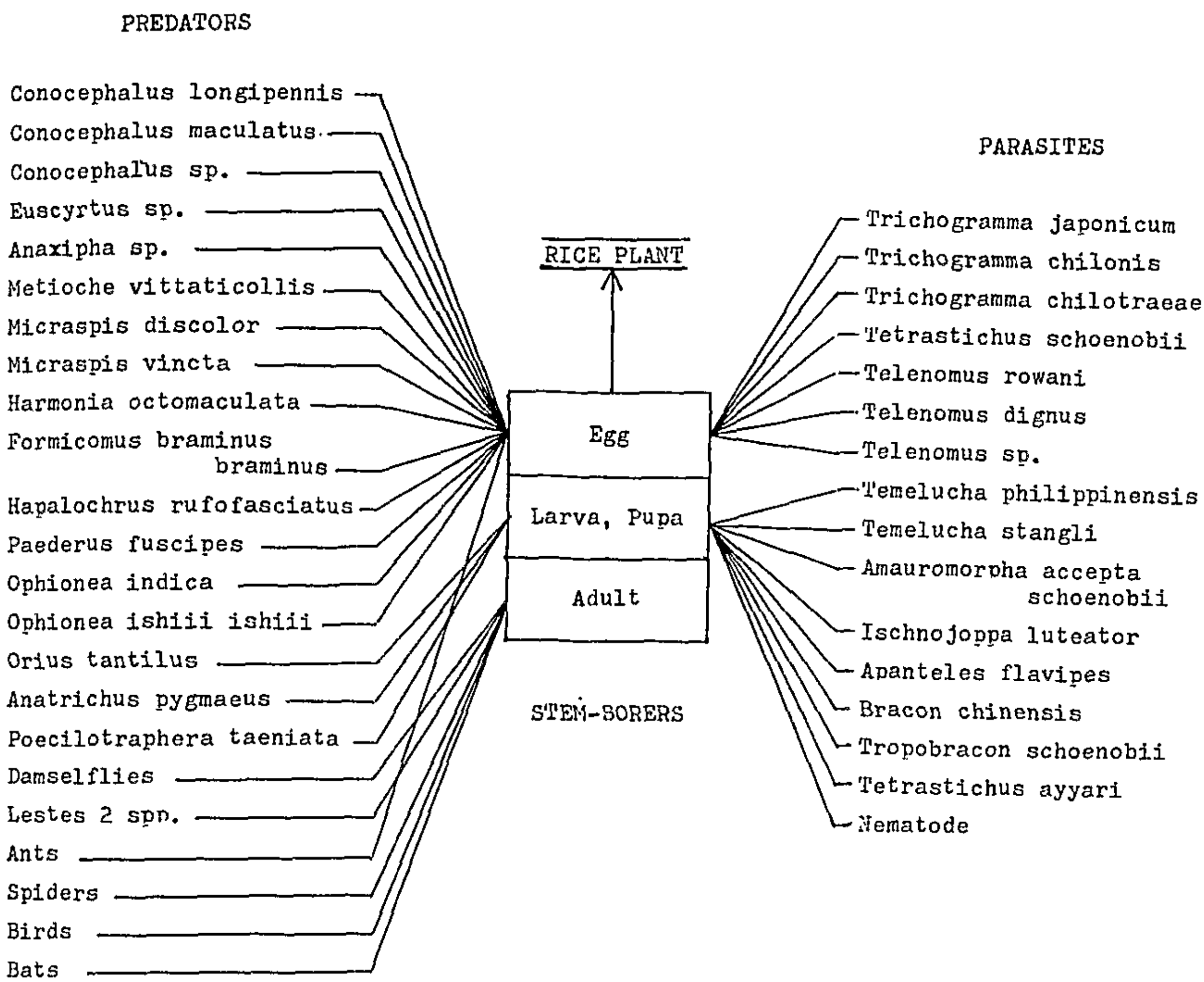

Figure 2. Food-chain relationship between the rice stem-borers and their natural enemies observed in Thailand (1972 - 1979).

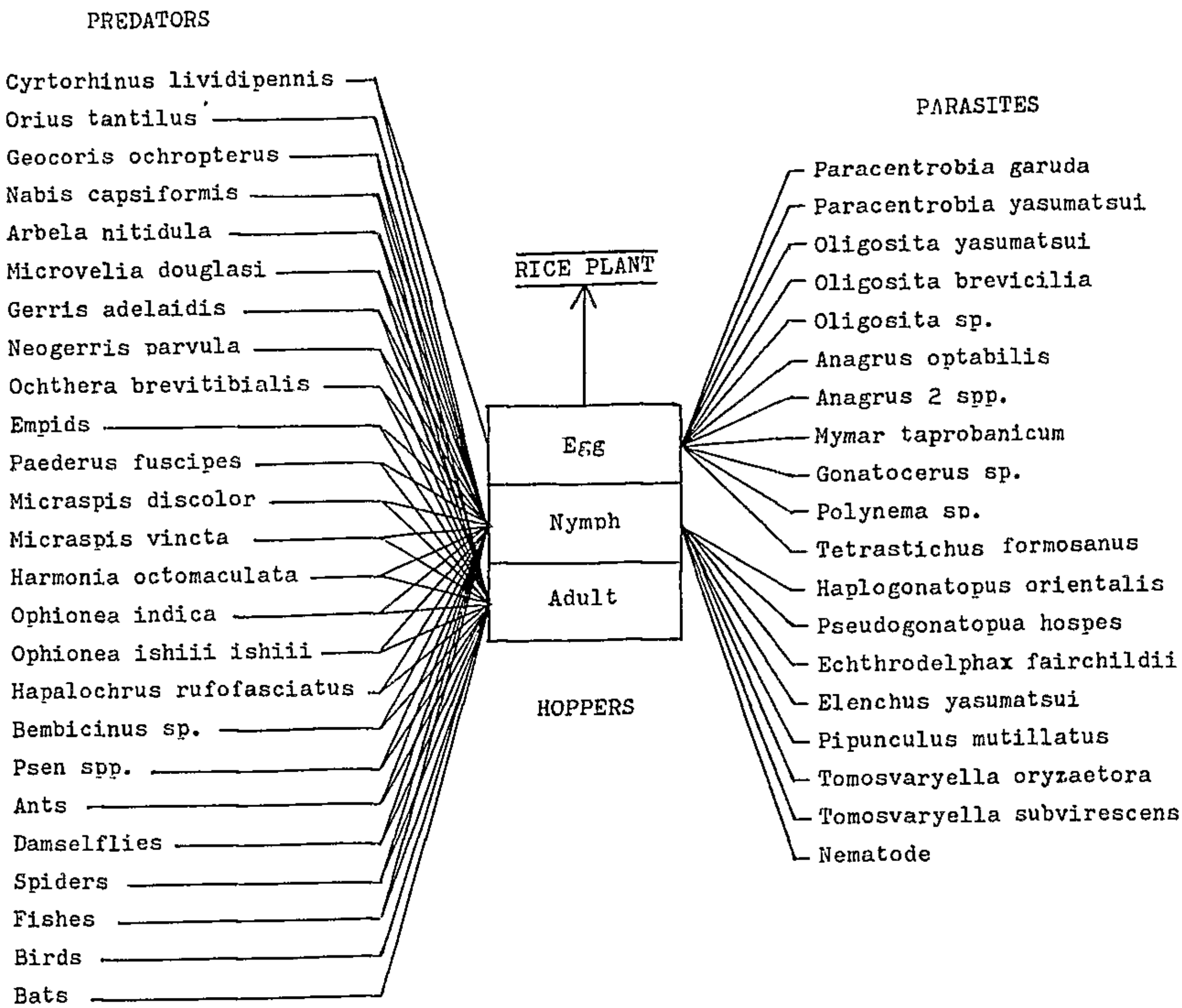

Figure 3. Food-chain relationship between the plant- and leaf-hoppers of rice and their natural enemies observed in Thailand (1972 - 1979).

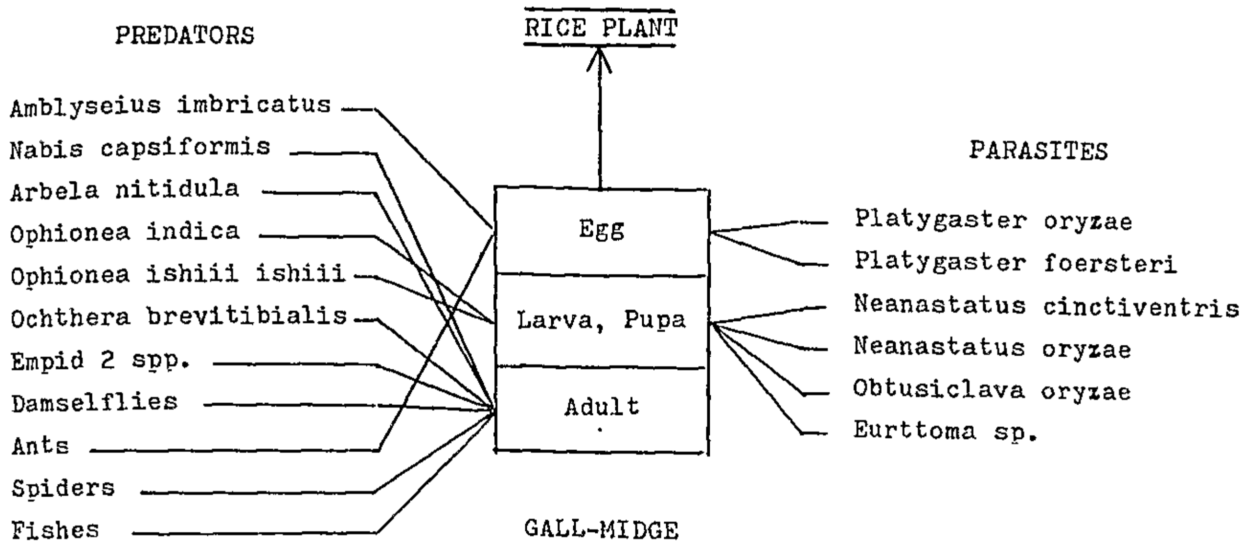

Figure 4. Food-chain relationship between the rice gall-midge and its natural enemies observed in Thailand (1972 - 1979).

Based upon the natural enemies of rice insect pests given above, the relationship between the insect natural enemies and their four groups of host pests are tabulated in the following tables.

Table 2. Families of some insect parasites of rice pests.

Parasites	Rice Defoliators	Rice Stem-borers	Rice Plant- or Leaf-hoppers	Rice Gall-midge
Strepsiptera				
Elenchidae	–	–	+	–
Halictophagidae	–	–	+	–
Hymenoptera				
Ichneumonidae	+	+	–	–
Braconidae	+	+	–	–
Platygasteridae	–	–	–	–
Scelionidae	+	+	–	–
Chalcididae	+	–	–	–
Eurytomidae	–	–	–	–
Eupelmidae	–	–	–	–
Pteromalidae	+	–	–	+
Elasmidae	+	–	–	+
Eulophidae	–	+	+	+
Encyrtidae	+	–	–	–
Trichogrammatidae	+	+	+	–
Mymaridae	–	–	+	+
Dryinidae	–	–	+	–
Bethylidae	+	–	–	–
Diptera				
Pipunculidae	–	–	+	–
Tachinidae	+	+	–	–

Table 3. Families of some insect predators of rice pests.

Predators	Rice Defoliators	Rice Stem-borers	Rice Plant- or Leaf-hoppers	Rice Gall-midge
Odonata				
Agrionidae	+	+	+	+
Lestidae	+	+	+	+
Libelluridae	+	+	+	–
Orthoptera				
Tettigoniidae	+	+	+	–
Encopteridae	+	+	–	–
Trigoniidae	+	+	–	–
Hemiptera				
Pentatomidae	+	–	–	–
Lygaeidae	+	–	+	–
Hebridae	–	–	+	–
Hydrometridae	–	–	+	–
Veliidae	–	–	+	–
Gerridae	–	–	+	–
Reduviidae	+	–	–	–
Nabiidae	+	–	+	+
Anthocoridae	+	+	+	–
Miridae	–	–	+	–
Saldidae	–	–	+	–
Coleoptera				
Carabidae	+	+	+	+
Staphylinidae	+	+	+	+
Malachiidae	+	+	+	–
Coccinellidae	+	+	+	–
Anthicidae	+	+	–	–
Hymenoptera				
Dryinidae	–	–	+	–
Formicidae	+	+	+	–
Sphecidae	–	–	+	–
Vespidae	+	–	–	–
Diptera				
Asilidae	–	–	+	–
Empididae	–	–	+	+
Platystomatidae	–	+	–	–
Ephydridae	–	–	–	–
Chloropidae	–	+	–	–

OBSERVATIONS ON THE ABUNDANCE AND ACTIVITIES OF NATURAL ENEMIES OF MAJOR RICE PESTS

During our field research trips we could collect a number of specimens of natural enemies of rice pests. The following table indicates well the relative abundance of several important species of natural enemies in Thailand.

Table 4. Number of collected specimens of natural enemies of rice pests.

Natural Enemy	Parasite or Predator	Number Collected
Amblyseius imbricatus	Predator	15970
Spiders	Predator	11605
Oligosita spp.	Parasite	11015
Anagrus spp.	Parasite	4143
Trichogramma spp.	Parasite	2027
Damselflies	Predator	1894
Telenomus spp.	Parasite	1434
Coccinellids	Predator	1432
Platygaster spp.	Parasite	1184
Conocephalus spp.	Predator	1042
Anatrichus pygmaeus	Predator	1041
Gonatocerus spp.	Parasite	938
Orius tantilus	Predator	672
Paracentrobia spp.	Parasite	598
Elenchus yasumatsui	Parasite	562
Tetrastichus formosanus	Parasite	497

Table 4. (Continued)

Natural Enemy	Parasite or Predator	Number Collected
Dryinids	Parasite	402
Tetrastichus schoenobii	Parasite	394
Sepedon spp.	Parasite	375
Cyrtorhinus lividipennis	Predator	364
Tachinids	Parasite	322
Pipunculids	Parasite	170
Poecilotraphera taeniata	Predator	167
Neanastatus spp.	Parasite	140
Ophionea spp.	Predator	131
Gryon nixoni	Parasite	125
Eurytoma sp.	Parasite	93
Mymar taprobanicum	Parasite	64

Of course, the figures showing the number of relative abundance of natural enemies may vary from year to year, from locality to locality, or from season to season. And we must bear in mind that the high number does not always mean the effectiveness of the species. In the table, spiders are as many as *Oligosita* species. But, the effectiveness of *Oligosita* species, egg parasites of plant- and leaf-hoppers, is far more superior to that of the spiders. The collected number of *Tetrastichus schoenobii* was strikingly less than that of *Trichogramma* species. But, the former species can consume the entire egg masses of stem-borers, while the latter species cannot parasitize the egg masses at 100% level.

Therefore, *Tetrastichus schoenobii* is far more important as a biological control agent. So, we must be careful in the interpretation and utilization of this table.

In the study of natural enemies of rice pests, it is extremely important to have the knowledge on the seasonal occurrence of each natural enemy. The result of our analysis of data obtained on the occurrence of some important parasites and predators of rice insect pests is given in Tables 5 and 6.

Table 5. Seasonal occurrence of some important parasites of rice pests as observed from 1972 to 1979 in Thailand.

Parasites \ Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Trichogramma spp.	+	+	+	+	+	+	+	+	+	+	+	-
Paracentrobia spp.	+	+	+	+	+	+	+	+	+	+	+	-
Oligosita spp.	+	+	+	+	+	+	+	+	+	+	+	-
Anagrus spp.	+	+	+	+	+	+	+	+	+	+	+	-
Gonatocerus spp.	+	+	+	+	+	+	+	+	+	+	+	-
Mymar taprobanicum	+	+	+	+	+	-	-	+	+	+	+	-
Telenomus spp.	+	+	+	+	+	+	+	+	+	+	+	-
Tetrastichus schoenobii	+	+	+	+	+	+	+	+	+	+	+	-
Tetrastichus formosanus	+	+	+	+	+	+	+	+	+	+	+	-
Platygaster spp.	-	+	+	+	+	+	+	+	+	+	+	-
Neanastatus spp.	+	+	+	+	+	+	+	+	+	+	+	-
Obtusiclava oryzae	-	+	+	+	+	+	+	+	+	+	-	-
Predaceous Ceratopogonids	-	+	+	+	+	+	-	+	+	+	+	-
Elasmus spp.	+	+	+	+	+	+	+	+	+	+	+	+
Apanteles spp.	+	+	+	-	+	+	+	+	+	+	+	+
Tropobracon schoenobii	+	+	+	+	-	+	-	+	+	-	+	+
Elenchus yasumatsui	-	+	+	+	+	-	-	+	+	+	+	-
Pipunculids	+	+	+	-	+	+	-	+	+	+	+	+

Table 6. Seasonal occurrence of some important predators of rice pests as observed from 1972 to 1979 in Thailand.

Months / Predators	I	II	III	IV	V	VII	VIII	IX	X	XI	XII
Amblyseius imbricatus	+	+	+	+	+	+	+	+	+	+	-
Conocephalus spp.	+	+	+	+	+	+	+	+	+	+	+
Damselflies	+	+	+	+	+	+	+	+	+	+	+
Spiders	+	+	+	+	+	+	+	+	+	+	+
Geocoris ochropterus	-	+	+	-	+	+	-	+	+	+	-
Nabis spp.	-	+	+	-	+	-	-	+	-	+	+
Orius tantilus	+	+	+	+	+	+	+	+	+	+	+
Cyrtorhinus lividipennis	-	-	-	+	+	+	+	+	+	+	+
Micraspis spp.	+	+	+	+	+	+	+	+	+	+	+
Harmonia octomaculata	+	+	+	+	+	+	+	+	+	+	+
Ophionea spp.	+	+	+	+	+	+	+	+	+	+	+
Paederus fuscipes	-	-	-	+	+	-	-	-	-	-	-
Formicomus braminus braminus	+	+	+	+	+	+	+	+	+	+	+
Ropalidia spp.	+	+	-	-	+	+	+	+	+	+	+
Anatrichus pygmaeus	+	+	+	+	+	+	+	+	+	+	+
Poecilotraphera taeniata	-	+	+	+	+	+	+	+	+	+	+

These tables indicate the fact that many of the important parasites and predators occur throughout the year round if the environment is suitable for their survival. The growing season of the first crop of rice usually starts in June and ends in October through November during the wet season followed by a long fallow period during the dry season. Farmers of Thailand have been producing rice without using any insecticides in many of the rain-fed rice paddies since the beginning of rice cultivation. This is the main reason why the populations of natural enemies are very high, usually suppressing the rice insect pests under economic injury level. After harvest many of the natural enemies may be forced to emmigrate from the rice paddies to the other favorable areas where they can survive during the fallow period. In Thailand, the favorable areas are scattered in the rice paddies. There are areas of ever-green vegetation with adequate moisture where wild rice or other leguminaceous weeds grow even in the dry season. There are corn or sugarcane fields nearby the rice paddies in the dry season. It is convenient for the natural enemies that there are several common insect pests between rice and corn or sugarcane. So, such areas may become refuge areas of natural enemies of rice insect pests,and may serve greatly to their conservation. Recently, with the development of irrigation system the area of rice paddies for the second crop of rice has been increasing. Our survey in such areas revealed that the population of natural enemies is as high as that of the first crop of rice area.

It is important to observe how many individuals of a given species of natural enemies can occupy one hill of rice plant. The following table shows the highest cases of some species of natural enemies.

Table 7. Estimated number of natural enemies found per hill in the rice paddy.

Natural enemy	Natural enemy/ hill	Natural enemy	Natural enemy/ hill
Amblyseius imbricatus	5.7	Spiders	1.1
Ophionea spp.	0.07	*Oligosita* spp.	5.0
Eurytoma sp.	0.03	*Anagrus* spp.	2.0
Platygaster spp.	0.4	*Paracentrobia* spp.	0.2
Neanastatus spp.	0.05	*Gonatocerus* spp.	0.9
Anatrichus pygmaeus	0.7	*Tetrastichus formosanus*	0.1
Poecilotraphera taeniata	0.1	*Trichogramma* spp.	0.4
Coccinellids	0.8	*Telenomus* spp.	0.3
Cyrtorhinus lividipennis	0.1	*Tetrastichus schoenobii*	0.1
Conocephalus spp.	0.7	Dryinids	0.4
		Elenchus yasumatsui	0.1

One of the commonest phenomena between the rice insect pests and their natural enemies is the co-existence of several species of parasites within an egg-mass or a nymph or adult of rice insect pests. In another word, more than two species of parasites are attacking one egg-mass of host insects or an individual host insect. We investigated the cases in the egg-masses of *Tryporyza incertulas*, *Nilaparvata lugens* and *Sogatella furcifera*. The results are shown in Tables 8 and 9.

Table 8. Example of 183 rice paddies where eggs of *Tryporyza incertulas* were parasitized by its parasites in various districts of Thailand (1972-1979).

Parasites	No. of cases	% of cases
Case of a single genus		
Trichogramma sp.	12	6.55
Telenomus sp.	12	6.55
Tetrastichus schoenobii	19	10.38
Case of co-existence of different genera		
Telenomus sp. and *Tetrastichus schoenobii*	35	19.12
Trichogramma sp. and *Tetrastichus schoenobii*	25	13.66
Trichogramma sp., *Telenomus* sp. and *Tetrastichus schoenobii*	64	34.97
Trichogramma sp. and *Telenomus* sp.	16	8.74

Table 9. Example of 177 rice paddies where eggs of *Nilaparvata lugens* and *Sogatella furcifera* were parasitized by their parasites in various districts of Thailand (1973-1979).

Parasites	No. of cases	% of cases
Case of a single genus		
Oligosita sp. (Dominant species: *yasumatsui*)	2	1.12
Anagrus sp. (Dominant species: *optabilis*)	2	1.12
Gonatocerus sp.	3	1.69
Mymarid sp. (Dominant species: *taprobanicum*)	1	0.56
Tetrastichus formosanus	4	2.25
Case of co-existence of different genera		
P, O, A, G, M, T	1	0.56
P, O, A, G, M	1	0.56
P, O, A, G, T	32	18.07
P, O, A, G	29	16.38
P, O, A, M	1	0.56
P, O, A, T	8	4.51
P, O, G, T	8	4.51
P, O, A	8	4.51
P, O, G	2	1.12
P, O, T	4	2.25
P, O	3	1.69
P, A, G, M, T	2	1.12
P, A, G, T	2	1.12
P, A, G	1	0.56
P, G, T	1	0.56
P, A	1	0.56
P, G	1	0.56
O, A, G, M	3	1.69

Table 9. (Continued)

Parasites	No. of cases	% of cases
O, A, M, T	1	0.56
O, A, G, T	9	5.08
O, A, G	10	5.64
O, A, M	1	0.56
O, A, T	8	4.51
O, A	10	5.64
O, G, M	1	0.56
O, G, T	1	0.56
O, M, T	1	0.56
O, G	4	2.25
O, M	1	0.56
O, T	4	2.25
A, G, T	1	0.56
A, G	1	0.56
G, T	3	1.69

As seen from Tables 8 — 9, egg-masses of three species of rice insect pests were usually attacked by more than one species of egg-parasites at the same time in the same rice paddies. On the contrary the emergence of one species of egg-parasite from one egg-mass is very rare. Each species of egg-parasites may have its specific life-cycle, behavior and adaptability against its environmental conditions. Although interspecific competition between the species of egg-parasites seems to occur, more advantage would be expected in the percentage of egg-parasitism if the fauna of egg-parasites is richer and the more egg-parasites complex is found in the rice paddies. In addition to the egg-parasite complex, there are many predaceous natural enemy complex against the eggs of rice insect pests.

The first and rather extensive survey on the spider fauna of the rice paddies of Thailand was initiated by the joint team of both Japanese and Thai entomologists in 1939, and since then, effort to collect material has been continued up to 1979. Following is a list of determined spiders collected by us during the period.

Uloboridae

Uloborus sp.

Theridiidae

Rhomphaea sp.

Ariamnes sp.

Conopistha argentatus (O.P. Cambridge)

Conopistha fissifrons (Cambridge)

Conopistha miniaces (Doleschall)

Conopistha sp.

Coleosoma blandus O.P. Cambridge

Theridion sp. 1

Theridion sp. 2

Theridion sp. 3

Theridion sp. 4

Theridion sp. 5

Linyphiidae

Linyphia sp.

Micryphantidae

Callitrichia sp.

Erigonidium sp.

Erigone sp.

Agriopidae

Araneus inustus (L. Koch)

Araneus mitificus (Simon)

Araneus sp.

Neoscona nautica (L. Koch)

Neoscona theisi (Walckenaer)

Singa sp.

Larinia sp.

Agriope catenulata (Doleschall)

Agriope sp. 1

Agriope sp. 2

Cyrtophora citricola (Forskal)

Nephila malabarensis (Walckenaer)

Cyclosa insulana (Costa)

Cyclosa mulmeinensis (Thorell)

Cyclosa sp.

Tetragnathidae

Leucauge decorata (Blackwall)

Leucauge sp.

Tylorida striata (Thorell)

Tetragnatha japonica Boesenberg et Strand

Tetragnatha javana (Thorell)

Tetragnatha mackenziei Gravely

Tetragnatha mandibulata Walchenaer

Tetragnatha nitens (Audouin)

Tetragnatha sp. 1

Tetragnatha sp. 2

Tetragnatha sp. 3

Tetragnatha sp. 4

Dyschirognatha sp.

Pisauridae

Dolomedes sp. 1

Dolomedes sp. 2

Hygropoda sp.

Lycosidae

Hippasa agelenoides (Simon)

Lycosa pseudoannulata (Boesenberg et Strand)

Pardosa sp.

Oxyopidae

Oxyopes javanus Thorell

Oxyopes lineatipes (L. Koch)

Oxyopes spp.

Thomisidae

Thomisus sp.

Roncinia sp.

Philodromus sp.

Pistius sp.

Clubionidae

Chiracanthium sp.

Clubiona japonicola Boesenberg et Strand

Clubiona sp.

Analysis of the collected data indicates that the spiders of the genus *Tetragnatha* were most dominant accounting for over 50% of the total spider population in the rice paddies. Among the other genera, the species of *Oxyopes* were more abundant comprising about 20% of the spider population, followed by the species of the genera *Clubiona*, *Theridion*, *Aranaeus*, *Tylorida*, etc. As to the percentage composition of the adult specimens of more important species, *Tetragnatha mandibulata* (Walckenaer) and *Oxyopes javanus* Thorell were the dominant species, followed by *Tetragnatha javana* (Thorell), *Tetragnatha* sp., *Clubiona japonicola* Boesenberg et Strand, etc. (Okuma, 1968; Okuma and Wongsiri, 1973). In one unit paddy, the following tendency of the distribution of spiders was observed: - in the central area, *Callitrichia* sp., *Larinia* sp., *Tetragnatha* sp. and *Tetragnatha javana javana* were abundant, and in the areas near levees *Tetragnatha mandibulata* and *Oxyopes lineatipes* were more numerous. Comparison of the spider fauna between the rice paddies with and without water was also made. In the rice paddies keeping water, *Agriope catenulata* (Doleschall), *Tetragnatha javana*, *Tetragnatha mandibulata*, *Tetragnatha* spp., and *Clubiona japonicola* were dominant species, while *Tetragnatha* sp., *Dyschiriognatha* sp., *Lycosa pseudoannulata* (Boesenberg et Strand), and *Runcinia* sp. were more numerous in the rice paddies only keeping residual moisture.

The number of species of spiders found in the rice paddies exceeds 70. According to our survey the distribution of spiders in a given rice paddy is not homogenous, and their movement from one place to another seems very sluggish. The spider population usually attain its highest peak at harvest time, but the spiders remain in the same habitat even after the harvest time. This behavior was noted clearly in the surveys of rice paddies at the Phatthalung Rice Experiment Station. In the paddy with plants just before flowering stage, 80 spiders were collected, while in the paddy with rice plants a few weeks old 47 spiders were found. On the other hand, in the non-irrigated paddy with the after-harvest ratoon plants the number of spiders collected was 85.

As the result of our studies the dragonfly fauna of rice paddies of Thailand is also very well known; a total of 33 species have been recorded. Among the Odonata only numbers of the family Agrionidae and several species of Lestidae and libellulidae are of great importance. The first study on the role played by Agrionidae (Damselflies) as natural enemies was carried out by us in 1973 when the exact status of this group of insects in the rice ecosystem was established. The study was carried out both qualitatively and quantitatively at the San Pa Tong and Khlong Luang Rice Experiment Stations. In addition we have made many field observations on these insects throughout Thailand. The following species of damselflies are known in the rice paddies of Thailand.

Aciagrion occidentale Laidlow

Aciagrion sp. A

Aciagrion sp. B

Agriocnemis d'abreui Fraser

Agriocnemis clauseni Fraser

Agriocnemis femina femina (Brauer)

Agriocnemis nana Laidlow

Agriocnemis pygmaea (Rambur)

Ceriagrion cerinorubellum Brauer

Ceriagrion latericium latericium Lieftinck

Ceriagrion coromandelianum (Fabricius)

Ceriagrion olivaceum olivaceum Laidlow

Ceriagrion praetermissum Lieftinck

Enallagna parvum Selys

Ischnura aurora (Brauer)

Ischnura senegalensis (Rambur)

Orychargia atrocyana (Selys)

Pseudagrion microcephalum (Rambur)

Pseudagrion pruinosum Burmeister

In the family Lestidae, *Lestes concinnus* Hagen et Selys, *Lestes elatus* Selys and *Platylestes platystyla* (Rambur) have been observed in rice paddies and in the Libellulidae, *Diplacodes trivialis, Neurothemis tullia* and *Palpopleura sexmaculata* are important predators.

Among the family Agrionidae (damselflies) the following species are mostly abundant and important: *Agriocnemis femina femina, Agriocnemis pygmaea, Ischnura senegalensis* and *Ischnura aurora.* The relative abundance of these species are shown in the following table.

One of the advantages that members of Agrionidae has over other species is that they do not engage in territorial behavior. In this reason the population may increase to a higher level in a given area than otherwise. Many of these damselflies, which breed in rice paddy, attack not only the flying rice pests but also those resting on the leaves of rice plant. Even the adult defoliators and stem-borers are prey of damselflies. The population of damselflies increased with the growth of the rice plant and reached the peak at about the flowering stage. An estimated number of adult damselflies per acre at the San Pa Tong Rice Experiment Station was 3227 on September 25, 1973. The distribution of damselflies in the rice paddy is rather homogenous. On the contrary, the distribution of members of other families of Odonata with territorial behavior is not homogenous. Therefore, the population of one species in a given area is too sparse to exert any control on the population of rice pests. In addition, they have been observed often preying upon damselflies which may affect their abundance. Although damselflies may cannibalistic on newly emerged weak individuals, this phenomenon does not seem to influence the population of damselflies because of the very high population. *Neurothemis tullia,* usually found among the hills of rice plants near the surface of the water, attacks rice pests. On September 19, 1978, we encountered a large numbers of a Libellulid, *Palpopleura sexmaculata,* on rice plants about to attack its prey on the top of the ears of the plant. In such a case when the Libellulid is abundant it may be of great importance.

Table 10. Number of four dominant damselflies collected in the rice paddies.

Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Total
Ischnura senegalensis												
female		16	50	6	14	2	0	20	133	56	23	583
male		6	48	5	11	4	1	22	104	46	16	
Ischnura aurora												
female		15	106	0	29	2	0	0	27	3	1	649
male		11	372	0	31	2	0	0	44	0	6	
Agriocnemis pygmaea												
female		11	60	0	41	17	1	2	1	4	3	244
male		13	27	0	37	19	0	0	3	3	2	
Agriocnemis pygmaea												
female	7	6	16	22	36	14	13	9	24	35	7	418
male	6	13	9	84	10	16	19	3	30	25	14	
	13	91	688	117	209	76	34	56	366	172	72	1,894

In the families of Orthoptera, the preying behavior of the members of Tettigoniidae, Encopteridae and Trigoniidae is considerable. Especially important are members of the genus *Conocephalus*, family Tettigoniidae, in many parts of the world. These Tettigoniids being carnivorous are among the most effective predators of eggs either laid singly or in masses by Lepidopterous rice pests. In our experimental plots at the San Pa Tong Rice Experiment Station the number of *Conocephalus* spp. was so abundant that it was difficult to find egg-mass of rice stem-borers. On the contrary, in the experimental plots located at the Khlong Luang Rice Experiment Station the number of *Conocephalus* spp. was rather scarce. Here we were able to find easily numbers of egg-masses of rice stem-borers, but in these plots the population of egg-parasites was high. These observations show that the control by predators was supplemented by the activity of egg-parasites. The importance of *Conocephalus* spp. as predator was recorded by Swezey as early as 1936 in Hawaii. *Conocephalus saltator*, known to be an immigrant insect in Hawaii as early as 1895, became especially abundant in leaf-hopper infested sugarcane fields. He wrote: "As there was no evidence of their being injurious to the cane, particular study of their habits revealed that they were feeding extremely on leafhoppers. They had the habit of lurking about the axils of the upper leaves, or the crown of the cane stalk just where the leaf-hoppers congregated in large numbers in the young cane, especially the young leafhoppers. In cage experiments grasshoppers would scarcely eat any of the cane leaves, but would readily devour leafhoppers when they were introduced. Freshly hatched grasshoppers starved to death in 5 to 6 days in the presence of tender grass and cane leaves, while those provided with leafhoppers were reared to maturity." Sometimes this grasshopper has caused considerable injury to rice by feeding on the heads during the milk stage.

Excellent studies were made by Rothschild in Sarawak on the feeding of *Conocephalus* on the egg-masses of stem borers. He showed excellent control of the egg-masses of *Tryporyza incertulas* and *Chilo suppressalis* by *Conocephalus* spp. He wrote in 1971 as follows: - It has earlier been noted that numbers of *Tryporyza* and *Chilo* egg masses found in the field were always at least 80% lower than expected, and this was thought to be due to predators. To determine which predators were responsible and predation rates, numbers of pyralid egg masses were attached to rice plants in the field in 1966 and 1967. These tests showed that the principal predators were the middle and late instar nymphs, and adults, of *Conocephalus* species, particularly *C. longipennis* (Haan)(Tettigoniidae), and also nymphs and adults of *Anaxipha* species (Gryllidae). Estimates of egg predation in several seasons were 83.5 and 54.6 in the case of *Tryporyza incertulas* in 1966 and 1967, respectively, and 89.7 and 75.0 in the case of *Chilo suppressalis* in 1966 and 1967, respectively. Eggs were placed out only once during the rice season in 1966, but over an extended period in 1967. Predation of *Tryporyza* eggs averaged about 55% in the latter season, but exceeded 87% when the borer was most abundant. A similar high rate of predation was noted in 1966. The rate of predation was generally rapid, and much of the removal of *Tryporyza* and *Chilo* eggs occurred within 12 h of placement into the filed. The eggs of *Chilo* were more rapidly attacked, possibly because they are exposed and not covered with felt as in *Tryporyza*. Pyralid borer females generally oviposit in the evening, and feeding tests in the field and laboratory showed that both *Conocephalus* and *Anaxipha* destroyed eggs at this time. Egg mass density did not appear to affect the rate of predation, and similar estimates as given above were obtained when numbers were equivalent to sixty masses/200 hills or only six masses/200 hills.

According to our observations the population of *Conocephalus* tends to decrease with the growth of rice plants. This may be attributed to the cannibalism and lack of food. For example, the number of *Conocephalus* observed in one experimental plot was 212 on October 6; 44, on October 15; 16, on October 26; and 16, on November 5, 1973. It was usually observed that the population of *Conocephalus* became very scarce just before harvest. We have not yet seen the damage of rice leaves or grains caused by *Conocephalus* in Thailand. It was reported that the species of *Conocephalus* cause damage to rice grains, particularly at the milky stage (Rothschild, 1971; Lim, 1974). But, as mentioned above, the population of *Conocephalus* is very low at the milky stage of rice plants. If the injury caused by *Conocephalus* is somewhat heavy, it is very easy to catch them by the sweep net method. We feel that the merit of these Tettigoniids as predators of the eggs of rice stem-borers and other rice pests is greater than the occasional small damage they cause.

The population of *Formicomes braminus braminus* La Ferté-Senectère (Anthicidae) and *Hapalochrus rufofasciatus* Pic (Malachiidae) in the rice paddies is usually not high. But, their predatory behavior is not negligible to mention. We can recognize the fact that they are very effective predators of the egg-masses of stem-borers and other rice pests. According to Lim(1974), *Hapalochrus rufofasciatus* was observed to be a very aggressive predator of the first instar larva of *Tryporyza incertulas* in Malaysia. In Thailand , we very often observed the aggressive predation of *Formicomes braminus braminus* and *Hapalochrus rufofasciatus* on the egg-masses of rice stem-borers. The following table indicates the number of these beetles collected by us in the rice paddies of Thailand.

Table 11. Number of *Formicomes braminus braminus* and *Hapalochrus rufofasciatus* collected by sweep net method in various rice paddies of Thailand.

Place and date of research	*Formicomes braminus braminus*	*Hapalochrus rufo-fasciatus*
Amphoe Mae Sariang, Mae Hong Son, 5.V. 1979	1	
Ban Thung Thei, Chiang Mai, 28. XI. 1972	10	
Ban Bo Hin, Amphoe Doi Saket, Chiang Mai, 29. XI. 1972	4	
Ban Mae Yoi, Amphoe San Sai, Chiang Mai, 24. VI. 1979	1	
Ban Thau Sieo, Amphoe San Pa Tong, Chiang Mai, 19. II. 1979	1	1
27. III. 1979		1
27. III. 1979		1
San Pa Tong Rice Exp. Sta., Chiang Mai, 19. II. 1979		3
Ban Yu Wha, Amphoe San Pa Tong, Chiang Mai, 7. V. 1978		1

Table 11. (Continued)

Place and date of research	*Formicomes braminus braminus*	*Hapalochrus rufo-fasciatus*
Ban Wang Nam Yard, Amphoe Chom Thong,		
Chiang Mai, 7. V. 1978		4
7. V. 1978		2
Ban Huai Nam Dib, Amphoe Chom Thong,		
Chiang Mai, 7. V. 1978		1
Amphoe Hang Dong, Chiang Mai,		
27. III. 1978		1
27. III. 1978	2	
Doi Pa-Morn, Doi Inthanon, Amphoe Hang		
Dong, Chiang Mai, 5. IX. 1978		1
Ban Thung Ka La, Amphoe Chiang Dao,		
Chiang Mai, 6. IX. 1978	2	
Ban Mae Kachiang, Amphoe Wiang Pa Pao, Chiang Rai,		
24. VI. 1979		2
Ban Pa Bong, Amphoe Muang, Chiang Rai,		
22. V. 1979		1
Ban Teen Doi, Amphoe Muang, Chiang Rai,		
27. III. 1979	1	
Ban Khao Tom, Amphoe Muang, Chiang Rai,		
22. V. 1979		2
Ban Kua Tae, Amphoe Muang, Chiang Rai,		
28. III. 1979	1	
Ban Non Sa ard, Amphoe Muang, Maha Sarakham,		
28. X. 1976	1	
Ban Puey, Amphoe Yang Talat, Kalasin,		
27. X. 1976	3	
Ban Yan Kee Nok, Amphoe Khuang Nai, Ubol		
Ratchathani, 28. X. 1976		1

Table 11. (Continued)

Place and date of research	*Formicomes braminus braminus*	*Hapalochrus rufo-fasciatus*
Ban Thang Sai, Ubol Ratchathani, 19. XI. 1979	19	
Amphoe Muang, Ubol Ratchathani, 20. XI. 1977	7	
Ban Don Chi, Amphoe Phibum Mangsahan, Ubol Ratchathani, 20. XI. 1977	1	
20. XI. 1977	8	
20. XI. 1977		1
20. XI. 1977		3
20. XI. 1977		4
Amphoe Khlong Khlong, Kamphaeng Phet, 3. V. 1978	8	
Ban Chondura, Lop Buri, 12. XII. 1972	2	
Ban Wang Khla Thum, Lop Buri, 12. XII. 1972	3	
Amphoe Ongkharak, Nakhon Nayok, 17. III. 1978	1	
Ban Lane, Nakhom Pathom , 9. III. 1978	4	
9. III. 1978	1	
9. III. 1978	20	
Amphoe Hua Hin, Prachuap Khiri Khan, 1. IV. 1978	1	
Nakhon Si Thammarat Rice Exp. Sta., 27. IV. 1978	2	
27. IV. 1978	1	
27. IV. 1978	1	
Phatthalung Rice Exp. Sta., 16. I. 1973	2	
29. IV. 1978	10	
29. IV. 1978	2	
Amphoe Khok Pho, Pattani, 18. I. 1973	1	
Amphoe Muang, Satun, 17. I. 1973	2	1
Kuan Kalong, Satun, 17. I. 1973		3

There are several records on the effectiveness of a predaceous Mirid, *Cyrtorhinus lividipennis.* According to the observations made in the IRRI (1973), this predator is an effective predator of *Nephotettix virescens* and *Nilaparvata lugens.* The searching capacity of the predator is not adequate to maintain a high percentage kill when the *N. lugens* density is comparatively low. In the experiment with *N. virescens,* about 50 leafhopper nymphs were killed per predator per day for at least 4 days. Such a feeding rate, if maintained in the field, would be most beneficial in controlling the pests. This predator killed more *N. virescens* than *N. lugens* per unit time. This may partly explain why *N. virescens* is sometimes much more scarce than *N. lugens* in the field.

In Malaysia, Lim(1974) wrote that experience in Malaysia has witnessed large numbers of *C. lividipennis* in the field and loss of hopper cultures on many occasions through contamination by this predator. Such findings and observation clearly indicate the significance and potential of this predator. In 1978, Ooi, Lim and Koh expressed their opinion that *C. lividipennis* is particularly important in the rice paddies of Malaysia in suppressing the population of the Brown Plant-hopper, and where high *Cyrtorhinus* population occurred, greater BPH numbers of up to 41/hill could be tolerated, depending on the predator/prey ratio.

In the Solomon Islands, Stapleys records (1975, 1976) are of interest. "*Cyrtorhinus lividipennis* will invade plots if not sprayed, and is capable of halting an infestation of BPH completely. Whether or not *C.* invades the rice paddies depends on the nearness of abundant grass, especially *Digitaria.*" "To achieve pest control and a balance of pest to predator, the ratio of Brown Planthopper to *Cyrtorhinus lividipennis* and *C. chinensis* should be 20 : 1 in the Solomon Islands." "It is important to maintain

As seen in the table showing the number of collected specimens of natural enemies of rice pests, the presence of *Cyrtorhinus lividipennis* in the rice paddies is not negligible. An estimated number of this predator per hill was 0.1, and this number was enough to control the leaf- and plant-hoppers under economic injury level during the studied periods. According to our observation, higher population of this predator was found in May(at the later period of the second crop of rice period) and September through November(in the later half of the first crop of rice period). *Nilaparvata lugens* is sometimes found on the leaves of *Digitaria* spp. and *Eleusone* spp. which were recorded as favored grasses of this predator by Stapley. Further observation is needed to ascertain such relationships between the Brown Plant-hopper, its host weeds, and the behavior of its predator.

The predaceous behavior and controlling effect of a Veliid, *Microvelia douglasi*, was first discovered by a Japanese entomologist, Oho, in Saga Prefecture many years ago. This predator feeds on the adults and young plant- and leaf-hoppers or other insects that fell on the surface of paddy water. Its effect seems to be very high in some cases. But, we must remember the fact that this Veliid, being a gregarious insect, is not expected to have a homogenous distribution in the rice paddies.

In 1975, we published the result of our study on the parasitism of both plant-and leaf-hoppers by the egg-parasites and *Elenchus yasumatsui* in the publication of FAO. The advantage of *Elenchus yasumatsui*, a a "reservoir" of its population. Probably a favored grass is *Eleusine indica*, and *Eleusine coracana* may also harbor the hoppers and *Cyrtorhinus*." In Fiji, Hinckley (1963) made observations on the ecology and control of *Sogatella furcifera* and *Nilaparvata lugens* on rice. He wrote that in drilled fields, the predatory Mirid, *Cyrtorhinus lividipennis vitiensis* Usinger provided effective control by destroying eggs of *N. lugens*, and, by the time the rice was six months old, it usually outnumbered the females of *N. lugens*. According to his opinion, one of the factors influencing outbreaks is relative abundance of *Cyrtorhinus* In India, Murthy et al. (1976) made observations on *Cyrtorhinus lividipennis* and wrote that the untreated plots did not exhibit any "hopperburn" symptoms despite the fact multiplication of the Brown Plant-hopper up to the middle of October. In Taiwan, Hsieh (1975) wrote that it is doubtful if the predation by *C. lividipennis* on the leafhopper has much effect on the pest population density.

Otake and Hokyo (1976) made observations on *Cyrtorhinus lividipennis* in Malaysia and Indonesia, and wrote as follows: - " The average numbers of the mirid, *Cyrtorrhinus lividipennis*, were very variable among the districts. High averages in some district, however, were brought about by the existence of paddy fields that *C. lividipennis* were collected abundantly from paddy fields and nurseries with high densities of plant- and leafhoppers, but the reverse was not always true as there were some cases in which the number of collected *Cyrtorrhinus* was small in spite of abundant existence of hoppers. Thus, it can be said that the responce of *C. lividipennis* to prey density was neither very sensitive nor very strong to bring about effective density-dependent control of the pests by the very predator." "The result of our investigation in Indonesia suggests that further study would still be necessary before any conclusion is drawn about the effectiveness of the mirid upon the pest population."

Strepsipteron, is that it attacks every nymphal as well as the brachypterous forms of leaf- and plant-hoppers found deep in the hill. Sometimes, the percentage of parasitism by this parasite exceeds 90% (This observation was made on September 28, 1977, in the rice paddy of Amphoe Phibun Mangsahan, Ubol Ratchathani Province). During our survey of natural enemies of rice pests throughout Thailand we noticed that the distribution of this parasite is limited in the northern part of Thailand. Unfortunately, the distribution of the above-mentioned FAO publication was too limited to be accessed by the world entomologists. Therefore, a part of our results showing our experiments which were performed both in Khlong Luang and San Pa Tong Rice Experiment Stations will be introduced again in another publication (Proceedings of the International Symposium on Problems of Insect Pest Management in Developing Countries. Tropical Agriculture Research Series, No. 14, 1981). On page 17 of our 1975 report recommendation was given like this : - Some natural enemeis occur only in restricted provinces in Thailand. In such cases, it is necessary to bring the population of natural enemies to other rice paddies where they are lacking or very weak if they occur. A good example is a Strepsipteron *(Elenchus yasumatsui)* parasitizing *Sogatella* and *Nilaparvata* in the north of Thailand. This parasite should be liberated to the northeastern and central parts of Thailand.

Since 1977, we have continued the survey on the parasitism of *Elenchus yasumatsui* and the Dryinid wasps in the rice paddies of various districts of Thailand. The following table indicates the analysed data on the number of parasitized nymphs or adults of *Sogatella furcifera* and *Nilaparvata lugens.* The Dryinidae usually found in the rice paddies of Thailand are *Pseudogonatopus hospes* Perkins, *Haplogonatopus orientalis* Rohwer and *Echthrodelphax fairchildii* Perkins (this species is the same as *Echthrodelphax bicolor* Esaki et Hashimoto described from Japan).

Table 12. Number of parasitized *Nilaparvata lugens* (N) and *Sogatella furcifera* (S) specimens collected by sweep net method in various rice paddies of Thailand. Figures in Table indicate number of specimens collected per 50 sweeps from the paddy.

Place and date of research	Parasitized by				Number of	
	Dryinids(D)		*Elenchus yasumatsui* (E)		(D + E)	(S + N)
	S	N	S	N		
Amphoe Mae Sariang, Mae Hong Son, 5. V. 1978	-	9	1	-	10	60
Ban Pa Bong, Amphoe Muang, Mae Hong Son, 6. V. 1978	-	-	-	9	9	4
6. V. 1978	8	-	-	-	8	170
Ban Pang Mu, Amphoe Muang, Mae Hong Son, 6. V. 1978	-	18	-	-	18	
6. V. 1978	8	-	-	-	8	81
Ban San Kab Nua, Amphoe Saraphi, Chiang Mai, 4. V. 1978	-	3	-	2	5	57
4. V. 1978	-	4	-	3	7	
Ban Wang Nam Yard, Amphoe Chom Thong, Chiang Mai, 7. V. 1978	-	3	-	-	3	24
Ban Huai Dib, Amphoe Chom Thong, Chiang Mai, 7. V. 1978	-	7	-	-	7	40
Ban Yu Wha, Amphoe San Pa Tong, Chiang Mai, 7. V. 1978	2	2	-	5	9	
Doi Pa-Morn, Doi Inthanon, Amphoe Hang Dong, Chiang Mai, 5. IX. 1978	13	3	26	17	49	
Mae Jo, Chiang Mai, 6. IX. 1978	-	6	3	-	9	22
6. IX. 1978	-	8	4	-	12	
Ban Thung Ka La, Amphoe Chiang Dao, Chiang Mai, 6. IX. 1978	1	4	9	-	14	18
6. IX. 1978	4	4	10	-	18	28
6. IX. 1978	1	14	25	4	44	
Ban Sob Kab, Amphoe Chiang Dao, Chiang Mai, 6. IX. 1978	1	-	1	-	2	37
6. IX. 1978	2	-	4	-	6	

Table 12. (Continued)

Place and date of research	Parasitized by Dryinids(D) S	N	Elenchus yasumatsui (E) S	N	Number of (D + E)	(S + N)
Doi Pa-Morn, Doi Inthanon, Amphoe						
Hang Dong, Chiang Mai, 5. IX. 1978	1	-	5	-	6	12
5. IX. 1978	1	-	4	-	5	8
5. IX. 1978	1	-	3	-	4	22
5. IX. 1978	2	-	1	-	3	21
5. IX. 1978	2	-	5	-	7	8
5. IX. 1978	-	2	2	-	4	29
Amphoe Doi Saket, Chiang Mai,						
19. XI. 1978	2	2	1	1	6	11
19. XI. 1978	2	2	-	2	6	24
19. XI. 1978	7	4	4	3	18	
19. XI. 1978	5	-	2	-	7	15
28. IX. 1978	-	14	16	-	30	72
Ban Mae Yoi, Amphoe San Sai, Chiang						
Mai, 24. VI. 1979	-	2	-	-	2	6
Amphoe Muang, Lamphun, 4. V. 1978	2	-	-	17	19	59
4. V. 1978	1	-	-	-	1	12
Ban Suk Sawadee, Amphoe Muang,						
Lampang, 20. II. 1979	-	1	-	-	1	11
Amphoe Muang, Phrae, 5. X. 1977	-	-	3	-	3	14
26. X. 1977	1	-	5	-	6	26
Ban Na Kam Hai, Amphoe Nong Bua						
Lampoo, Udon Thani, 26. X. 1976	1	-	1	-	2	8
Ban Nong Nok Kiang, Amphoe Phen,						
Udon Thani, 8. IX. 1978	2	-	5	-	7	11
Amphoe Muang, Khon Kaen, 12. VIII. 1977	-	-	1	-	1	
12. VIII. 1977	-	-	1	-	1	
29. X. 1976	-	13	-	1	14	41
9. XI. 1977	3	-	-	2	5	11
20. XI. 1977	-	6	-	-	6	2

Table 12. (Continued)

Place and date of research	Parasitized by Dryinids(D) S	N	Elenchus yasumatsui (E) S	N	Number of (D + E)	(S + N)
Ban Non Sa ard, Amphoe Muang,						
Maha Sarakham, 28. X. 1976	-	3	-	4	7	24
28- X. 1976	-	1	-	1	2	
Ban Pone Thang, Amphoe Renu-nakorn, Nakhon Phanom,						
10. IX. 1978	5	-	9	-	14	12
10. IX. 1978	-	6	-	1	7	6
Ban Yan Kee Nok, Amphoe Khuang Nai, Ubol Ratchathani,						
28. X. 1976	-	2	-	2	4	8
Amphoe Phibun Mangsahan, Ubol						
Ratchathani, 5. IX. 1977	-	-	5	7	12	12
6. IX. 1977	1	-	20	2	23	38
25. IX. 1977	-	-	13	-	13	20
28. IX. 1877	-	-	35	5	40	
5. X. 1977	-	-	3	-	3	
18. X. 1977	-	3	-	27	30	38
18. X. 1977	2	1	27	-	30	175
Ban Thang Sai, Ubol Ratchathani,						
19. XI. 1979	8	-	1	-	9	2
Ban Muad, Amphoe Kantharalak,						
Si Sa Ket, 19. X. 1977	3	-	-	-	3	
Ban Boo Soong, Si Sa Ket,						
21. XI. 1977	6	-	2	-	8	12
21. XI. 1977	2	9	10	-	21	73
Ban Sangka Talag, Surin,						
21. XI. 1977	140	-	54	-	194	477
25. XI. 1977	-	52	13	2	67	117
Amphoe Khlong Khlong, Kamphaeng						
Phet, 3. III. 1978	-	-	-	1		
Phatthalung, 25. I. 1979	-	-	1	-	1	3

As to the parasitism of *Nephotettix* spp. by the Dryinids and Strepsiptera, we encountered a very few cases in Thailand as shown in Table 13.

Table 13. Number of parasitized *Nephotettix* specimens collected by sweep net method in various rice paddies of Thailand. Figures in Table indicate number collected per 50 sweeps from the paddy.

Place and date of research	Parasitized by	
	Strepsiptera	Dryinids
Ban Yu Wha, Amphoe San Pa Tong, Chiang Mai, 7. V. 1978	2	1
Doi Pa-Morn, Doi Inthanon, Amphoe Hang Dong, Chiang Mai, 19. XI. 1978	1	-
Ban Wang Nam Yard, Amphoe Chom Thong, Chiang Mai, 7. V. 1978	1	-
7. V. 1978	1	1
7. V. 1978	-	1
Ban Rong Ku, Amphoe Hang Dong, Chiang Mai, 27. III. 1979	1	-
Ban Mae Yai, Amphoe San Sai, Chiang Mai, 24. III. 1979	-	1
Ban Teen Doi, Amphoe Muang, Chiang Rai, 27. III. 1979	-	2
Amphoe Muang, Lamphun, 4. V. 1978	1	-
Ban Non Sa ard, Amphoe Muang, Maha Sarakham, 28. X. 1976	1	-
Ban Sangka Talag, Surin, 21. XI. 1977	-	5
Ban Boo Soong, Si Sa Ket, 21. XI. 1977	-	3
Si Sa Ket, 44 km apart from Ubol Ratchathani, 19. XI. 1977	-	10
Ban Thang Sai, Ubol Ratchathani, 19. XI. 1977	-	3
Ban Bannam priew, Chachoengsao, 12. VII. 1978	-	5
Ban Bangkhanag, Chachoengsao, 20. VI. 1978	-	2
12. VII. 1978	-	3

As seen from the table given above, the population of Strepsiptera and Dryinids parasitizing *Nephotettix* species in Thailand is very low. We have observed only 8 cases of parasitism by Strepsiptera for the past three years, making a high contrast to the case of *Nilaparvata* and *Sogatella* species.

Nilaparvata lugens is sometimes harboring the larvae of both Dryinid and *Elenchus yasumatsui*. We encountered the following cases.

1. One Brown Plant-hopper specimen which was parasitized by one Dryinid and one *Elenchus yasumatsui* was collected on October 28, 1978, in a rice paddy in Amphoe Doi Saket, Chiang Mai Province.

2. The same case was found on October 26, 1977, in a rice paddy in Amphoe Muang, Phrae Province.

3. Three specimens each of which was parasitized as in the case 1 were collected on September 6, 1977, in a rice paddy in Amphoe Phibun Mangsahan, Ubol Ratchathani Province.

4. Three specimens of the same kind were collected on November 21, 1977, in a rice paddy in the village of Sangka Talag of Surin Province.

In such cases, the larva of *Elenchus yasumatsui* seems to be eaten by the larva of Dryinid.

So far as the higher percentage parasitism of hoppers by a complex of Pipunculids and Strepsiptera or a complex of Dryinids and Strepsiptera is concerned, the following reports may be interesting in Southeastern Asia. According to Munroe (1975), it is evident that natural control by parasites (Pipunculids and Strepsiptera) is an important factor in the population dynamics of rice plant- and leaf-hoppers in Sarawak, and in the case of field collected material of *Nilaparvata lugens* percentage parasitism by these parasites was 67%. According to Otake (1977), the degree of parasitism of the Brown Plant-hopper in Sri Lanka was not very high, although there were some cases in which the total amount of parasitism by Elenchids and Dryinids reached a level of 40%. Gowda (1978) reported that the percentage parasitism of *N. lugens* by the species of Dryinids (*Haplogonatopus* sp. and *Echthrodelphax fairchildi*) was 51% in India. Manjunath's record (1979) on the natural enemies of *N. lugens* is of great interest. He made observations in and around Mandya and other areas in India during 1977 - 1978. The highest percentage parasitism of the Brown Plant-hopper by Dryinids (*Dryinus* sp. and *Haplogonatopus orientalis*) was 10.2, and the same by Strepsiptera (*Elenchus* sp. and *Halictophagus* sp.) was 21.6. About 1,500 triungulins emerged from a female host in about a minute, and another 1,000 larvae were recovered from the same host when it was dissected.

From the table given above, the ratio of hoppers to Dryinids, *Elenchus yasumatsui* or a complex of Dryinids and Strepsiptera was sometimes enough to suppress the population of hoppers to a greater extent, especially considering the number of triungulins of *Elenchus*. Usually, the population of Dryinids is not high, but the Dryinids have a potential of increasing their numbers. For example, the number of *Sogatella furcifera* parasitized by Dryinids and *Elenchus* on November 21, 1977, was 140 and 54, respectively, as compared to 477, the number of hoppers. Such ratios are sufficient to control the population of hoppers under economic injury level. In this connection, Manjunath, Rai and Gowda (1978) wrote that the percentage parasitism of the Brown Plant-hopper by Dryinids in India was 51%. Thus, we can assume that the Dryinidae and Strepsiptera are sometimes playing an important role in the control of hoppers.

First reliable report on the egg-parasites of plant- and leaf hoppers injurious to rice in Thailand was published in 1976 by Nishida, Wongsiri and Wongsiri. Although the exact relation between the species of egg-parasites and their host hoppers in the report was not written, it is apparent that *Anagrus optabilis* (Perkins) was the parasite of *Nilaparvata lugens, Sogatella furcifera* and *Nephotettix* species, and *Paracentrobia yasumatsui* was the parasite of eggs of *Nilaparvata lugens* and *Nephotettix nigropictus.* They collected data from 21 localities, and the data obtained indicate considerable variation in parasitism. On the high side, parasitism approaching 100 percent was obtained, and on the low side, parasitism of less than 10 percent was obtained. *Anagrus optabilis* was the most numerous species. They observed that in general egg parasitism was high even though the host density (number per stem) was low, less than three per stem for many areas. The non-pest status of plant- and leaf hoppers in many areas of Thailand appears to be due to mainly to egg parasitism. They further found that parasitism was high in rice paddies near or adjacent to uncultivated wild grass areas. They considered that the high parasitism near the border may be due to the presence of breeding sites between crop cycles, and it may also due to the shelter offered by wild vegetation against fires which are often used to clear after-harvest straw.

In 1975, we reported the occurrence of about 7 species of egg-parasites of plant- and leaf-hoppers in Thailand: - *Paracentrobia yasumatsui, Paracentrobia garuda* Subba Rao, *Oligosta* sp. (Trichogrammatidae), *Anagrus optabilis* (Perkins), *Mymar taprobanicum* Ward, *Polynema* sp., and *Gonatocerus* sp. (Mymaridae). At that time eggs of *Nephotettix* spp. and *Nilaparvata lugens* were known to be attacked by *Anagrus optabilis*, and eggs of *Nilaparvata lugens* were known to be attacked by *Paracentrobia yasumatsui*, *P. garuda* and *Gonatocerus* sp. We observed that the egg-parasites are very abundant and contribute greatly to the population decrease of leaf- and plant-hoppers, and sometimes, the percentage of parasitism reaches 100.

In October and November of 1977, Miura, Hirashima and the staff of the Entomology and Zoology Division, Department of Agriculture, Thai Government made an extensive survey on *Sogatella furcifera, Nilaparvata lugens, Nephotettix nigropictus* and *N. virescens* and their natural enemies in various districts of Thailand, and they obtained the following results.

Sogatella furcifera: - The percentage parasitism of *Anagrus optabilis* was 20 - 100% for egg-masses(often less than 50%), and 8.93 - 83.33% for individual eggs per one egg-mass. As the eggs of *Sogatella furcifera* were deposited shallowly into the tissue of rice plant, they are easily parasitized by *Anagrus optabilis*

Nilaparvata lugens: - The percentage parasitism of *Anagrus optabilis* was low, being 40 -50% for egg-masses and 9.68 - 25.00% for individual eggs per one egg-mass.

Nephotettix nigropictus and *N. virescens:* - *Paracentrobia* sp. and *Gonatocerus* sp. were reared. In the case of the former parasite, the percentage parasitism was very high; 100% for the egg-masses, and 81 - 90% for the individual eggs. In the case of the latter species, the same was 100% for the egg-masses, and 73 - 97% for the individual eggs.

Miura and his coworkers also made an investigation on four species of hoppers and their Dryinid and Strepsipterous parasites, and got the following results.

Sogatella furcifera: - It was estimated that the percentage parasitism of Dryinid wasps was about 20%. The percentage parasitism of Stylopids was 1 - 4% in northern Thailand. It was considered that the percentage parasitism of the Stylopids fluctuates according to seasons of the year, and Stylopids are found to be parasitic on *Sogatella furcifera* in northern Thailand only.

Nilaparvata lugens: - Both Dryinids and Stylopids were very few in number.

Nephotettix nigropictus and *N. virescens*: - The percentage parasitism of Dryinid wasps was less than 25.0%. Stylopid parasites were very few in number, and the percentage parasitism was 0.67 - 0.83%.

In India, Samal and Misra (1979) recorded that the percentage parasitism of the Brown Plant-hopper by three egg-parasites (*Anagrus* sp., *Oligosita* and *Tetrastichus* sp.) was 21 - 28%, the highest percentage reaching a level of 65.5 % in September.

In northern part of Thailand, the outbreak of *Nilaparvata lugens* and *Sogatella furcifera* is very rare. This has been attributed to the activity of a complex of egg-parasites and a Strepsipteron. They are *Paracentrobia garuda*, *P. yasumatsui*, *Oligosita yasumatsui* Viggiani et Subba Rao(Trichogrammatidae), *Anagrus optabilis*, *Mymar taprobanicum*, *Gonatocerus* sp. (Mymaridae), and *Tetrastichus formosanus* (Timberlake)(Eulophidae). In 1977, Chandra reported his observation on *Tetrastichus* sp. as a new parasitoid-predator of the Brown Plant-hopper in the Philippines. According to his observation, one larva of this Eulophid attacks several eggs in the egg-mass of the Brown Plant-hopper in the leaf sheath tissue before pupation, just as *Tetrastichus schoenobii* in which several larvae consume the entire eggs in the egg-mass of the rice stem-borers of the genus *Tryporyza* or *Scirpophaga*. The species of *Tetrastichus* recorded by Chandra from the Philippines and the one recorded by Samal and Misra(1979) from Orissa, India, may be *Tetrastichus formosanus*.

The importance of egg-parasites of the rice stem-borers is well known and not necessary to repeat. Generally speaking, the egg-parasites are more important than the larval or pupal parasites in Thailand. Among the egg-parasites, the most important are *Telenomus rowani* (Gahan) and *Tetrastichus schoenobii* Ferrière as in other South and East Asian countries. In Sri Lanka, Fernando (1967) wrote like this: - "The searching ability of *T. dignus* (this species is no doubt *Telenomus rowani*) is so marked that females of this parasite have frequently been found on the anal tufts of female *Tryporyza incertulas* collected at light traps. The anal tufts of T.

incertulas likely contain an attractant for *T. dignus* (T. rowani). This tuft of hairs and scales is applied by the female *T. incertulas* over its egg masses." In Sarawak, Rothschild (1970) could not find any evidence that *T. rowani* dispersed by phoresy. On December 13, 1972, we made a research trip to Chainat Rice Experiment Station. We brought several pots with young rice plants in order to get fresh egg-masses of *T. incertulas.* In the evening we collected large numbers of adult moths by setting a light trap near the rice paddy. The moths were confined to the cage with several pots mentioned above. This cage has never been exposed to the rice paddy. Among numbers of egg-masses laid on the leaves of young rice plants, adults of *Telenomus rowani* emerged from one egg-mass. This fact indicates that one female moth put into the cage might have harbored one individual of female *T. rowani* on her anal hair tufts.

In Thailand, the commonest social wasps are the members of the genus *Ropalidia*, family Vespidae. The commonest species are *Ropalidia marginata sundaica* van ver Vecht and *R. variegata jacobsoni* (Buysson). If there are nests of *Ropalidia* spp. near the rice paddies, the wasps will visit the rice paddy frequently and will carry the defoliator larvae injurious to rice to their nests. It has been observed that the larvae of leaf-roller or other Lepidopterous larvae are often promptly eliminated from the rice paddy within a few days.

Among the Tachinidae found in the rice paddies, *Argyrophylax nigritibialis* Baranov and *Halidaya luteipennis* Walker are most important as larval parasites of rice defoliators. Our observation showed that the parasitism of the larvae of rice defoliators by the Tachinid parasites was higher in the second crop of rice then in the first one, the ratio being 227 : 59.

As to the activity of fungi, bacteria and Nematodes, there are some records in Southern Asia. For example, the parasitism of rice stem-borers by the species of *Hexamermis* (Mermithidae, Nematoda) was 16 - 17% during the rainy season in India (Rao et al., 1968), and the maximum percentage parasitism of *Nilaparvata lugens* and *Sogatella furcifera* by the species of *Hexamermis* reached 39 (usually 16.7 - 18.1) in India (Manjunath, 1978). According to Narayanasamy and Baskaran (1979), neither the fungus, *Cephalosporium lecanii* nor the bacterium, *Bacillus thuringiensis* var. *alesti*, reduced incidence of whorl maggot, stem borer, or leaf folder.

During the past seven years we have never seen the epizootics of naturally occurring insect pathogens in the rice paddies of Thailand. So far as we are aware and the literature are concerned, the role played by the insect pathogens -- bacteria, fungi, protozoa, viruses and nematodes -- as regulatory agents of rice insect pests is very weak and not important in South and East Asian countries. Therefore, the use of insect pathogens in the rice paddies is regarded as impractical at the moment and also in the near future.

EVALUATION OF NATURAL ENEMIES OF RICE PESTS

The evaluation of natural enemies of rice pests are becoming necessary for future control of rice pests and also for exchange of natural enemies between the countries as well as within the country from one district to another.

For the past several years we have accumulated data on the abundance of natural enemies of four groups of rice pests; viz. defoliators, stem-borers, plant- and leaf-hoppers, and gall-midge. Though our analysis of the collected material is not yet finished, an attempt was made to evaluate natural enemies of rice pests in Thailand based upon quantitative determinations and extensive observations. Such an evaluation, never been attempted in the past, would be of use for the entomologists working on biological control or integrated rice pest control not only in Thailand but also elsewhere in the world. Because of the numerous factors that can influence the activity of natural enemies the evaluation are only rough estimates.

Each species was rated on a scale of 0 to 10, 0 indicating the least effective and 10 the most. As there may be a wide range of variation in the activity of natural enemies in different localities, the rating was based on the highest potential of a given species. This does not mean that it is always effective throughout the country and throughout the seasons. But, we can assume that it has been worked well in suppressing the population of rice pests in certain areas and under certain conditions of the rice ecosystem in Thailand. The result of our evaluations are shown in Figures 5-8.

In the evaluation and utilization of natural enemies of rice pests, we must not forget another important problem. If we can mass-rear one species of natural enemy that was not highly recognized in our present evaluation, we will be able to utilize it as a biotic insecticide and release it in the rice paddy on a large scale. Therefore, the low evaluation of the species at the moment does not mean that the species is permanently useless as a biological control agent even by the augmentation method. It is extremely necessary to develop the mass-rearing method of each natural enemy of rice pests by a low producing cost and by a method as simple as possible.

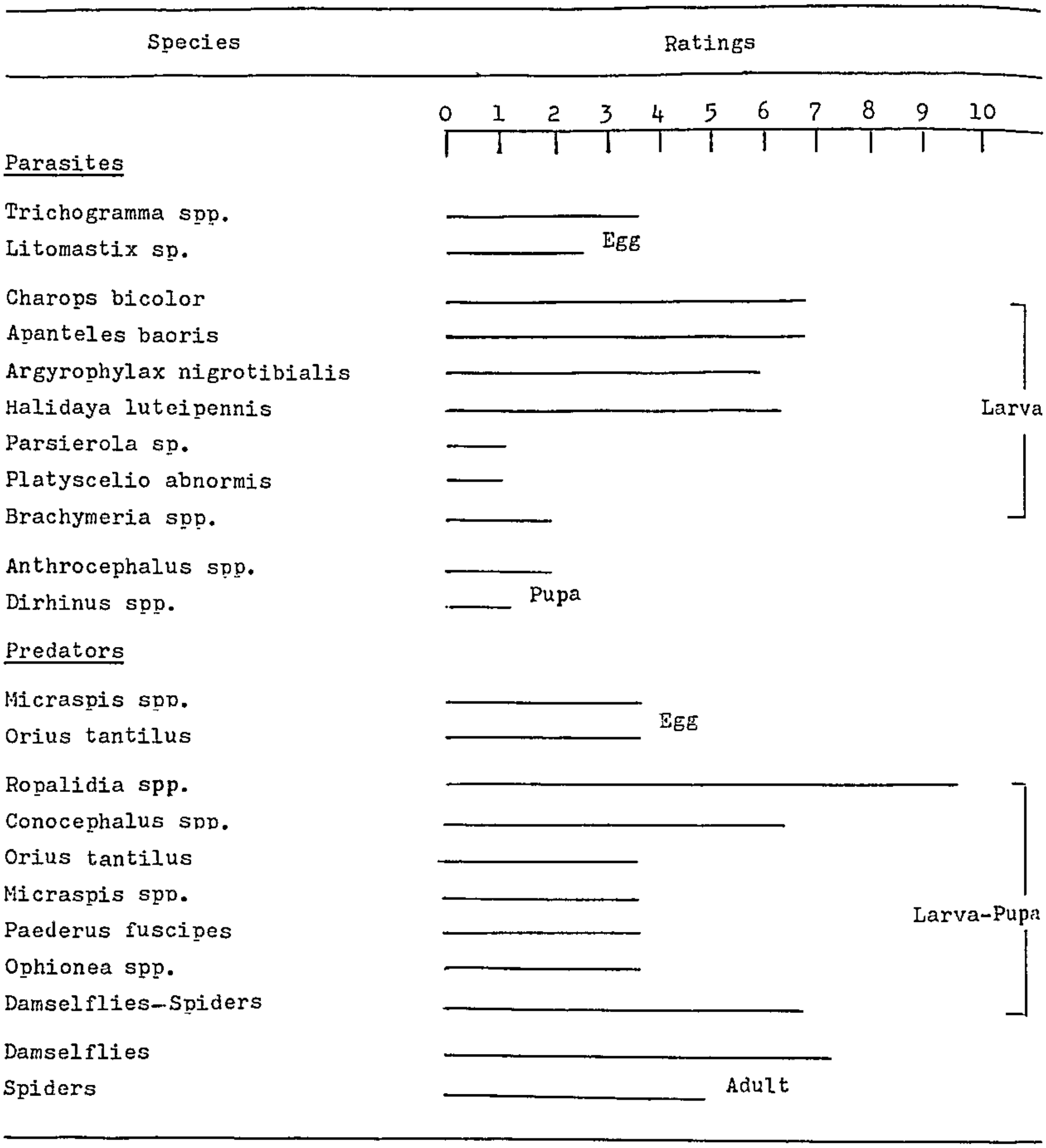

Figure 5. Rating of natural enemies of the defoliators.

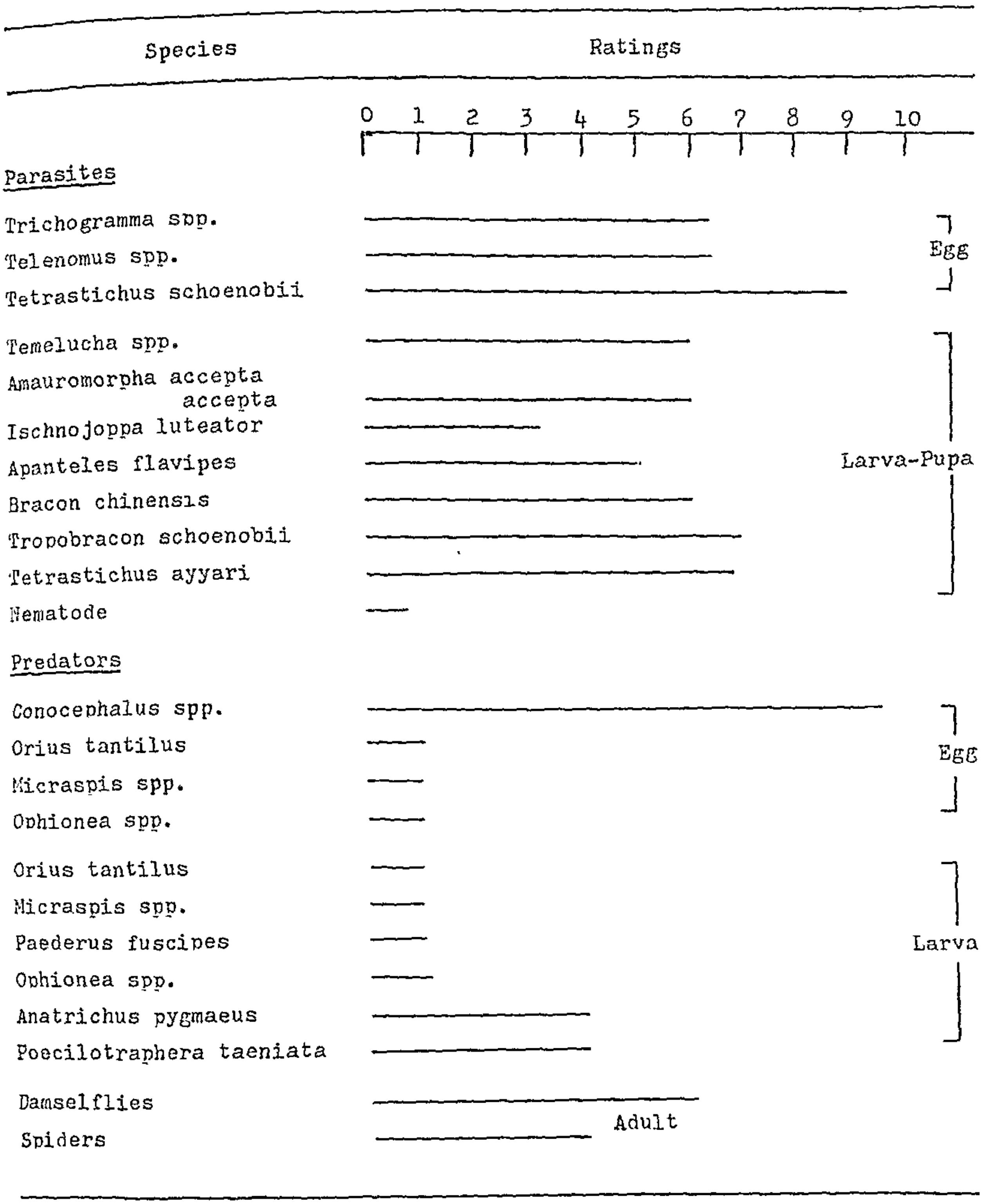

Figure 6. Rating of natural enemies of the stem-borers.

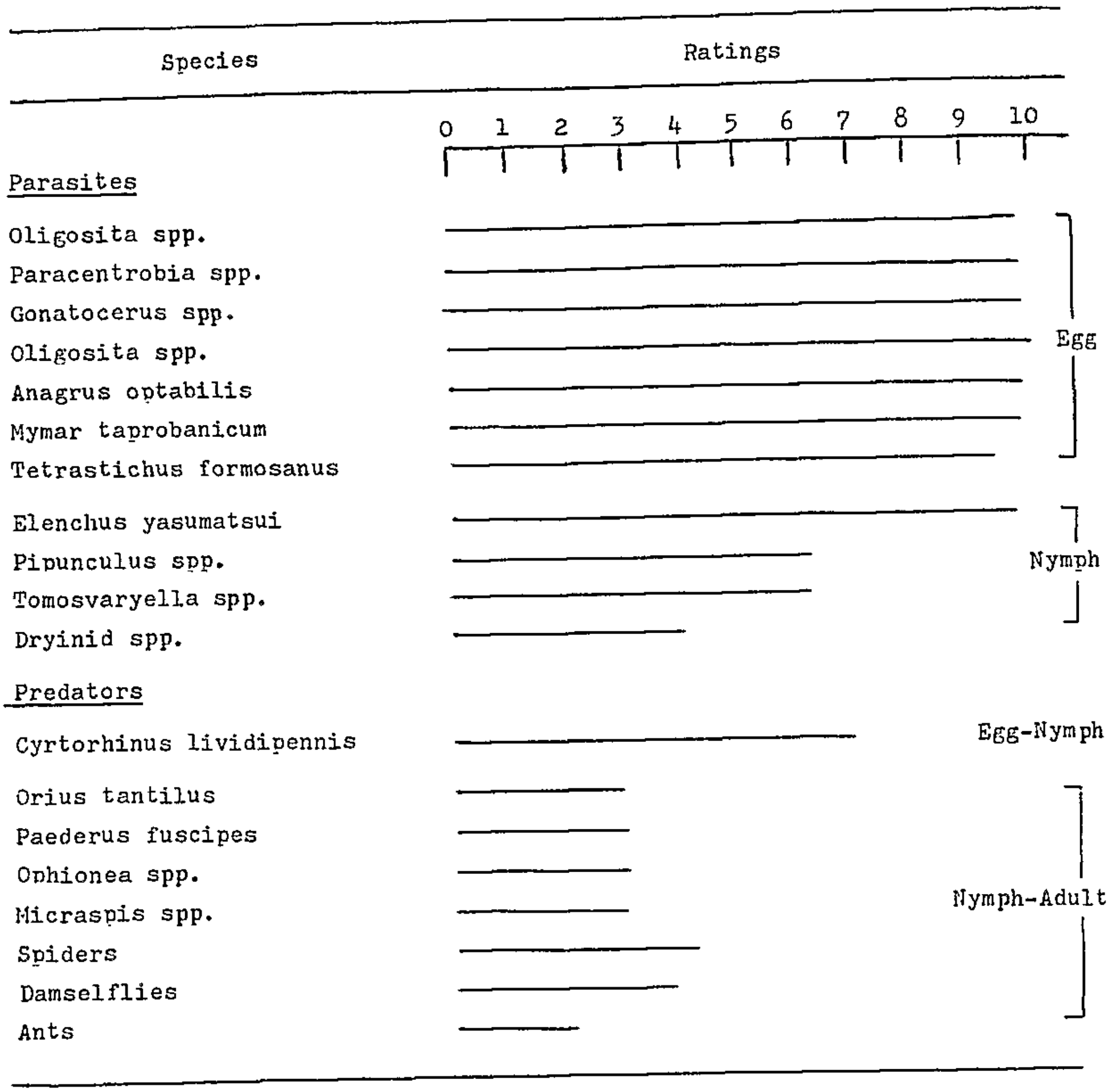

Figure 7. Rating of natural enemies of plant- and leaf-hoppers.

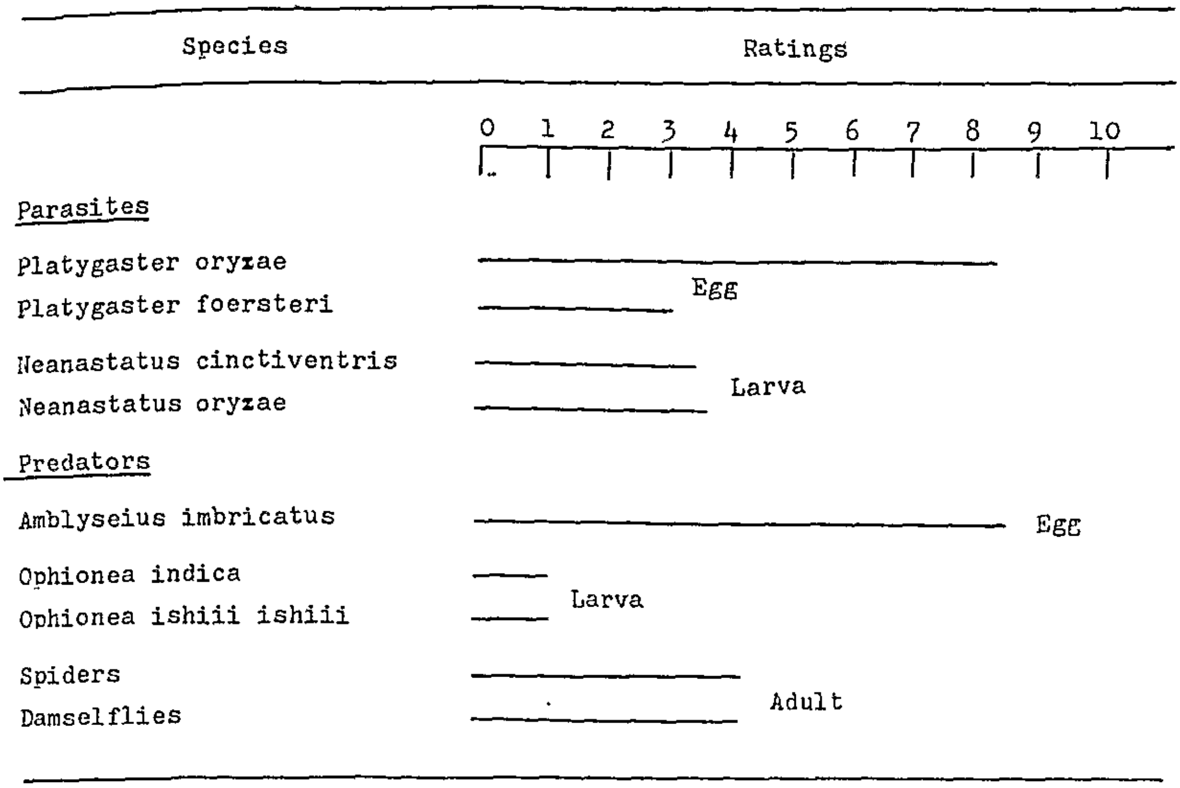

Figure 8. Rating of natural enemies of the gall-midge.

SURVIVAL OF NATURAL ENEMIES OF RICE PESTS IN THE CROPPING SYSTEM OF THAILAND*

Interest in integrated pest management of rice pests has led to an increased awareness of the importance of the utilization of natural enemies and their conservation. The role of indigenous natural enemies as control agents for rice pests has already been reported. Both utilization and conservation requires information on the ecology and behavior of natural enemies. The purpose of this chapter is to describe the rice paddy environment and to point out some of the attributes of natural enemies which enable them to survive and be successful as biological control agents. This chapter is based on the results of studies and observations made in rice paddies throughout Thailand during the past ten years.

Rice environment and natural enemies

Rice is not a perenial crop. It matures in 3-5 months after seeding depending upon variety. In general the environment for natural enemies is favorable during the growth of the crop in localities where excessive pesticides are not used. However, environmental conditions become less favorable after the crop is harvested. Successful natural enemies must be able to survive the post-harvest conditions.

The cropping systems and the post-harvest conditions of the paddy fields vary in Thailand. Because of the importance of post-harvest conditions to natural enemies, let us examine some of the typical cropping systems from

*Joint work with Prof. T. Nishida, Department of Entomology, College of Tropical Agriculture, University of Hawaii at Manoa, Honolulu.

the standpoint of the duration of the crop and the fallowing period.

A diagramatic presentation of the common cropping systems is shown in Figure 9. In A the crop is grown under irrigation. There is no distinct fallowing period because of the overlapping of crops. In A-1 the crop is grown throughout the year under irrigation in small plots on experiment station farms. In B the crop is grown under irrigation in low poorly drained areas such as in Nakhon Pathom areas. The crop is grown during the dry season and the paddies are in fallow during the wet season. The fallowing paddies are inundated. In C the crop is grown rain-fed. There is one crop during the wet season followed by a long fallowing period during the dry season. It is common in north, northeast, and central Thailand. In D the crop is grown rain-fed. The one crop per year is grown during the wet season at the end and beginning of the year. The dry fallow period is from March to September. This system is common in south Thailand where the wet season is delayed because of the late arrival of the southeast monsoon.

The conditions of the fallowing rice paddies varies considerably. In the dry areas the land is parched dry and usually grazed so intensely that there is hardly any vegetation, except in localized low swampy areas. In the poorly drained lowland areas, weeds, volunteer rice, and wild rice may be found. In other areas, crops other than rice are cultivated under irrigation during the fallow period.

The existing cropping system seems very unfavorable to the natural enemies of rice pests because of the discontinuity of the crop and variation in rainfall. However, this is not true for Yasumatsu (1975) and Yasumatsu *et al.* (1975) have found a rich fauna of natural enemies in Thailand in spite of this seemingly hostile environment. It seems that the natural enemies of rice pests of Thailand, being the product of a selective process brought about by a cropping system of great antiquity, are capable of surviving under seemingly hostile environment.

Non-rice area and natural enemies

The importance of the non-rice areas to the natural enemies of rice pests has been pointed out (Yasumatsu, 1975). In this chapter its importance is discussed in relation to movements of natural enemies in response to environmental disturbance of the rice paddies caused by cultural practices such as harvesting the crop and withdrawing of water from the paddies as the crop matures.

In Thailand the natural enemies of rice pests are dependent upon two ecosystems, rice ecosystem, and non-rice ecosystem. This dependency is shown in Figures 10-11. The movement of natural enemies from the non-rice area into rice paddies begins soon after rice is planted. The population then builds up to a peak at crop maturity. When the crop is harvested the natural enemies move out into the non-rice area. The relative numbers entering the field are less than those going out. The figures also indicate comparative effects of excessive pesticide usage. For example, in Figure 10 where no pesticides had been used, there are high numbers of immigrating and emigrating population as well as a high population build-up in the rice areas. However, as shown in Figure 11, excessive pesticide usage can lead the reduced number of immigrating and emigrating natural enemies. This is because the natural enemy population cannot build up in the polluted rice paddies during the immigration and emigration period.

The congregation of natural enemies in favorable areas after harvest was observed in south Thailand; a one-crop rain-fed area, system A-1 in Figure 9.

It is the practice of experimental stations to grow rice more or less continuously in small experimental plots under irrigation even during the dry fallow period. Natural enemies surrounding harvested rice areas congregate in large numbers on these experimental rice plantings. Possibly because of these natural enemies, damage from pests was observed to be extremely low. The growing of these off-season crop will be valuable in the conservation of natural enemies.

The above discussion illustrates the importance of maintaining a healthy movement of natural enemies in and out of the rice paddies. Once this movement is destroyed, it would be necessary to depend heavily on pesticides, which could lead to economic and environmental problems. It would also take a long time to restore the original natural enemy fauna.

Recent perturbation in the natural enemy environment

In its evolutionary development, the natural enemy fauna of rice pests have never been subjected to such drastic perturbations in the environment as they are today. Ironically, some of these perturbations are taking place through necessity under the name of integrated pest management.

One of the major perturbations that is becoming increasingly important is pesticide pollution in the natural enemy environment. One of the objectives of the current integrated pest management program in Thailand is to maintain a healthy environment so that there will be a free movement of natural enemies into and out of rice areas. It is indeed fortunate that in Thailand intensive pesticide usage on rice is generally restricted to the irrigated areas which represent about 20% of the total rice area.

Though subtle in its effects, the introduction of new rice varieties, which are drastically different from the indigenous ones, can affect natural enemies adversely. New varieties are often bred for pest resistance, which is likely to cause a decrease in pest density. Natural enemies that are not adapted to low host or prey densities will perish. Changes in the architecture of the plant may also create unfavorable micro-environmental conditions for some natural enemies and this could also lead to loss of natural enemies. On the other hand, new varieties may act as a selective factor which could bring the environment of rice pests being about desirable changes in the natural enemy complex.

Multiple cropping in irrigated areas may have either positive or negative effects on natural enemies of rice pests. These effects have not been studied; however, according to Yasumatsu (1975) multiple cropping may be beneficial to natural enemies if pesticides are used judiciously.

Crop rotation in rice paddies is a practice that is gaining increased attention because of the interest in maximizing food production. Some rotation systems may be beneficial, while others may be detrimental. Further studies are needed in those area.

Survival attributes of natural enemies

Having shown that, in spite of the seemingly harsh rice environment, there is a rich fauna of indigenous natural enemies, let us examine some of the attributes necessary for their survival.

Motility. Motility refers to the ability of natural enemies to move in and out of crop areas. To survive, natural enemies of rice pests must be able to disperse out of rice fields after harvest and return rapidly soon after the planting of the next crop. Without such capability any species of natural enemy cannot survive under most of the rice cropping systems of Thailand.

Ability to reproduce rapidly. Rice, a rapidly growing plant, has pests that are also capable of rapid reproduction. For this reason, natural enemies must also reproduce in time with the development of the pests. Although certain species of natural enemies arrive in rice paddies earlier than others, most of them belong in the category of "r" strategists according to the classification of Force (1972). Natural enemies in this category migrate into the rice field early and reproduce rapidly. It seems unlikely that the "k" strategists would be successful in the rice paddies; however, a "k" species that is effective in both rice and non-rice areas will be of great value.

Non-specificity. While specificity is a desirable attribute in the biological control of certain pests, it is a characteristic that makes survival difficult in most rice cropping systems. During the long and harsh fallow period hosts or prey become very scarce in the rice and non-rice areas. Natural enemies must be able to survive on alternative hosts or prey until the following rice planting. The occurrence of Hymenopterous parasites of rice pests attacking pests of sugarcane or corn during the fallow period, reported by Yasumatsu (1975), is an example of beneficial non-specificity. Non-specificity is of importance because some of the major rice pests are almost specific to rice. For this reason they become very scarce and suitable stages for natural enemy must, therefore, reproduce on hosts other than rice pests.

Resistance to physical stress. Rice is grown during seasons of high temperature, humidity, and rainfall. Flooding brought about by the monsoons is also common in rice paddies. To be successful, natural enemies must be able to survive under these adverse conditions. Hot dry conditions also prevail during the fallow period. Some of the rice stem-borers undergo aestivation during this period. Whether or not natural enemies undergo such inactivity is not known.

Discussion. The major factors affecting the survival of natural enemies in Thailand are discussed in this chapter. Some of these factors are naturally occurring while others are inherent to the rice cropping system. An understanding of these factors will enable one to recognize beneficial and detrimental actions in pest management programs so that steps can be taken to preserve natural enemies.

The information presented here will be of value in carrying out biological control as a component of integrated pest management program. For example, the release of newly introduced natural enemies should be made in areas of differing cropping systems for it might be possible that establishment and success may not depend on climatic factors, but on the cropping systems. Also, search for natural enemies and their introduction should take into consideration some of these factors.

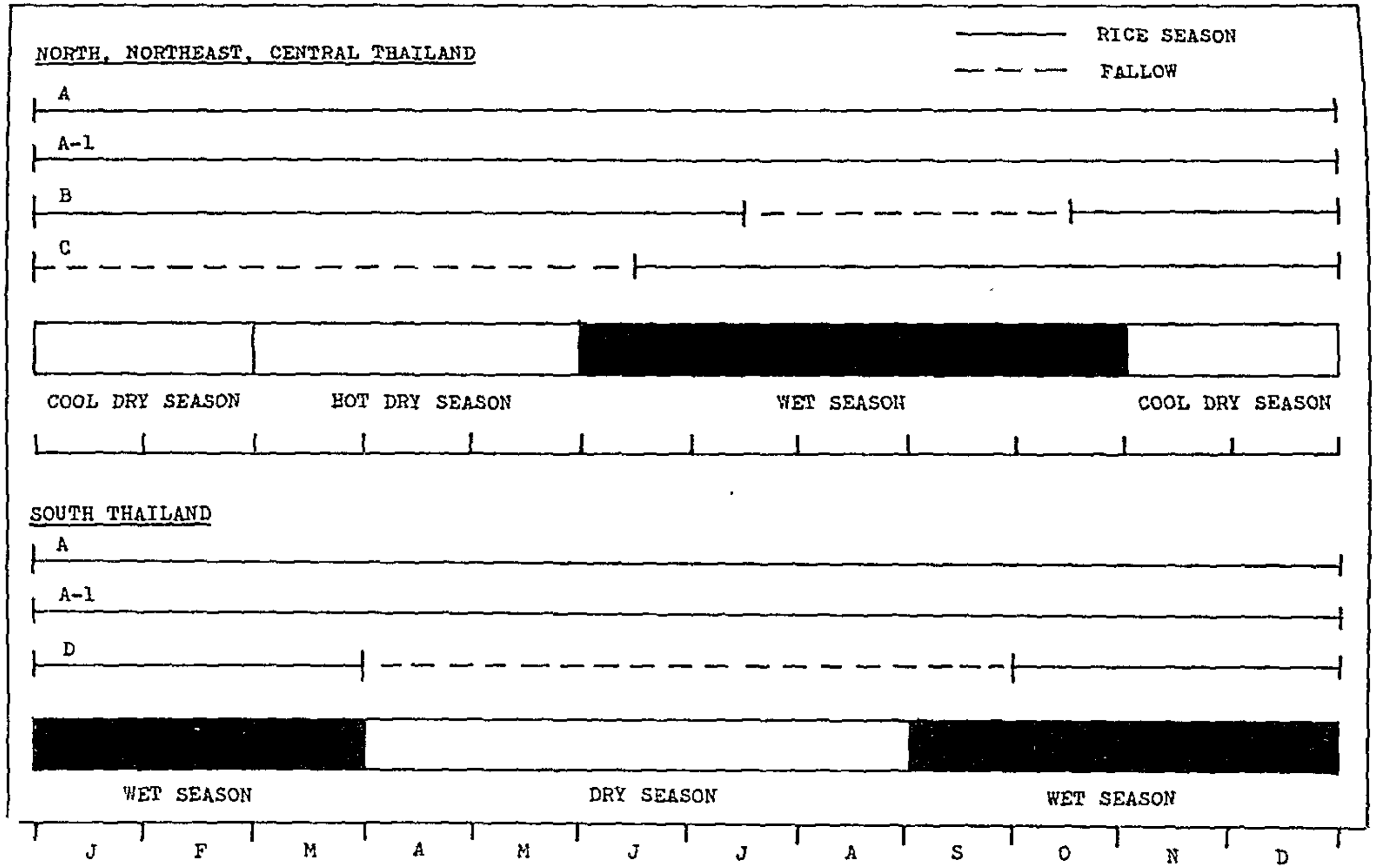

Figure 9. Diagram showing climatic conditions and duration of the annual cropping and fallowing seasons in the different regions of Thailand. A, irrigated crops; A-1, irrigated experimental plots; B, irrigated crops in low, poorly drained areas; C, rain-fed crops of north, northeast and central Thailand; and D, rain-fed crops of peninsula Thailand in south.

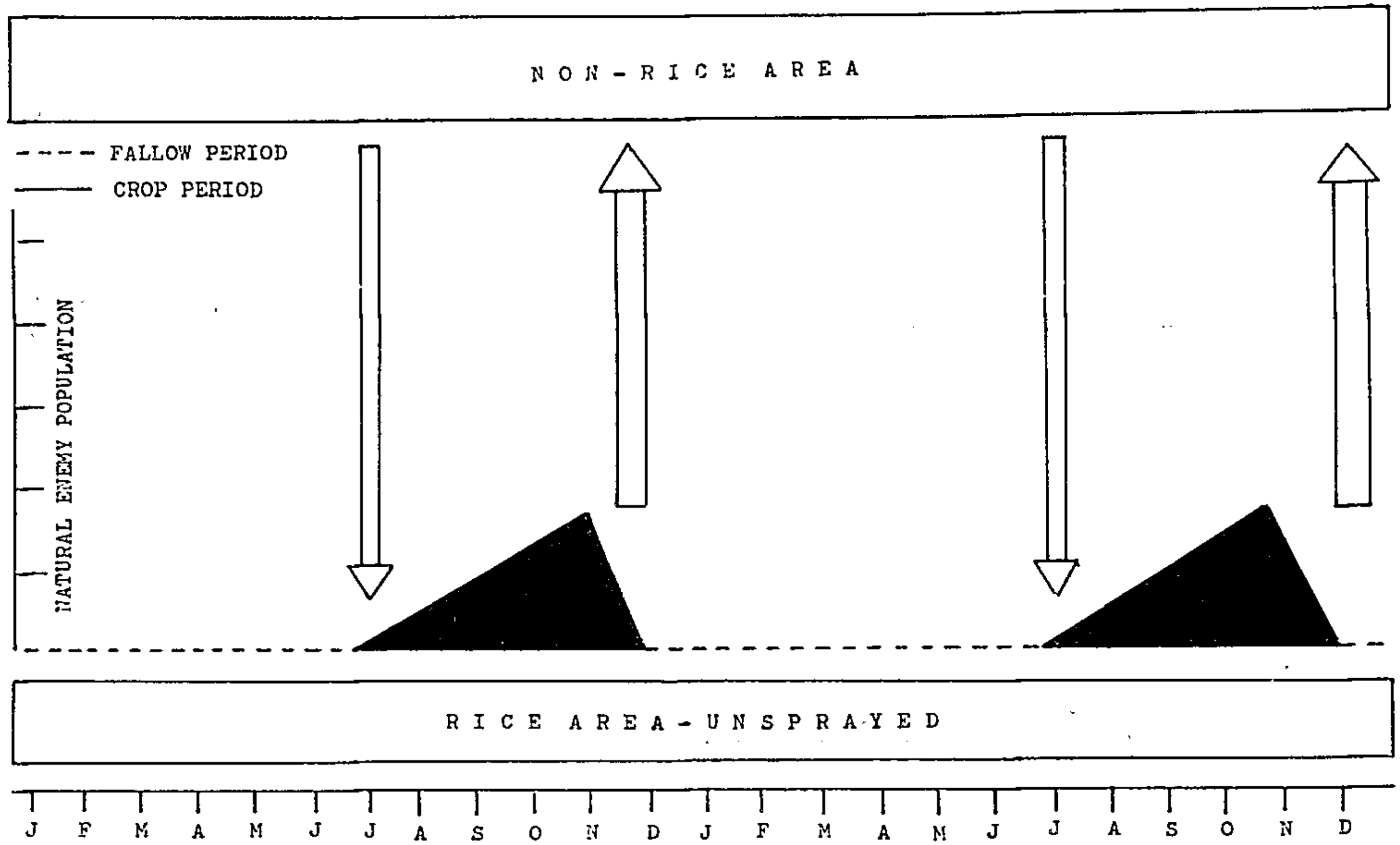

Figure 10. Movement of natural enemies of rice pests in and out of rice area in response to rice cultivation in the one crop, rain-fed areas. Diagram shows movement in unsprayed rice areas; width of arrows indicates relative abundance.

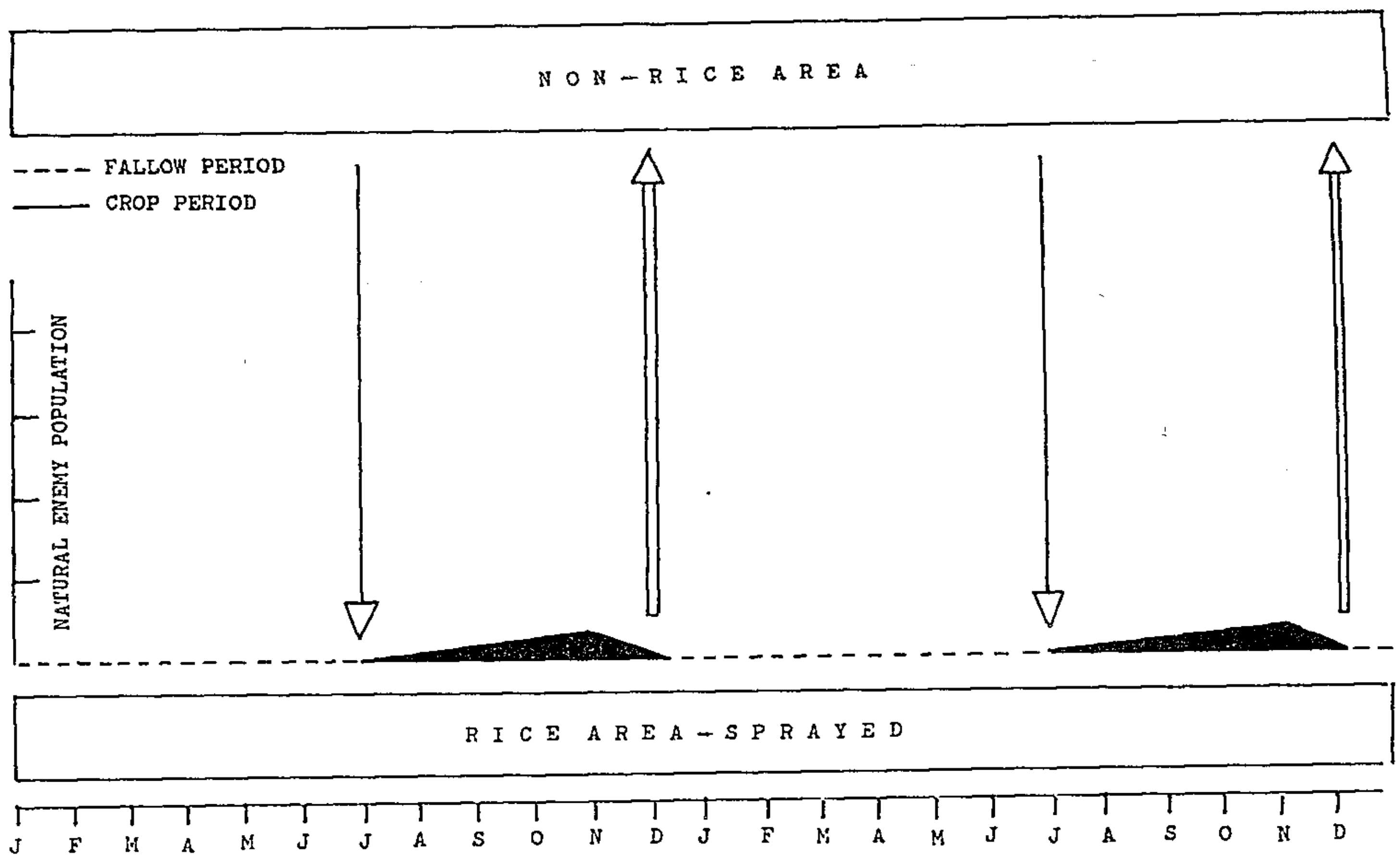

Figure 11. Movement of natural enemies of rice pests in and out of rice area in response to rice cultivation in the one crop, rain-fed areas. Diagram shows movement in sprayed areas; width of arrows indicates relative abundance.

SIGNIFICANCE OF REFUGE AREAS OF NATURAL ENEMIES

As pointed out very often, farmers have been producing rice without applying any insecticides in many of the rain-fed rice paddies since the beginning of rice cultivation in Thailand. This may be attributed exclusively to the abundance of many species of natural enemies which have been contributing much to the suppression of rice pest populations below economic injury level. Around 80% of the rice cultivating areas of Thailand grow only one crop a year. After harvesting there follows a long and dry fallow period when no rice plant is available for rice pests. The rice pests and their natural enemies seem well adapted to this condition. Rice stem-borers may enter diapause in the full-grown larval stage deep in the stubble of rice plant during a long fallow period. Now the question arises as to where the natural enemies are during the fallow period. It may be possible that some parasite larvae of stem-borers may enter diapause within their host larvae in the fallow period. But, after harvest many of the natural enemies may be forced to emmigrate from the rice paddy to the other favorable areas where they can survive during the fallow period. In the following year they migrate into the rice paddies used as the nurseries and into paddies with newly transplanted rice. This behavior is discussed with Prof. Nishida under another chapter entitled "Survival of natural enemies of rice pests in cropping systems of Thailand."

In Thailand there are areas of ever-green vegetation with adequate moisture where wild rice or other Leguminaceous plants grow even during the dry season. We have made special survey trips to such areas to make observations on natural enemies. We made survey trips to south Thailand where the paddies were all in fallow except the experimental paddies in two experimental stations at Phatthalung and Nakhon Si Thammarat. We checked the paddies with rice in differing growth stages in the experimental fields. It was surprising to find that there were many natural enemies that had gathered on the rice plants from surrounding fallow areas. The following tables show our survey data in detail.

Table 14. Number of insects collected by the sweep net method in the off-season experimental paddies of the Phatthalung Rice Experiment Station, April 27, 1978.

Species	Host	Number per 50 sweeps
Paddy 1. Figures in Table indicate number collected per 50 sweeps from the paddy where rice plants were just before flowering stage with well irrigated water.		
	Parasites	
Ichneumonid	Stem-borer or defoliator (larva)	6
Charops unicolor	Defoliator (larva)	2
Tropobracon schoenobii	Stem-borer (larva)	13
Anagrus spp.	Hopper (egg)	144
Mymar taprobanicum	Hopper (egg)	2
Other Mymarid	Hopper (egg)	3
Trichogramma spp.	Stem-borer or defoliator (egg)	21
Oligosita spp.	Hopper (egg)	187
Gonatocerus sp.	Hopper (egg)	3
Tetrastichus schoenobii	Stem-borer (egg)	7
Tetrastichus formosanus	Hopper (egg)	10
Gryon nixoni	*Leptocorysa* (egg)	5

Table 14. (Continued)

Species	Host	Number per 50 sweeps
Other Scelionids	Moth or bug (egg)	41
Idris sp.	Spider (egg)	1
Aphanogmus sp.	Hyperparasite	8
Torymid	?	2
Eupteromalus parnarae	*Apanteles* (larva)	6
Elasmus sp.	Defoliator (larva)	2
Encyrtid	Defoliator (larva)	4
Eulophid	Defoliator (larva)	6
Parsierola sp.	Defoliator (larva)	2
Other Bethylid	Defoliator (larva)	2
Tachinid	Defoliator (larva)	7
	Predators	
Spiders	Rice insects	80
Amblyseius imbricatus	Rice gall-midge (egg), etc.	978
Agriocnemis pygmaeus	Stem-borer, defoliator, hopper (adult and larva)	62
Ischnura senegalensis	Stem-borer, defoliator, hopper (adult and larva)	2
Conocephalus sp.	Stem-borer (egg), hopper, etc.	18
Scymnus sp.	Aphid	2
Micraspis discolor	Thrips; hopper, stem-borer, defoliator (egg and larva), etc.	101

Table 14. (Continued)

Species	Host	Number per 50 sweeps
Harmonia octomaculata	Aphid; hopper, stem-borer, defoliator (egg and larva), etc.	3
Paederus fuscipes	Hopper; stem-borer, defoliator (egg and larva), etc.	2
Carabid	?	13
Ophionea ishiii ishiii	Hopper; defoliator (larva), etc.	29
Formicomus braminus	Stem-borer (egg), etc.	10
Cyrtorhinus lividipennis	Hopper (egg and 1st. instar larva)	35
Orius tantilus	Hopper, thrips; stem-borer, defoliator (egg and young larva)	2
Zicrona caerulea	Defoliator (larva)	2
Reduviid	Defoliator (larva), etc.	2
Anatrichus pygmaeus	Stem-borer (larva)	8
Poecilotraphera taeniata	Stem-borer (larva)	40
Predaceous Ceratopogonid	Chironomid (adult)	5
Trigoniid	Stem-borer, defoliator (egg, larva)	55
	Beneficial insect	
Sepedon ferruginea		15
	Other insects	
Dicladispa armigera		1
Nilaparvata lugens		1
Recilia dorsalis		4

Table 14. (Continued)

Species	Host	Number per 50 sweeps
Thaia		9
Hopper larva		245
Thrips		1145
Various Hemiptera		155
Scotinophara sp.		11
Leptocorysa sp.		2
Curculionid		6
Chrysomelid		23
Orthoptera		117
Chironomid		483
Larrid		1
Ceratina sp.		1

Paddy 2. Figures in Table indicate number collected per 50 sweeps from the paddy where young plants a few weeks old were planted with well irrigated water.

	Parasites	
Braconid	Defoliator (larva)	9
Charops bicolor	Defoliator (larva)	3
Ichneumonid	Defoliator (larva)	2
Anagrus sp.	Hopper (egg)	8
Oligosita spp.	Hopper (egg)	14
Gonatocerus sp.	Hopper (egg)	1

Table 14. (Continued)

Species	Host	Number per 50 sweeps
Paracentrobia sp.	Hopper (egg)	1
Trichogramma sp.	Stem-borer, defoliator (egg)	2
Tetrastichus schoenobii	Stem-borer (egg)	6
Eupteromalus parnarae	*Apanteles* (larva)	6
Gryon nixoni	*Leptocorysa* (egg)	4
Other Scelionid	?	22
Aphanogmus sp.	Hyperparasite	2
Eupelmid	?	1
Aphelinus sp.	Aphid	1
Platygasterid	?	1
Bethylid	Defoliator (larva)	2
Tachinid	Defoliator (larva)	14
	<u>Predators</u>	
Spiders	Rice insects	47
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	35
Ischnura senegalensis	Stem-borer, defoliator, hopper (adult and larva), etc.	4
Conocephalus sp.	Stem-borer (egg), hopper, etc.	1
Trigoniid	Stem-borer, defoliator (egg, larva)	6
Micraspis discolor	Thrips; hopper, stem-borer, defoliator (egg and larva), etc.	7

Table 14. (Continued)

Species	Host	Number per 50 sweeps
Harmonia octomaculata	Aphid; stem-borer, defoliator, hopper (egg and larva), etc.	1
Ophionea ishiii ishiii	Hopper; stem-borer, defoliator (egg and larva), etc.	1
Paederus fuscipes	Hopper; stem-borer, defoliator (egg and larva), etc.	1
Cyrtorhinus lividipennis	Hopper (egg and 1st. instar larva)	1
Orius tantilus	Hopper, thrips; stem-borer, defoliator (egg and young larva)	1
	<u>Other insects</u>	
Dicradispa armigera		1
Nilaparvata lugens		5
Recilia dorsalis		1
Nephotettix sp.		2
Other Homoptera		94
Homoptera larva		185
Scotinophara sp.		1
Thaia		5
Chrysomelid		31
Orthoptera		4
Thrips		20
Diptera		23

Table 14. (Continued)

Species	Host	Number per 50 sweeps
Ceratopogonid		43
Chironomid		323

Paddy 3. Figure in Table indicate number collected per 50 sweeps from the paddy where only ratoon plants were seen without water.

	Parasites	
Bracon sp.	?	1
Braconid	?	1
Oligosita sp.	Hopper (egg)	4
Telenomus sp.	Stem-borer (egg)	1
Tetrastichus schoenobii	Stem-borer (egg)	3
Tetrastichus sp.	?	1
Elasmid	Defoliator (egg)	4
Eulophid	?	1
Eupelmid	?	1
Encyrtid	Defoliator (larva)	1
Aphelinus sp.	Aphid	3
	Predators	
Spiders	Rice insects	86
Micraspis discolor	Thrips; hopper, stem-borer, defoliator (egg and larva), etc.	2
Formicomus braminus	Stem-borer (egg), etc.	2
Predaceous Ceratopogonid	Chironomid	4
Ants	Rice insects	7

Table 14. (Continued)

Species	Host	Number per 50 sweeps
	Other insects	
Nephotettix sp.		9
Recilia dorsalis		1
Thaia		1
Other Homoptera		16
Homoptera larva		19
Thrips		73
Hemiptera		7
Chrysomelid		1
Curculionid		1
Chironomid		50
Other Diptera		1
Orthoptera		6

Table 15. Number of insects collected by the sweep net method in the off-season experimental paddies of the Phatthalung Rice Experiment Station, January 25, 1979. Figures in Table indicate number collected per 50 sweeps from the paddy where the age of rice plant stage was 60 days with irrigated water.

Species	Host	Number per 50 sweeps
Paddy 1.		
Apanteles sp.	Defoliator (larva)	2
Braconid	Defoliator (larva)	2
Charops bicolor	Defoliator (larva)	1
Oligosita sp.	Hopper (egg)	2
Gonatocerus sp.	Hopper (egg)	5
Trichogrammatid	Stem-borer, defoliator (egg)	7
Anagrus sp.	Hopper (egg)	4
Tetrastichus schoenobii	Stem-borer (egg)	4
Tetrastichus sp.	?	1
Elasmus sp.	Defoliator (larva)	2
Eupteromalus parnarae	*Apanteles* (larva)	2
Idris spp.	Spider (egg)	26
Aphelinus sp.	Aphid	2
Pipunculid	Hopper	2
	Predators	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	550
Spiders	Rice insects	39

Table 15. (Continued)

Species	Host	Number per 50 sweeps
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	5
Ischnura senegalensis	Stem-borer, defoliator, hopper (adult and larva), etc.	4
Ophionea ishiii ishiii	Hopper; stem-borer, defoliator (egg and larva), etc.	2
Predaceous Ceratopogonid	Chironomid	4
	Beneficial insect	
Sepedon sp.		2
	Other insects	
Nilaparvata lugens		2
Nephotettix spp.		8
Nephotettix larva		7
Thaia		1
Thrips		48
Chironomid		180
Ceratopogonid		4
Other Diptera		3
Paddy 2.		
	Parasites	
Xanthopimpla sp.	Stem-borer, defoliator (larva)	1
Ichneumonid	?	1

Table 15. (Continued)

Species	Host	Number per 50 sweeps
Apanteles sp.	Defoliator (larva)	2
Braconid	Defoliator (larva)	2
Anagrus sp.	Hopper (egg)	6
Oligosita spp.	Hopper (egg)	19
Gonatocerus sp.	Hopper (egg)	1
Paracentrobia sp.	Hopper (egg)	2
Trichogramma spp.	Stem-borer, defoliator (egg)	9
Tetrastichus schoenobii	Stem-borer (egg)	4
Tetrastichus sp.	?	2
Elasmus sp.	Defoliator (larva)	1
Eupteromalus parnarae	*Apanteles* (larva)	1
Telenomus sp.	Stem-borer (egg)	4
Idris spp.	Spider (egg)	53
Other Scelionid	?	3
Aphanogmus sp.	Hyperparasite	2
Parsierola sp.	Defoliator (larva)	1
Elenchus yasumatsui	*Nilaparvata lugens, Sogatella furcifera* (larva)	1
	Predators	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	592
Spiders	Rice insects	38

Table 15. (Continued)

Species	Host	Number per 50 sweeps
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	8
Diplacodes trivialis	Stem-borer, defoliator (adult), etc.	1
Ophionea ishiii ishiii	Hopper; stem-borer, defoliator (egg and larva), etc.	1
Orius tantilus	Hopper, thrips; stem-borer, defoliator (egg and young larva)	1
Predaceous Ceratopogonid	Chironomid	3
	Beneficial insect	
Sepedon sp.		1
	Other insects	
Nephotettix sp.		7
Nephotettix larva		$
Thaia		1
Other Homoptera		3
Mirid		1
Ceratopogonid		6
Chironomid		193
Other Diptera		3

Table 16. Number of insects collected by the sweep net method in the off-season experimental paddies of the Nakhon Si Thammarat Rice Experiment Station, April 27, 1978. Figures in Table indicate number collected per 50 sweeps from the paddy where the rice plants were in the panicle development and heading stages with irrigated water.

Species	Host	Number per 50 sweeps
Paddy 1.		
	Parasites	
Ichneumon sp.	Defoliator (larva)	1
Xanthopimpla sp.	Stem-borer (larva)	2
Charops bicolor	Defoliator (larva)	5
Bracon chinensis	Stem-borer (larva)	2
Tropobracon schoenobii	Stem-borer (larva)	19
Apanteles sp.	Defoliator (larva)	1
Anagrus sp.	Hopper (egg)	1
Oligosita spp.	Hopper (egg)	175
Gonatocerus sp.	Hopper (egg)	3
Paracentrobia sp.	Hopper (egg)	6
Tetrastichus schoenobii	Stem-borer (egg)	3
Tetrastichus sp.	?	19
Eulophus sp.	?	2
Elasmus sp.	Defoliator (larva)	1
Eupteromalus parnarae	*Apanteles* (larva)	2
Eurytoma sp.	?	2

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Elasmus sp.	Defoliator (larva)	1
Eupteromalus parnarae	*Apanteles* (larva)	2
Eurytoma sp.	?	2
Encyrtid	Defoliator (larva)	2
Telenomus sp.	Stem-borer (egg)	5
Other Scelionid	?	13
Torymid	?	1
Diapriid	Diptera (pupa)	3
Cynipid	?	1
Aphelinus sp.	Aphid	1
Drynid	Hopper (larva and adult)	2
Parsierola sp.	Defoliator (larva)	1
Other Bethylid	Defoliator (larva)	2
	<u>Predators</u>	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	67
Spiders	Rice insects	199
Conocephalus sp. larva	Stem-borer, defoliator (egg and larva), hopper, etc.	12
Trigoniid	Stem-borer, defoliator (egg, larva)	10
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	7
Micraspis discolor	Thrips; hopper, stem-borer, defoliator (egg, and larva), etc.	30

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Paederus fuscipes	Hopper; stem-borer, defoliator (egg and larva), etc.	11
Formicomus braminus	Stem-borer (egg), etc.	2
Hapalochrus rufofasciatus	Stem-borer, defoliator (egg and larva) etc.	9
Reduviid	Rice insects	3
Poecilotraphera taeniata	Stem-borer (larva)	7
Anatrichus pygmaeus	Stem-borer (larva)	32
Predaceous Ceratopogonid	Chironomid	1
Ropalidia marginata	Defoliator (larva)	1
Ant	Rice insects	1
	Other insects	
Nephotettix sp.		6
Hopper larva		256
Thaia		27
Pentatomid and larva		41
Other homoptera		6
Thrips		89
Psyllid		83
Chrysomelid		50
Hydrophylid		115
Orthoptera		41
Diptera		219

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Paddy 2.		
	Parasites	
Ichneumonid	Defoliater (larva)	5
Xanthopimpla sp.	Stem-borer (larva)	1
Charops bicolor	Defoliator (larva)	3
Tropobracon schoenobii	Stem-borer (larva)	2
Anagrus sp.	Hopper (egg)	8
Oligosita spp.	Hopper (egg)	451
Gonatocerus sp.	Hopper (egg)	1
Paracentrobia sp.	Hopper (egg)	10
Trichogramma spp.	Stem-borer, defoliator (egg)	26
Tetrastichus schoenobii	Stem-borer (egg)	9
Tetrastichus formosanus	Hopper (egg)	45
Elasmus sp.	Defoliator (larva)	1
Eulophus sp.	?	6
Eupteromalus parnarae	*Apanteles* (larva)	2
Pteromalid	?	1
Eurytoma sp.	?	1
Encyrtid	Defoliator (larva)	1
Scelio facialis	Grasshopper (egg)	1
Telenomus sp.	Stem-borer (egg)	11
Gryon nixoni	*Leptocorysa* (egg)	3

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Other Scelionid	?	20
Platygasterid	?	1
Aphanogmus spp.	Hyperparasite	22
Diapriid	Diptera (pupa)	7
Aphelinus sp.	Aphid	1
Bethylid	Defoliator (larva)	1
Tachinid	Defoliator (larva)	12
	Predators	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	270
Spiders	Rice insects	165
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	2
Ischnura senegalensis	Stem-borer, defoliator, hopper (adult and larva), etc.	4
Brachythemis contaminata	Stem-borer, defoliator (adult), etc.	1
Micraspis discolor	Thrips; hopper, stem-borer, defoliator (egg, larva), etc.	295
Paederus fuscipes	Hopper; stem-borer, defoliator (egg and larval), etc.	63
Ophionea ishiii ishiii	Hopper, stem-borer, defoliator (egg and larva), etc.	1
Formicomus braminus	Stem-borer (egg), etc.	3

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Hapalochrus rufofasciatus	Stem-borer, defoliator (egg and larva), etc.	3
Reduviid	Rice insects	1
Orius tantilus	Hopper, thrips, stem-borer, defoliator (egg and young larva)	13
Poecilotraphera taeniata	Stem-borer (larva)	41
Anatrichus pygmaeus	Stem-borer (larva)	76
Conocephalus sp.	Stem-borer, defoliator (egg and larva), hopper, etc.	1
Trigoniid	Stem-borer, defoliator (egg, larva)	21
Predaceous Ceratopogonid	Chironomid	19
Ropalidia marginata	Defoliator (larva)	4
Odynerus sp.	Defoliator (larva)	2
	Beneficial insect	
Sepedon sp.		9
	Other insects	
Nephotettix sp.		2
Nephotettix larva		1162
Nilaparvata lugens		6
Recilia dorsalis		1
Thaia		30
Other hoppers		24

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Mirid		1
Hemiptera		4
Thrips		24
Dicladispa armigera		18
Other Chrysomelid		19
Hydrophilid		120
Staphylinid		1
Pselaphid		2
Ceratopogonid		21
Other Diptera		196
Paddy 3.		
	Parasites	
Ichneumonid	Defoliator (larva)	3
Charops bicolor	Defoliator (larva)	2
Bracon chinensis	Stem-borer (larva)	1
Tropobracon schoenobii	Stem-borer (larva)	1
Braconid	Defoliator (larva)	3
Anagrus sp.	Hopper (egg)	3
Oligosita spp.	Hopper (egg)	131
Paracentrobia sp.	Hopper (egg)	7
Trichogramma spp.	Stem-borer, defoliator (egg)	25

Table 16. (Continued)

Species	Host	Number per 50 Sweeps
Eupteromalus parnarae	*Apanteles* (larva)	2
Tetrastichus schoenobii	Stem-borer (egg)	11
Tetrastichus formosanus	Hopper (egg)	20
Elasmus sp.	Defoliator (larva)	1
Telenomus sp.	Stem-borer (egg)	11
Scelio facialis	Grasshopper (egg)	1
Other Scelionid	?	14
Aphanogmus sp.	Hyperparasite	6
Aphelinus sp.	Aphid	2
Parsierola sp.	Defoliator (larva)	3
Pipunculid	Hopper (larva)	1
Tachinid	Defoliator (larva)	10
	Predators	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	44
Spiders	Rice insects	74
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	5
Neurothemis tullia tullia	Stem-borer, defoliator (adult), etc.	1
Conocephalus sp. larva	Stem-borer, defoliator (egg and larva), hopper, etc.	5
Trigoniid	Stem-borer, defoliator (egg, larva)	10

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Micraspis discolor	Thrips; hopper, stem-borer, defoliator (egg and larva), etc.	83
Paederus fuscipes	Hopper; stem-borer, defoliator (egg and larva), etc.	12
Ophionea indica	Hopper, stem-borer, defoliator (egg and larva), etc.	1
Ophionea ishiii ishiii	Hopper, stem-borer, defoliator (egg and larva), etc.	1
Formicomus braminus	Stem-borer (egg), etc.	1
Hapalochrus rufofasciatus	Stem-borer, defoliator (egg and larva), etc.	4
Orius tantilus	Hopper, thrips, stem-borer, defoliator (egg and young larva)	2
Predaceous Ceratopogonid	Chironomid	18
Ropalidia marginata	Defoliator (larva)	1
	<u>Other insects</u>	
Nephotettix sp.		1
Nephotettix sp. larva		493
Sogatella furcifera		3
Thaia		9
Other Homoptera		7
Hemiptera		8

Table 16. (Continued)

Species	Host	Number per 50 sweeps
Thrips		58
Dicradispa armigera		6
Chrysomelid		24
Hydrophylid		38
Staphylinid		2
Curculionid		7
Orthoptera		1
Diptera		41

On February 20th, 1979 we made a survey in north Thailand, Ban Suk Sawadee, Amphoe Muang, Lampang. This one crop rice area was very dry with very few green vegetated areas. We came across a long ditch with plenty of water where there were weeds in and along the edges. Our survey here showed the occurrence of many species of natural enemies of rice pests (Table 17). It was apparent that this area was only a refuge area of the natural enemies of rice pests.

Table 17. Number of insects collected by the sweep net method along the long ditch with plenty of water and green wild grasses, at Ban Suk Sawadee, Amphoe Muang, Lampang, February 20, 1979. Vast areas surrounding this ditch were very dry, being completely isolated from the green vegetated areas. Figures in Table indicate number collected per 50 sweeps from the ditch area.

Species	Host	Number per 50 sweeps
	Parasites	
Bracon chinensis	Stem-borer (larva)	1
Tropobracon schoenobii	Stem-borer (larva)	1
Phanerotoma sp.	?	1
Braconid	?	2
Anagrus sp.	Hopper (egg)	3
Oligosita sp.	Hopper (egg)	12
Gonatocerus sp.	Hopper (egg)	1
Trichogramma sp.	Stem-borer (egg)	1
Tetrastichus schoenobii	Stem-borer (egg)	1
Tetrastichus formosanus	Hopper (egg)	1
Elasmus sp.	Defoliator (larva)	1
Pteromalid	?	7
Eurytoma sp.	Rice gall-midge (larva)	1
Telenomus sp.	Stem-borer (egg)	52
Other Scelionid	?	2
Aphanogmus sp.	Hyperparasite	3

Table 17. (Continued)

Species	Host	Number per 50 sweeps
Cynipid	?	1
Aphelinus sp.	Aphid	5
Bethylid	Defoliator (larva)	1
Drynid	Hopper (larva)	1
Pipunculid	Hopper (larva)	1
Tachinid	Defoliator (larva)	1
	Predators	
Spiders		175
Agriocnemis femina	Stem-borer, defoliator, hopper (adult and larva), etc.	13
Conocephalus sp.	Stem-borer, defoliator (egg and larva), hopper, etc.	5
Conocephalus sp. larva	Stem-borer, defoliator (egg and larva), hopper, etc.	35
Trigoniid	Stem-borer, defoliator (egg, larva)	6
Cybocephalus sp.	?	3
Predaceous Ceratopogonid	Chironomid	8
Ant (*Monomorium* sp.)	Rice insects	2
	Other insects	
Sogatella furcifera		3
Other Homoptera		24
Homoptera larva		168

Table 17. (Continued)

Species	Host	Number per 50 sweeps
Hemiptera		2
Thrips		12
Chrysomelid		6
Bruchid		26
Curculionid		2
Ceratopogonid		85
Chironomid		120
Euscyrtus sp.		34
Euscyrtus sp. larva		50
Oxya sp. larva		22
Oxya sp.		15

In the central plain, we made several research trips to the wild rice areas to study the natural enemies of rice pests. We found several wild rice areas adjacent to rice paddies where rice plants were not yet transplanted. In Chachoengsao area farmers are cultivating two (sometimes three) crops of rice per year thanks to the development of irrigation system. But, owing to various factors involved in farming there may be some intervals between the harvest of the first crop and the start of the second one. In such a case the presence of wild rice area may serve greatly to the conservation or refuge area of natural enemies of rice pests. The following tables show the fact clearly.

Table 18. Number of insects collected by the sweep net method in the wild rice area of Bannampriew, Chachoengsao, June 29, 1978.

Species	Host	Number collected
	Parasites	
Anagrus sp.	Hopper (egg)	2
Oligosita spp.	Hopper (egg)	21
Gonatocerus sp.	Hopper (egg)	26
Trichogramma spp.	Stem-borer, defoliator (egg)	6
Tetrastichus schoenobii	Stem-borer (egg)	1
Tetrastichus sp. 1	?	2
Tetrastichus sp. 2	?	3
Tetrastichus sp. 3	?	4
Elasmus sp.	Defoliator (larva)	1
Telenomus sp.	Stem-borer (egg)	1
Other Scelionid	?	4
Platygaster oryzae	Rice gall-midge (egg)	21
Encyrtid	?	1
Predaceous Ceratopogonid		1
	Predators	
Spiders	Rice insects	50
Agriocnemis d'abreui	Stem-borer, defoliator, hopper (adult and larva), etc.	2
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	4

Table 18. (Continued)

Species	Host	Number collected
Neurothemis tullia tullia	Stem-borer, defoliator (adult), etc.	5
Harmonia octomaculata	Aphid, stem-borer, defoliator, hopper (egg and larva), etc.	1
Ants (4 spp.)	Rice insects	13
	Other insects	
Miscellaneous species		abundant

Table 19. Number of insects collected by the sweep net method in the wild rice area of Bannampriew, Chachoengsao, July 12, 1978.

Species	Host	Number collected
	<u>Parasites</u>	
Anagrus sp.	Hopper (egg)	2
Oligosita spp.	Hopper (egg)	13
Gonatocerus spp.	Hopper (egg)	18
Paracentrobia sp.	Hopper (egg)	1
Trichogramma spp.	Stem-borer, defoliator (egg)	9
Tetrastichus formosanus	Hopper (egg)	2
Tetrastichus schoenobii	Stem-borer (egg)	5
Telenomus sp.	Stem-borer (egg)	21
Gryon nixoni	*Leptocorysa* (egg)	2
Idris sp.	Spider (egg)	1
Other Scelionid	?	7
Aphanogmus sp.	Hyperparasite	5
Eupteromalus parnarae	*Apanteles* (larva)	1
Neanastatus oryzae	Rice gall-midge (larva)	1
Obtusiclava oryzae	Rice gall-midge (larva)	2
Platygaster oryzae	Rice gall-midge (egg)	43
Encyrtid	?	3
Aphelinus sp.	Aphid	6
Bethylid	Defoliator (larva)	1
Dryinid	*Nephotettix* (larva)	5

Table 19. (Continued)

Species	Host	Number collected
	Predators	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	42
Spiders	Rice insects	45
Agriocnemis d'abreui	Stem-borer, defoliator, hopper (adult and larva), etc.	3
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	15
Ischnura senegalensis	Stem-borer, defoliator, hopper (adult and larva), etc.	1
Neurothemis tullia tullia	Stem-borer, defoliator (adult), etc.	1
Conocephalus sp.	Stem-borer, defoliator (egg and larva), hopper, etc.	1
Micraspis discolor	Thrips, hopper, stem-borer, defoliator (egg and larva), etc.	1
Harmonia octomaculata	Aphid, stem-borer, defoliator, hopper (egg and larva), etc.	1
Carabid	Rice insects	1
Anatrichus pygmaeus	Stem-borer (larva)	2
Predaceous Ceratopogonid	Chironomid	1
Ants (4 spp.)	Rice insects	102
	Other insects	
Homoptera		57
Dicradispa armigera		1

Table 19. (Continued)

Species	Host	Number collected
Ceratopogonid		3
Chironomid		173
Small Diptera		13
Orthoptera		38
Thrips		11

Table 20. Number of insects collected by the sweep net method in the wild rice area of Bangkanark, Chachoengsao, June 29, 1978.

Species	Host	Number collected
	Parasites	
Anagrus sp.	Hopper (egg)	8
Oligosita spp.	Hopper (egg)	28
Gonatocerus sp.	Hopper (egg)	7
Paracentrobia sp.	Hopper (egg)	2
Trichogramma sp.	Stem-borer, defoliator (egg)	3
Tetrastichus schoenobii	Stem-borer (egg)	2
Tetrastichus sp. 1	?	5
Tetrastichus sp. 2	?	2
Elasmus sp.	Defoliator (larva)	1
Telenomus sp.	Stem-borer (egg)	2
Scelio facialis	Grasshopper (egg)	1
Other Scelionid	?	5
Platygaster oryzae	Rice gall-midge (egg)	1
Idris sp.	Spider (egg)	1
Obtusiclava oryzae	Rice gall-midge (larva)	1
Encyrtid	?	1
Cynipid	?	1
Aphelinus sp.	Aphid	2
Dryinid	*Nephotettix* (larva)	2

Table 20. (Continued)

Species	Host	Number collected
	Predators	
Spiders	Rice insects	80
Agriocnemis d'abreui	Stem-borer, defoliator, hopper (adult and larva), etc.	1
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	2
Conocephalus sp.	Stem-borer, defoliator (egg and larva), hopper, etc.	2
Conocephalus sp. larva	Stem-borer, defoliator (egg and larva), hopper, etc.	1
Mantid	Rice insects	1
Poecilotraphera taeniata	Stem-borer (larva)	1
Anatrichus pygmaeus	Stem-borer (larva)	1
Ropalidia marginata	Defoliator (larva)	1
Odynerus sp.	Defoliator (larva)	1
Ants (5 spp.)	Rice insects	44
	Beneficial insect	
Sepedon sp.		1
	Other insects	
Thrips		6
Orthoptera		25
Other insects		abundant

Table 20. Number of insects collected by the sweep net method in the wild rice area of Bangkanark, Chachoengsao, July 12, 1978.

Species	Host	Number collected
	<u>Parasites</u>	
Anagrus sp.	Hopper (egg)	1
Oligosita spp.	Hopper (egg)	12
Mymarid	Hopper (egg)	3
Gonatocerus sp.	Hopper (egg)	39
Paracentrobia sp.	Hopper (egg)	2
Trichogramma sp.	Stem-borer, defoliator (egg)	7
Tetrastichus schoenobii	Stem-borer (egg)	3
Tetrastichus formosanus	Hopper (egg)	2
Tetrastichus ayyari	Stem-borer (larva)	6
Tetrastichus sp.	?	1
Telenomus sp.	Stem-borer (egg)	24
Scelionids	?	28
Eurytoma sp.	Rice gall-midge (larva)	3
Eupteromalus parnarae	*Apanteles* (larva)	4
Elasmus sp.	Defoliator (larva)	6
Spalangia sp.	Diptera (puparium)	2
Encyrtid	Defoliator (larva)	1
Braconid	Defoliator (larva)	1
Platygaster oryzae	Rice gall-midge (egg)	7
Neanastatus oryzae	Rice gall-midge (larva)	3
Obtusiclava oryzae	Rice gall-midge (larva)	2

Table 20. (Continued)

Species	Host	Number collected
Cynipid	?	1
Bethylid	Defoliator (larva)	1
Dryinid	*Nephotettix* (larva)	45
Podagrion sp.	Mantid (egg)	1
	<u>Predators</u>	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	numerous
Spiders	Rice insects	50
Agriocnemis d'abreui	Stem-borer, defoliator, hopper (adult and larva), etc.	5
Agriocnemis femina	Stem-borer, defoliator, hopper (adult and larva), etc.	1
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	16
Diplacodes nebulosa	Stem-borer, defoliator (adult)	1
Micraspis discolor	Thrips, hopper, stem-borer, defoliator (egg and larva), etc.	1
Predaceous Ceratopogonid	Chironomid (adult)	7
Ropalidia fasciata	Defoliator (larva)	1
Ants (3 spp.)	Rice insects	34
	<u>Other insects</u>	
Thrips		48
Chironomids		numerous

Table 20. (Continued)

Species	Host	Number collected
Elaterid		8
Other Coleoptera		7
Homoptera		6
Hemiptera		1
Encopterid (adult and larva)		21

Table 21. Number of insects collected by the sweep net method in the wild rice area of Bangkanark, Chachoengsao, July 28, 1978.

Species	Host	Number collected
	Parasites	
Oligosita spp.	Hopper (egg)	5
Gonatocerus sp.	Hopper (egg)	7
Mymarid	Hopper (egg)	1
Trichogramma sp.	Stem-borer (egg)	3
Telenomus sp.	Stem-borer (egg)	11
Gryon nixoni	*Leptocorysa* (egg)	7
Scelionids	?	8
Aphanogmus sp.	Hyperparasite	6
Tetrastichus spp.	?	3
Obtusiclava oryzae	Rice gall-midge (larva)	1
Diapriid	Diptera (puparium)	1
Cynipid	?	1
Encyrtid	Defoliator (larva)	3
Chalcid	?	1
	Predators	
Amblyseius imbricatus	Rice gall-midge (egg), etc.	5
Spiders	Rice insects	83
Agriocnemis d'abreui	Stem-borer, defoliator, hopper (adult and larva), etc.	1
Neurothemis tullia tullia	Stem-borer, defoliator (adult)	2

Table 21. (Continued)

Species	Host	Number collected
Micraspis discolor	Thrips, hopper, stem-borer, defoliator (egg and larva), etc.	2
Cybocephalus sp.	?	7
Anatrichus pygmaeus	Rice Stem-borer (larva)	3
Predaceous Ceratopogonids	Chironomid (adult)	13
Tapinoma sp.		202
Technomyrmex sp.		81
Pheidole sp.		10
Other ants		34
	Other insects	
Thrips		30
Euscyrtus sp.		25
Scotinophara sp.		1
Homoptera		65
Elaterids		10
Curculionids		1
Chrysomelids		3
Carabids		4
Other insects		very few

Corn and sugarcane have the same or closely related insect pests, especially stem-borers as rice. So, if rice plants are not available, the natural enemies move to corn or sugarcane fields nearby where they attack the same or other pests. The natural enemies involved here include various species of predators including *Harmonia octomaculata*, *Micraspis discolor*, *Micraspis vincta*, *Formicomus braminus*, *Hapalochrus rufofasciatus*, *Poecilotraphera taeniata* and such parasites as *Apanteles* spp., *Bracon chinensis*, *Tropobracon schoenobii*, *Tetrastichus ayyari*, *Tetrastichus schoenobii*, *Trichogramma* spp. and *Telenomus* sp.

Recently, with the development of irrigation system, the area of rice paddies for the second crop has been increasing. Our survey revealed that the natural enemies of rice pests has increased in such areas. On February 21, 1979, we sampled a rice paddy in Amphoe Wiang Pa Pao, Chiang Rai Province. The result is shown as in the following table.

Table 22. Number of insects collected by the sweep net method at an isolated rice paddy of Amphoe Wiang Pa Pao, Chiang Rai, February 21, 1979. The rice plants were transplanted rather earlier in the season and in the tillering stage. Nearby this rice paddy there was found not a single rice paddy, and the surrounding areas just started to prepare paddies for the second crop. Figures in table indicate number collected per 50 sweeps.

Species	Host	Number per 50 sweeps
	Parasites	
Charops bicolor	Defoliator (larva)	1
Ichneumonids	Defoliator (larva)	5
Bracon chinensis	Stem-borer (larva)	2
Tropobracon schoenobii	Stem-borer (larva)	2
Apanteles spp.	Defoliator (larva)	2
Dacnusa sp.	Leaf miner (larva)	1
Other Braconid	?	1
Mymar taprobanicum	Hopper (egg)	1
Anagrus sp.	Hopper (egg)	9
Oligosita sp.	Hopper (egg)	11
Paracentrobia sp.	Hopper (egg)	9
Gonatocerus sp.	Hopper (egg)	1
Trichogramma spp.	Stem-borer, defoliator (egg)	45
Tetrastichus schoenobii	Stem-borer (egg)	19
Tetrastichus formosanus	Hopper (egg)	2

Table 22. (Continued)

Species	Host	Number per 50 sweeps
Tetrastichus sp. 1	?	1
Tetrastichus sp. 2	?	1
Elasmus sp.	Defoliator (larva)	3
Eupteromalus parnarae	*Apanteles* (larva)	9
Pteromalid	?	1
Eurytoma sp.	Rice gall-midge (larva)	11
Telenomus sp.	Stem-borer (egg)	2
Other Scelionids	?	29
Encyrtid	Defoliator (larva)	4
Aphanogmus sp.	Hyperparasite	2
Cynipid	?	3
Aphelinus sp.	Aphid	8
Pipunculids	Hopper (larva)	2
Tachinids	Defoliator (larva)	36
	<u>Predators</u>	
Spiders	Rice insects	162
Agriocnemis pygmaea	Stem-borer, defoliator, hopper (adult and larva), etc.	1
Ischnura senegalensis	Stem-borer, defoliator, hopper (adult and larva), etc.	4
Diplacodes trivialis	Stem-borer, defoliator (adult)	2
Micraspis discolor	Thrips, stem-borer, hopper, defoliator (egg and larva), etc.	14

Table 22. (Continued)

Species	Host	Number per 50 sweeps
Nabis capsiformis	Defoliator (larva), hopper, etc.	2
Orius tantilus	Hopper, thrips, stem-borer, defoliator (egg and young larva)	1
Anatrichus pygmaeus	Stem-borer (larva)	235
Empids	?	29
Syrphid	Aphid	1
Predaceous Ceratopogonid	Chironomid	4
Orthoptera	?	4
	<u>Other insects</u>	
Nephotettix sp.		5
Nephotettix spp. larva		195
Recilia dorsalis		2
Other Homoptera		18
Other Homoptera larva		30
Lygaeids		4
Psyllid		3
Thrips		73
Chrysomelids		19
Curculionids		17
Bruchids		27
Fungivorous beetle larva		130
Pyralid larva		3

Table 22. (Continued)

Species	Host	Number per 50 sweeps
Oxya sp.		4
Oxya sp. larva		26
Ceratopogonids and other small Diptera		378

The natural enemies listed above might be those that have moved into the paddy of the second crop from nearby refuge areas.

The alternate hosts of *Trichogramma* spp. are interesting when we consider the parasitic wasps in which natural enemies survive. *Trichogramma* spp. have alternate hosts, egg-masses of the marsh-flies of the genus *Sepedon*. If egg-masses of stem-borers are not available in the rice paddies, the *Trichogramma* spp. move into the swamp or ditch areas where egg-masses of *Sepedon* are available. Or, in case the egg-masses of stem-borers are very few to parasitize in the rice paddies, the *Trichogramma* spp. can utilize the egg-masses of *Sepedon* flies which are also very commonly found in the rice paddies. Anyway, the presence of *Sepedon* flies is very important in the maintenance of populations of *Trichogramma* species in rice cultivation.

In Thailand, there occur four species: *Sepedon sauteri*, *S. plumbella*, *S. ferruginea* and *S. lotifera*. These marsh-flies lay their eggs on the surface of the leaves of rice, wild rice or other aquatic weeds. The habitat of *Sepedon* flies is therefore an excellent refuge area for *Trichogramma*. The larvae of marsh-flies feed on aquatic snails which may transmit fluke disease to domestic animals. So, marsh-flies are useful in the biological control of stem-borers and aquatic snails at the same time.

One of the most important egg-parasites of *Tryporyza* or *Scirpophaga* moths is the species of the genus *Telenomus* belonging to the family Scelionidae. Recently we found that the egg-mass of a species of *Tabanus*, hornfly, may serve as an alternate host of *Telenomus* species. The egg-masses of this *Tabanus* are usually found on the leaves of rice, wild rice or some other weeds in the rice paddies or swamp areas. Therefore, the presence of *Tabanus* species in or nearby the rice paddies is very significant in keeping and conserving populations of *Telenomus* species in rice cultivation.

INSECT PESTS ON CROPS NEAR RICE PADDIES
— COMMON NATURAL ENEMIES

It would appear that when rice plants are not available in the paddies in the dry season some parasites and predators utilize the hosts on sugarcane and grain. When these crops are cultivated nearby in the same season, some natural enemies of rice pests escape from one crop field where, for instance, insecticides have been applied, to another which is insecticides free. Studies were made of the insect pests of sugarcane and grain near the rice paddies and their natural enemies. The following natural enemies were commonly found in rice, grain and sugarcane fields.

Parasites:

Trichogramma japonicum ....parsitic on eggs of stem-borers infesting rice, grain and sugarcane.

Trichogramma ishiii ....the same as above.

Trichogramma chilotraeae ......parasitic on eggs of *Chilo polychrysus* on rice, *Chilo infuscatellus* on sugarcane and *Ostrinia furnacalis* on grain.

Telenomus dignus ....parasitic on eggs of *Chilo suppressalis* and *Chilo polychrysus*.

Telenomus rowani ....parasitic on eggs covered with hairs of stem-borers on rice, grain and sugarcane.

Telenomus sp. ....the same as above.

Tetrastichus schoenobii ......parasitic on eggs covered with hairs of stem-borers on rice, grain and sugarcane.

Apanteles flavipes ....parasitic on larvae of stem-borers on rice, grain and sugarcane.

Bracon chinensis ....the same as above.

Tropobracon schoenobii ....the same as above.

Amauromorpha accepta schoenobii ....the same as above.

Tetrastichus ayyari ....parasitic on pupae of stem-borers on rice, grain and sugarcane.

Predators: -

Anatrichus pygmaeus ....predaceous on larvae of stem-borers on rice, grain and sugarcane.

Poecilotraphera taeniata ......the same as above.

Conocephalus longipennis ......predaceous on eggs of stem-borers and

	defoliators and nymphs and adults of leaf- and plant-hoppers on rice, grain and sugarcane.
Conocephalus maculatus	the same as above.
Conocephalus sp.	the same as above.
Micraspis discolor	predaceous on eggs of stem-borers and defoliators, larvae of defoliators and nymphs of leaf- and plant-hoppers on rice, grain and sugarcane.
Micraspis vincta	the same as above.
Harmonia octomaculata	the same as above.
Ophionea indica	predaceous on larvae of defoliators and gall-midge and nymphs and adults of leaf- and plant-hoppers on rice, grain and sugarcane.
Ophionea ishiii	the same as above.
Paederus fuscipes	predaceous on eggs, larvae and nymphs of stem-borers and defoliators, and nymphs and adults of leaf- and plant-hoppers on rice, grain and sugarcane.
Formicomus braminus braminus ..	predaceous on eggs of stem-borers on rice, grain and sugarcane, and larvae and pupae of defoliators on rice, grain and sugarcane.
Hapalochrus rufofasciatus	predaceous on eggs stem-borers on rice, grain and sugarcane, on eggs, larvae, and pupae of defoliators on rice, grain, and sugarcane, and on nymphs and adults of leaf- and plant-hoppers on rice, grain and sugarcane.
Ropalidia variegata jacobsoni ..	predaceous on larvae of defoliators on rice, grain and sugarcane.
Ropalidia fasciata	the same as above.
Ropalidia marginata sundaica ..	the same as above,
Some spiders..................	predaceous on larvae and adults of defoliators on rice, grain and sugarcane, on adults of stem-borers on rice, grain and sugarcane, on adults of gall-midge on rice, and on nymphs and adults of leaf- and plant-hoppers on rice, grain and sugarcane.

Some ants......................predaceous on eggs, larvae and pupae of defoliators on rice, grain and sugarcane, on eggs and adults of stem-borers on rice, grain and sugarcane, on nymphs and adults of leaf- and plant-hoppers on rice, grain and sugarcane, and on eggs of gall-midge on rice.

RESISTANT VARIETIES OF RICE AGAINST INSECT PESTS AND DISEASES

The development and use of rice varieties resistant to pests and diseases have been regarded as the most effective components of integrated rice pest and disease control. Many works along this line have been and are under investigation and trial in rice growing countries. Thailand is not an exception. In Thailand, Division of Breeding, Department of Agriculture, Ministry of Agriculture and Cooperatives is responsible to this field and has developed some pest and disease resistant ones. Among the major pests and diseases of rice, efforts have been made exclusively to develop the resistant varieties of rice against *Nephotettix* spp., *Nilaparvata lugens*, *Orseolia oryzae*, Blast, Bacterial Leaf Blight, Tungro Virus and Brown Spot diseases. The susceptibility of all recommended varieties of these pests and diseases is summarized in the following tables. In this connection, considerations should be taken in the vector insects which transmit the following diseases to the rice plant.

Yellow Orange Leaf (Tungro) : Caused by virus, transmitted by *Nephotettix virescens*, *N. nigropictus* and *Recilia dorsalis*.

Ragged Stunt : Caused by virus, transmitted by *Nilaparvata lugens*.

Grassy Stunt : Cause unknown, transmitted by *Nilaparvata lugens*.

Orange Leaf : Caused by mycoplasma-like organism, transmitted by *Recilia dorsalis*.

Yellow Dwarf : Caused by mycoplasma-like organism, transmitted by *Nephotettix virescens* and *N. nigropictus*.

Table 23. Susceptibility of all recommended varieties of rice against *Nephotettix* spp. and diseases in Thailand.

Resistant varieties

Non-glutinous varieties

Khao Leuang 88 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Nam Sa-gui 19 (Photo-sensitive, moderately susceptible against Blast and Brown Spot, susceptible against Bacterial Leaf Blight and Tungro Virus)

Puang Rai 2 (Photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, moderately susceptible against Brown Spot)

RD_3 (Non-photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_9 (Moderately resistant, high yielding, non-photo-sensitive, susceptible against Blast and Tungro Virus, highly susceptible against Bacterial Leaf Blight, moderately resistant against Brown Spot)

Glutinous rice variety

RD_4 (High yielding, non-photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, resistant against Brown Spot).

Susceptible varieties

Non-glutinous varieties

Khao Dawk Mali 105 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Khao Pahk Maw 148 (Photo-sensitive, moderately susceptible against Blast, Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Leuang Pratew 123 (Photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, moderately susceptible against Tungro Virus and Brown Spot)

Leuang Yai 148 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Nahng Mon S-4 (Photo-sensitive, moderately susceptible against Blast, Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Taichung $(N)_1$ (Non-photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, moderately susceptible against Tungro Virus and Brown Spot)

RD_1 (High yielding, non-photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_5 (Highly susceptible, non-photo-sensitive, moderately resistant against Blast, resistant against Bacterial Leaf Blight, susceptible against Tungro Virus, moderately susceptible against Brown

Spot)

RD_7 (High yielding, non-photo-sensitive, moderately resistant against Blast, resistant against Bacterial Leaf Blight, susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_{11} (High yielding, non-photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_{13} (High yielding, photo-sensitive, resistant against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_{15} (Photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_{17} (High yielding, non-photo-sensitive)

RD_{19} (High yielding, photo-sensitive)

Khao Leuang 88 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Glutinous varieties

Hahng Yi 71 (Photo-sensitive, resistant against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately susceptible against Brown Spot)

Muey Nawng 62M (Photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

Niaw San Pah Tawng (New San Pa Tong) (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_2 (High yielding, non-photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, moderately susceptible against Tungro Virus, resistant against Brown Spot)

RD_6 (High yielding, photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_8 (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

Table 24. Susceptibility of all recommended varieties of rice against *Nilaparvata lugens* and diseases in Thailand.

Resistant Varieties

Non-glutinous variety

RD_9 (Highly resistant, high yielding, non-photo-sensitive, susceptible against Blast and Tungro Virus, highly susceptible against Bacterial Leaf Blight, moderately resistant against Brown Spot)

Glutinous variety

RD_4 (Highly resistant, high yielding, non-photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, resistant against Brown Spot)

Susceptible varieties

Non-glutinous varieties

Khao Dawk Mali 105 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Khao Leuang 88 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight, and Brown Spot, highly susceptible against Tungro Virus)

Khao Pahk Maw 148 (Photo-sensitive, moderately susceptible against Blast, Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Leb Mue Nahng 111 (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

Leuang Pratew 123 (Photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, moderately susceptible against Tungro Virus and Brown Spot)

Leuang Yai 148 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Nahng Mon S-4 (Photo-sensitive, moderately susceptible against Blast, Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Nahng Payah 132 (Photo-sensitive, susceptible against Blast and Tungro Virus, moderately susceptible against Bacterial Leaf Blight, moderately resistant against Brown Spot)

Nam Sa-gui 19 (Photo-sensitive, moderately susceptible against Blast and Brown Spot, susceptible against Bacterial Leaf Blight and Tungro Virus)

Peuak Nam 43 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

Tapow Gaew 161 (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_1 (Highly susceptible, high yielding, non-photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_3 (Highly susceptible, high yielding, non-photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_5 (Highly susceptible, non-photo-sensitive, moderately resistant against Blast and Bacterial Leaf Blight, susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_6 (High yielding, photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_7 (Highly susceptible, high yielding, non-photo-sensitive, moderately resistant against Blast, resistant against Bacterial Leaf Blight, susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_{11} (Highly susceptible, high yielding, non-photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_{13} (Photo-sensitive, resistant against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_{15} (Photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_{17} (High yielding, non-photo-sensitive)

RD_{19} (High yielding, photo-sensitive)

Khao Leuang 88 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot; susceptible against Tungro Virus)

Glutinous varieties

Muey Nawng 62M (Photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

Nahng Chalawng (Photo-sensitive, moderately resistant against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately susceptible against Brown Spot)

Niaw San Pah Tawng (New San Pa Tong) (Photo-sensitive, moderately susceptible against Tungro Virus, moderately resistant against Brown Spot)

Hahng Yi 71 (Photo-sensitive, resistant against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately susceptible against Brown Spot)

Pin Gaew (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

RD_2 (Highly susceptible, high yielding, non-photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, moderately susceptible against Tungro Virus, resistant against Brown Spot)

RD_6 (Photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight, and Tungro Virus, moderately resistant against Brown Spot)

RD_8 (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

Table 25. Susceptibility of all recommended varieties of rice against *Orseolia oryzae* and diseases in Thailand.

Resistant varieties

Glutinous varieties

Muey Nawng 62M (Highly resistant, photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_4 (Highly resistant, high yielding, non-photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, resistant against Brown Spot)

Susceptible varieties

Non-glutinous varieties

Khao Dawk Mali 105 (Photo-sensitive, susceptible against Blast moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Khao Pahk Maw 148 (Photo-sensitive, moderately susceptible against Blast, Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Khao Reung 88 (Photo-sensitive)

Leb Mue Nahng 111 (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

Leuang Pratew 123 (Photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, moderately susceptible against Tungro Virus and Brown Spot)

Leuang Yai 148 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Nahng Mon S-4 (Photo-sensitive, moderately susceptible against Blast, Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus.

Nahng Payah 132 (Photo-sensitive, susceptible against Blast and Tungro Virus, moderately susceptible against Bacterial Leaf Blight, moderately resistant against Brown Spot)

Peuak Nam 43 (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

Pin Gaew (Photo-sensitive, susceptible against Blast, moderately susceptible against Bacterial Leaf Blight and Brown Spot, highly susceptible against Tungro Virus)

Tapow Gaew 161 (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_1 (Highly susceptible, high yielding, non-photo-sensitive, susceptible against Blast, Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_3 (High yielding, non-photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_5 (Non-photo-sensitive, moderately resistant against Blast and Bacterial Leaf Blight, susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_7 (Highly susceptible, high yielding, non-photo-sensitive, moderately resistant against Blast, resistant against Bacterial Leaf Blight, susceptible against Tungro Virus, moderately susceptible against Brown Spot)

RD_9 (Non-photo-sensitive, susceptible against Blast and Tungro Virus, highly susceptible against Bacterial Leaf Blight, moderately resistant against Brown Spot)

RD_{11} (Highly susceptible, high yielding, non-photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_{13} (Photo-sensitive, resistant against Blast, susceptible against Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_{15} (Photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_{17} (High yielding, non-photo-sensitive)

RD_{19} (High yielding, photo-sensitive)

Glutinous varieties

Nahng Chalawng (Photo-sensitive, moderately resistant against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately susceptible against Brown Spot)

Niaw San Pah Tawng (New San Pa Tong) (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, susceptible against Tungro Virus, moderately resistant against Brown Spot)

RD_2 (High yielding, non-photo-sensitive, susceptible against Blast and Bacterial Leaf Blight, moderately susceptible against Tungro Virus, resistant against Brown Spot)

RD_6 (Photo-sensitive, moderately susceptible against Blast, susceptible against Bacterial Leaf Blight and Tungro Virus, moderately resistant against Brown Spot)

RD_8 (Photo-sensitive, moderately susceptible against Blast and Bacterial Leaf Blight, highly susceptible against Tungro Virus, moderately resistant against Brown Spot)

As pointed out by Horber (1972),"breeding resistant crops is neither simple nor quick. The insect-host plant relationship requires intricate knowledge of the physiology and behavior of insects, morphology, physiology and genetics of plants. Several genes must be combined and their frequency increased to confer the resistance required in the majority of the plant population. Resistant developed to a pest may not be permanent, or may leave the plant unprotected from another pest."

Insect-resistance is said to be divided into three categories : "(1) Non-preference, rendering the plant unfit to attractive to insect pests as food, for oviposition, or shelter; (2) Antibiosis, adversely affecting growth, survival or reproduction of the pest; and (3) Tolerance, imparting ability to withstand, or to recover from injury, despite supporting a pest population that would severely damage susceptible hosts." As mentioned by Horber (1972), the proper balance of the three categories of resistance in the same variety can be achieved and evaluated in pest management programs involving large area over extended periods. "Unfortunately, the present resistant cultivars of rice plant have been developed and tested rather in a very narrow area in one country under comparatively shorter period."

It has been a well-known fact that the improved varieties of cultivated plants vary in their characteristic susceptibility to insect pests very often, affected by such factors as climates (seasons included), cultivation methods, nutritional conditions of the plants, places, etc. There are many examples in which some resistant cultivars were not resistant when they were used in areas other than the place where they were screened and breeded and they suffered a severe damage by the pests. For example, several resistant varieties of rice plant which were said to be very resistant to the Brown Plant Hopper were introduced and cultivated widely in the Solomon Islands several years ago. These were screened in the IRRI. These cultivars were promptly attacked by the pest in question and severe infestation to rice plants occurred on the islands. In such cases, plant breeders and the applied entomologists involved in this problem express their opinion that there might be created a special biotype of the pest to which the new cultivar is not resistant at all. And many other entomologists simply follow their opinion without making any questions. Why we must consider the problem and make speculations only from the side of insect pests? It seems that the plant breeders and the applied entomologists believe firmly the susceptibility of the new cultivar as definite. Therefore, the attack by insect pests to the new so-called resistant cultivar is thought to be caused by the new biotype of insect pests. We must not forget to consider or analyze the problem also from the side of rice plant.

In this connection one experiment made by Dr. Hidaka and Mr. Vanich (1979) on the rice gall-midge is of great interest. In Thailand, a resistant cultivar to the rice gall-midge is RD_4. They kept the trays of 25 days old rice seedlings in three big insect cages in the insect rearing room, and released female midges to these cages at a rate of 5, 15, and 30, respectively. These rice seedlings were dissected at 30 days after larval penetration into the growing points for checking adult emergence, larval development, and gall formation. The number of tillers was more abundant in 30 adult plot than 5 and 15 adult plots, and the tillers also increased more in 15 adult plot than 5 adult one. The number of tillers clearly increased in order of 30, 15, and 5 adults. Galls were formed more abundant in the 30 adult plot than the other plots. The number of adults was observed to be more numerous in the 30 adult plot than the other plots. The number of larvae penetrated into rice plants was also more numerous in the 30 adult plot than the other two. Thus, it was revealed that the resistant cultivars RD_4 was seriously damaged under high population density of the gall-midge, and the degree of damaged tillers was positively proportional to the level of population density of the adult released so far as their experiment was concerned.

The fact that in the case of heavy outbreak of a pest or under the pressure of high population of the insect pest even the cultivar normally resistant to the pest in question has no ability to withstand its attack may throw some questions to us : (1) The unreliability of the cultivar as a resistant variety or the resistant gene(s) has not well fixed or screened, and (2) The higher the population of pest the more the possibility of creating most aggressive population. It seems desirable that before designating a new cultivar as resistant to a certain pest we cultivate the new cultivar in a rather larger areas (possibly in the heavy outbreak areas) continuously for several years to prove its real resistance to the pest.

CHEMICAL CONTROL OF RICE PESTS

For the rational development of integrated rice pest control it is most desirable to utilize and conserve natural enemies of rice pests together with the minimum use of insecticides to suppress the population of rice pests to non-pest status.

In the utilization and conservation of natural enemies of rice pests consideration should be taken in the selection of insecticides (if possible, systemic insecticides), their timing of application, formulation and application selectivity. The adverse effect of insecticides upon natural enemies has been well investigated in many parts of the world. The widespectrum organic synthetic insecticides destroy natural enemies completely and directly. While some insecticides tend to weaken the fecundity of female natural enemies, others shorten the longevity of natural enemies. Some natural enemies may avoid the environment polluted with insecticides and their ability or activity to search for their host pests may become very weak.

To avoid such adverse influences it is most desirable to use the granular formulations of insecticides directly to paddy water or soil. This granular type insecticides are less toxic to the operator than sprays or dusts. Application can be broadcast in the same manner as fertilizers or seeds. Further, insecticides of granular formulations may not affect not only natural enemies but also not toxic to fish which are very important protein source of the farmers in Thailand. The timing of insecticide application should be done against the stage or position of the pests when they are most susceptible or accessible to the insecticides. Partial or spotted treatments of rice paddies to control rice pests are also necessary to avoid the unnecessary application of insecticides, to avoid the waste use of insecticides or to save the natural enemies as many as possible. Anyway, in the rice paddies insecticides should be applied only in case of need when the population of a certain pest is tending to increase above the level of economic injury and only to the area where its application is desirable. In addition, the dosage should be as minimum as possible with minimum side effects.

At the moment our Division of Entomology and Zooology, Department of Agriculture is recommending the use of following insecticides to the farmers only when insecticide use is necessary (Table 26).

In one of our experimental plots at the Rice Experiment Station at Khlong Luang, we made observations on the population of damselflies between the insecticide treated and untreated paddies in 1974. The size of one replication plot : 100 m^2, spacing between hills 25 x 25 cm, one row with 20 hills; three replications; weed control by hands; fertilizer N : P : K = 10 : 20 : 0 Kg/Rai, two applications after transplanting, after 20 days and 40 days; rice varieties used RD_2 and TN_1 (both susceptible to rice pests); insecticides used - strong contact insecticides per week or ten days).

The damselflies which we collected or observed in our experimental paddies were divided into two groups according to their origins. Damselflies of the first group belong to the population emigrated from the surrounding paddies, while those of the second group breeded in and originated from our experimental paddies. In the insecticide sprayed plots many nymphs of damselflies living on the soil surface of paddies may be killed by the insecticide. On the contrary in the unsprayed plots they multiply themselves continuously in the rice paddies, thus increasing their populations as clearly seen in the table given below.

Table 26 Insecticides currently recommended to the farmers and their application methods in Thailand.

Pest	Insecticide and its formulation	Dosage used	Date of application after transplanting
Rice stem-borers	Carbofuran (Furadan) 3% G.	1 - 2 kg/ha	20, 40 and 60 days
	Caldan (Padan) 4% G.	1 - 2 kg/ha	20, 40 and 60 days
	Triazophos (Hostathion) 5% G.	1 - 2 kg/ha	20, 40 and 60 days
	Birlane 10% G.	1 - 2 kg/ha	20, 40 and 60 days
	BHC 6% G.	1 - 2 kg/ha	20, 40 and 60 days
	Monocrotophos (Azodrin) 56% W.S.C.	1 kg/ha	20, 40 and 60 days
Rice gall midge	Cytrolane 2% G.	1 - 2 kg/ha	15 and 30 days
	Dyfonate 5% G.	1 - 2 kg/ha	15 and 30 days
	Carbofuran (Furadan) 3% G.	1 - 2 kg/ha	15 and 30 days
	Triazophos (Hostathion) 5% G.	1 - 2 kg/ha	15 and 30 days
Defoliators and Leaf-rollers	Fenitrothion (Sumithion) 80% E.C.	40 ml/20 l	In case of need
	Carbaryl (Denapon, Nac, Sevin) 85% W.P.	40 ml/20 l	In case of need
Plant- and Leaf-hoppers	MIPCIN (MIPC) 50% W.P.	40 gr/20 l	10, 20 and 30 days
	Bassa (BPMC) 50% E.C.	40 gr/20 l	10, 20 and 30 days
	Carbofuran (Furadan) 2% F.	100 ml/20 l	10, 20 and 30 days
	Carbofuran (Furadan) 3% G.	1 kg/ha	30 and 50 days
Nephotettix spp.	Carbaryl (Denapon, Nac, Sevin) 85% W.P.	40 gr/20 l	10, 20 and 30 days

Carbofuran (Furadan) : 2,3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate

Caldan (Padan) : 1.3-bis(carbamoylthio)-2-CN. N-diethylamino-propane

Triazophos (Hostathion) : 1-phenyl-3-(0,0-diethyl-thiono-phosphoryl)-1,2,4-triazol

Birlane : 2-chloro-1-(2,4-dichloro = phenyl) vinyl diethyl phosphate

BHC : 1,2,3,4,5,6-hexachlorocyclohexane

Monocrotophos (Azodrin) : 3-(dimethoxyphosphinyloxy)-N-methyl- cis-crotonamide

Cytrolane : 2-(duethoxyphosphinylimino)-4-methyl-1-3-dithiolane

Dyfonate : 0-ethyl 3-phenyl ethylphos = phonodithioate

Fenitrothion (Sumithion) : 0, 0-dimethyl-0-(4-nitro-m-tolyl) phosphorothioate

Carbanyle (Denapon, Nac, Sevin) : 1-naphthyl methylcarbamate

Mipcin (MIPC) : 0-cumenyl methylcarbamate

Bassa (BPMC) : 0-sec-butylphenyl methylcarbamate

Table 27. Estimated number of damselflies per 24 blocks of plots in the experimental paddies at Khlong Luang Rice Experiment Station. The insecticides treated and untreated plots were separated by another rice paddies of about 20 meters in width.

Date of research	Treated plots (A)	Untreated plots (B)	B/A
26. VII. 1974	120	282	2.4
5. VIII. 1974	210	350	1.6
5. IX. 1974	148	408	2.8
17. IX. 1974	195	905	4.6
7. X. 1974	29	178	6.1

(The damselflies chiefly concerned were *Agriocnemis pygmaea*, *A. femina femina* and *Ischnura senegalensis*.)

This observation indicates definitely that even in the case of damselflies which are able to fly in or out the rice paddy freely and very easily, the damage caused by the insecticide treatment is severe to the nymphs of damselflies living on the soil of rice paddy water, and consequently the population of damselflies, predators of rice pests, may become lower as compared to the untreated paddies.

FACTORS TO BE CONSIDERED IN THE DEVELOPMENT OF INTEGRATED RICE PEST CONTROL PROGRAM

Based on many years of field observations and taking into consideration such factors as population dynamics, behavior and habits of rice pests, natural enemies, and environmental conditions of rice ecosystem, we developed a schematic model of an integrated rice pest control program as shown in Figure 12. In this model, the problem of Chironomidae and weeds will be discussed later. In this connection, it will be interesting and useful to compare this model with a similar one made by Prof. Nishida (1978). In our model, the part "Sequential assessment of pests and their natural enemies" may correspond with the diagram showing integrated control of a pest utilizing non-chemical and chemical control methods shown diagrammatically by Prof. Nishida (Figure 13).

The left half of our model is in the category of the manipulation or modification of rice ecosystem. As shown in the figure the presence of wild rice, Leguminaceous weeds, corn and sugarcane near the rice paddy is of considerable importance within the framework of integrated rice pest control. One of the serious problems rises that some of the pests are common to these plants. This means that wild rice, Leguminaceous weeds, corn, sugarcane and rice have common pests which have the same complex of natural enemies. When the rice plant is not available after harvesting or during the fallow period, these non-rice areas become refuge areas of natural enemies, thus preventing their extinction. Furthermore, shrubs and trees near rice paddies and farmers' houses provide nesting site for *Ropalidia* wasps which are very important predators of Lepidopterous larvae feeding on the leaves of rice plant.

The presence of plants, which produce pollen and honey, in the vicinity of rice paddies is also worthy of consideration. The plants belonging to the Umbelliferaeae are most desirable as pollen and honey sources. Many parasitic wasps (Braconidae, Ichneumonidae, etc.) and Tachinidae are attracted to the flowers before oviposition. The ovaries cannot develop without a diet of honey and pollen. The planting of such food bearing plants will be beneficial to the natural enemies of rice pests.

It is necessary to make regular sequential assessment of rice pests at 7 - 10 day intervals together with observations on the abundance of natural enemies. If the population of rice pests remains under economic injury level, it is not necessary to apply any insecticides at all. In case there is a need for insecticide application, it is desirable to use systemic and granular insecticides at minimum rates. To determine the so-called economic threshold level or economic injury level under which no insecticidal treatment is necessary is a difficult problem. The level will be changed from country to country, from district to district, from pest species to pest species, from rice variety to variety and so on, and is also closely related to plant age as well as insect population. Dr. Lim (1978) wrote that "an approximate threshold level of 10 BPH/hill was adopted, i.e. fields having population higher than this were normally treated. Where high predator population also occurred, greater BPH numbers of up to 40/hill could be tolerated, depending on the predator/prey ratio (BPH : *Nilaparvata lugens*)." Prof. Nishida recommends or suggests the economic threshold level for *Nilaparvata lugens* as follows :

Seedbed : 3% infested seedlings out of total 100.

A seedling is infested if it was at least one adult.

Once a week surveillance.

Transplanted rice : 5% adult BPH/hill.

Once a week surveillance.

Broadcast rice : 10% BPH/hill out of a total of 100

Once a week surveillance.

Dr. Dyck (1978) wrote that in the greenhouse the 25 BPH/hill is acceptable as the economic injury level, while in the field even 50 BPH/hill is safe as an economic injury level. He also showed the following data (1974).

Pest Observation time	Economic threshold level Rice variety IR22	 IR20
Tungro virus	1 adult GLH/hill plus virus source within 100 m (1-80 DT)	5 adult GLH/hill plus virus source (1-80 DT)
	0.5 adult GLH/hill	2 adult GLH/hill
Dead heart (30 DT)	10% dead hearts	the same
White head	1.0 borer/100 tillers	the same
Leaf hoppers (weekly)	20 insects/hill	the same
Plant hoppers (weekly)	20 young nymphs/tiller	the same

GLH: *Nephotettix* sp. DT: days after transplanting.

According to Castodio et al. (1974) the population of 10-25 BPH/hill has no effect on older rice plants, but 300-400 insects/hill may cause "hopperburn" and death of plants. Populations of BPH species are frequently highest and most damaging at the time from 70 days after transplanting to harvest. Prof. Nishida wrote as follows : The economic threshold level is that population level of a pest at which spray are used to prevent serious injury to the crop. Therefore, the economic threshold level must be known before carrying out surveillance. However, the determination of the economic threshold level is a complicated one and time consuming undertaking. Therefore, a tentative estimated value may be used. This value can be changed with field observations so that a working value can be obtained through trial and error.

Anyway, at the moment to the Brown Planthopper, rice gall-midge and rice stem-borers the economic threshold level will be acceptable at the 10% damage per 100 hills.

The use of resistant varieties of rice plant is highly desirable. If a rice variety is partially resistant to an insect pest, its population on such a variety may be lower than that on a susceptible one. This means that natural enemies may have difficulty in finding their host insects because many of them are host-density dependent. In such cases we need host-density independent or non-specific natural enemies. To this category predators are most suitable in the case of rice pests. As mentioned before, the populations of predaceous natural enemies of rice pests are very abundant in the rice paddies of Thailand. If such natural enemies are not available, the method of augmentation of parasites or predators may be employed. The natural enemies can be mass-reared for augmentation release instead of using insecticides. The candidate natural enemies will be selected from our diagrams showing the evaluations of natural enemies. It should be kept in mind that we can use natural enemies with relatively low rating which can be easily mass-reared on a commercial scale.

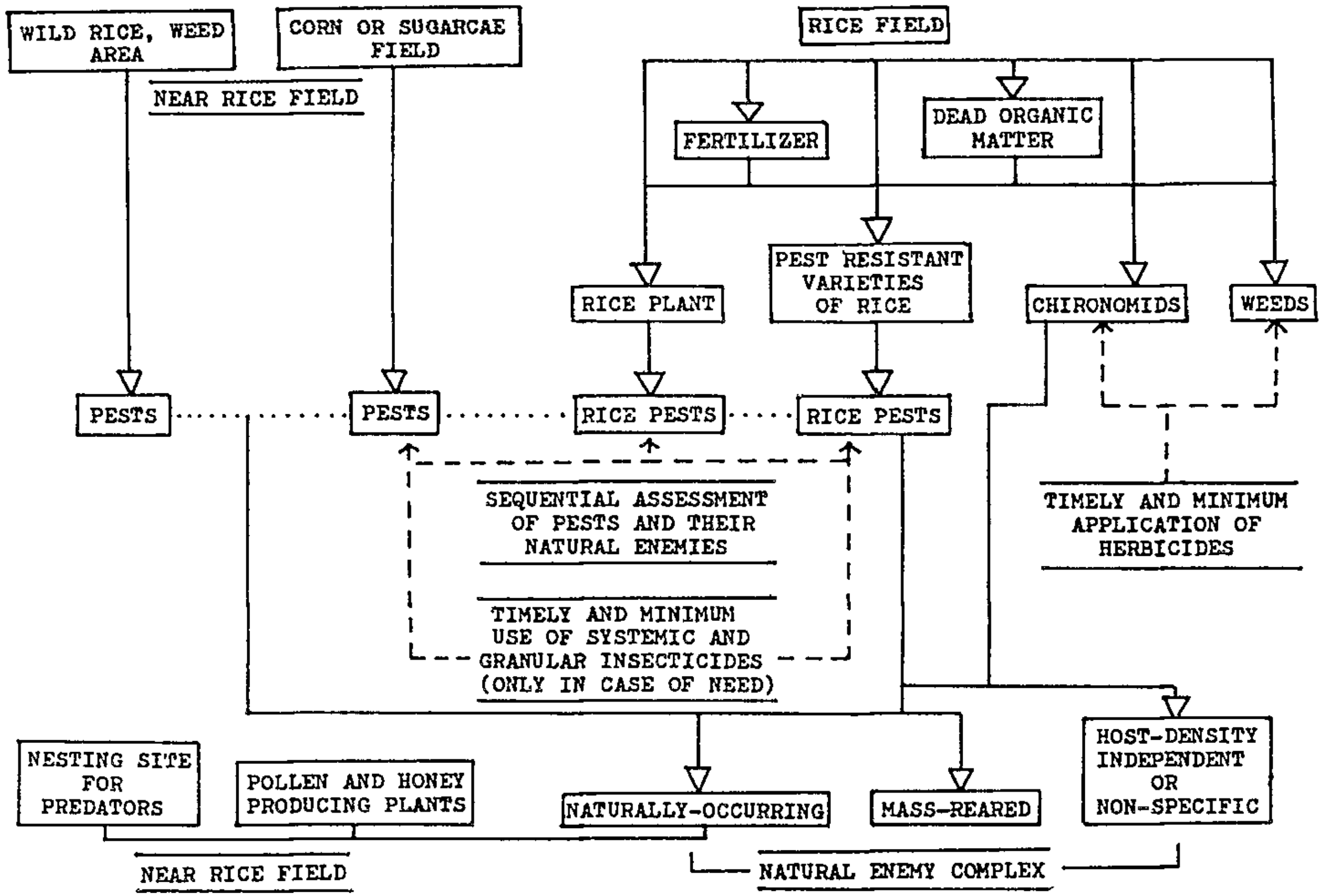

Figure 12. Schematic model of factors involved in the development of integrated rice pest control program.

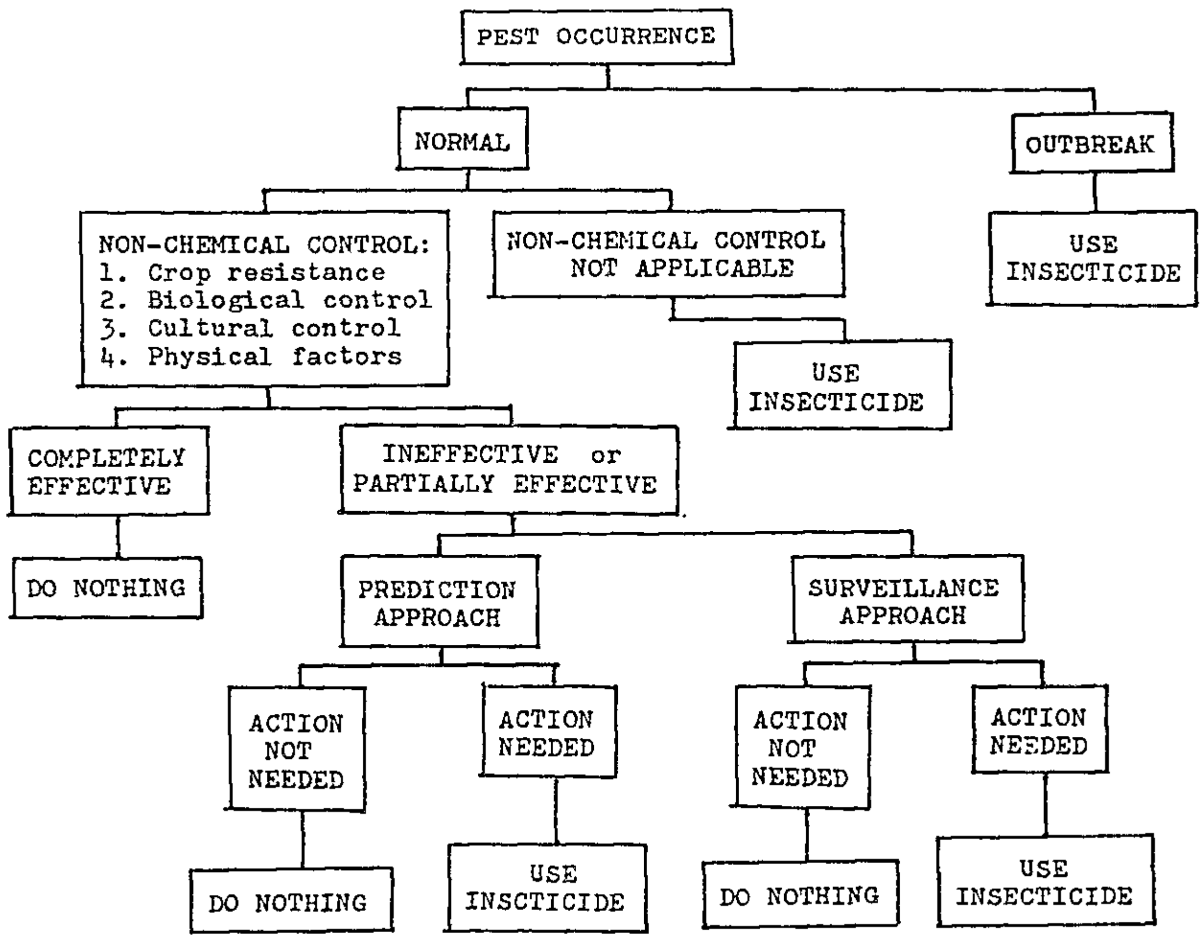

Figure 13. Diagram showing integrated control in pest utilizing non-chemical and chemical control methods (Nishida, 1978, slightly modified).

THE ROLE OF CHIRONOMIDAE IN THE RICE ECOSYSTEM AND THE REGULATION OF ITS POPULATION BY BIOTIC FACTORS AND CHEMICALS

The most dominant component of the insect fauna in the rice paddies is no doubt members of the family Chironomidae. The fact that the Chironomid population is usually very high suggests some significant relationship with other insects living in the rice ecosystem. Since 1976 we have been engaged in an extensive survey of the Chironomid fauna in the rice paddies of Thailand. There are more than 31 species, many unrecorded from Thailand, some new to science. The taxonomic study is now underway by Professor Hashimoto of Shizuoka University, Japan. Up to the present we could collect the following species which were all determined by Professor Hashimoto.

Chironomini

1. *Chironomus circumdatus* Kieffer
2. *Chironomus kiiensis* Tokunaga
3. *Chironomus javanus* Kieffer
4. *Chironomus crassiforceps* Kieffer
5. *Chironomus glauciventris* Kieffer
6. *Chironomus tainanus* Kieffer
7. *Chironomus dissidens* Walker
8. *Chironomus* n. sp. 1
9. *Chironomus* n. sp. 2
10. *Dicrotendipes formosanus* Kieffer
11. *Dicrotendipes niveicauda* (Kieffer)
12. *Dicrotendipes flexus* (Johannsen)
13. *Xenochironomus xenolabis* (Kieffer)
14. *Xenochironomus* n. sp.

15. *Cryptochironomus fulvus* (Johannsen)
16. *Parachironomus apicalis* (Kieffer)
17. *Parachironomus* n. sp. 1
18. *Parachironomus tener* Kieffer
19. *Parachironomus* n. sp. 2
20. *Parachironomus* n. sp. 3
21. *Parachironomus* n. sp. 4
22. *Harnischia viridula* (Fabricius)
23. *Harnischia curtilamellata* (Malloch)
24. *Harnischia incidata* Townes
25. *Polypedilum nubifer* (Skuse)
26. *Polypedilum vectus* (Johannsen)
27. *Polypedilum sturalis* Johannsen
28. *Polypedilum yapensis* Tokunaga
29. *Lauterborniella varipennis* Conquillett

Tanytarsini

30. *Tanytarsus formosanus* Kieffer
31. *Tanytarsus ponapensis* Tokunaga
32. *Tanytarsus atridorsum* Kieffer

Almost all the species mentioned above are new to the fauna of Thailand.

Very little attention has hitherto been paid to the role played by Chironomids in the rice ecosystem except Yasumatsu's short note in 1975. He wrote : "An outbreak of Chironomids may cause a weakening of the activity of spiders and damselflies and other predators on their attack on rice pests. The fragile Chironomids are easily caught by spiders and damselflies and are more attractive prey than the rice pests. Therefore, some care should be taken to keep rice paddies clean." The occurrence of Chironomids in the rice paddies has a close connection to the presence of dead organic matter on the surface of soil. The relation between Chironomids and their predators is shown schematically in Figure 13. When the popualtion of Chironomids is high, the activities of the predaceous natural enemies of rice pests tend to be focused on the Chironomids rather than on rice pests (Figure 14B). Consequently, the beneficial effects of predators will be reduced to a great extent. Therefore, any field research on rice pests and their predators that pay no attention to the significance of Chironomids in the rice ecosystem is not satisfactory and gives unreliable result when used in the development of integrated rice pest control.

On the other hand, the presence of Chironomids in the rice paddies is very important either in keeping or conserving the population of natural enemies of rice pests when the population of rice pests is not high. Chironomids are also food of fish in rice paddies. On the other hand, in some countries high population of Chironomids may cause damage to the younger plants of rice. So, the problem concerning the Chironomids is very much complicated.

Among the group-specific predators of Chironomids, predaceous Ceratopogonidae is of great interest. Through the kind identification of Dr. Wirth of the Systematic Insect Laboratory, USDA and Dr. Ratanaworabhan of the Thailand Institute of Scientific and Technological Research, we can enumerate 31 species from the rice paddies of Thailand, including many unrecorded and new species. Drs. Wirth and Ratanaworabhan will publish the taxonomic paper entitled "New species and records of predaceous midges from rice paddies in Thailand(Diptera: Ceratopogonidae)" in the near future. A vast amount of material collected by us includes the following species.

Stilobezziini

1. *Alluaudomyia formosana* Okada
2. *Alluaudomyia marginalis* Wirth et Delfinado
3. *Alluaudomyia xanthocoma* (Kieffer)
4. *Stilobezzia festiva* Kieffer
5. *Stilobezzia* sp.

Sphaeromiini

6. *Brachypogon* sp.
7. *Calyptopogon brevitarsis* Macfie
8. *Calyptopogon gibbosus* (Wiedemann)
9. *Calyptopogon javanensis* (Kieffer)
10. *Homohelea insons* (Johannsen)
11. *Jenkinshelea niphane* Grogan et Wirth
12. *Jenkinshelea tokunagai* Grogan et Wirth
13. *Leehelea hollandiensis* (Tokunaga)
14. *Mackerrasomyia* n. sp.
15. *Nilobezzia acanthopus* (de Meijere)
16. *Nilobezzia raphaelis* (Salm)
17. *Nilobezzia* n. sp.
18. *Sphaeromias discolor* (de Meijere)
19. *Xenohelea* n. sp.
20. *Xenohelea polydora* Macfie

Palpomyiini

21. *Bezzia* n. sp. 1
22. *Bezzia* n. sp. 2
23. *Bezzia micronyx* Kieffer
24. *Bezzia* n. sp. 3
25. *Bezzia serena* Johannsen
26. *Bezzia* n. sp. 4
27. *Bezzia* n. sp. 5
28. *Palpomyia* sp.
29. *Phaenobezzia eucera* (Kieffer)
30. *Phaenobezzia javana* (Kieffer)
31. *Phaenobezzia* n. sp.

Out of a total 31 species collected, *Nilobezzia raphaelis* (Salm) was the most dominant species. The other abundant species were in the following descending order: – *Bezzia* n. sp. 5, *Nilobezzia acanthops* (de Meijere), *Homohelea insons* (Johannsen), *Phaenobezzia* n. sp., *Phaenobezzia javana* (Kieffer) and *Bezzia* n. sp. 2.

The number of Chironomids and the female predaceous Ceratopogonids collected per 50 sweeps from various rice paddies is shown in the following tables.

Another group-specific controlling factor of the population of Chironomids is a Mermitid, a Nematod, which casterates the Chironomids. The specific name of this Nematod has not yet been determined. Adults of more than 60 % of the population of *Parachironomus tener* Kieffer were seen parasitized by this Nematod in the rice paddy of Doi Pa-Morn, Doi Inthanon, Chiang Mai Province on 20 of September, 1976.

There are many other predaceous natural enemies of the Chironomid larvae in the rice paddies, including some aquatic beetles and Hemiptera, and nymphs of Odonata and fishes.

Table 28. Number of Chironomids and the female predaceous Ceratopogonids collected by sweep net method in various rice paddies of Thailand. E: Estimated number of Chironomids captured by the predaceous Ceratopogonid (PX12). Bio.: Supposed complete biological control of Chironomids by the predaceous Ceratopogonid.

Place and date of research		Chironomid	Predaceous Ceratopogonid	E	Bio.
Mae Sariang, Mae Hong Son, 5. III. 1978					
	A	432	34	408	Bio.
	B	1232	106	1272	Bio.
	C	456	64	768	Bio.
Pa Bong, Muang, Mae Hong Son, 6. III. 1978					
	A	1330	168	2016	Bio.
	B	64	15	180	Bio.
	C	96	3	36	
Pang Mu, Muang, Mae Hong Son, 6. III. 1978					
	A	784	51	612	
	B	490	61	732	Bio.
	C	4480	48	576	
Pa Bong, Chiang Rai, 20. II. 1979					
	A	641	23	276	
	B	837	7	84	
	C	1126	16	192	
Wiang Pa Pao, Chiang Rai, 21. II. 1979		1556	4	48	
Mae Kachiang, Chiang Rai, 21. II. 1979		1599	24	288	
Den, Muang, Chiang Rai, 22. II. 1979		2037	3	36	

Table 28. (Continued)

Place and date of research		Chironomid	Predaceous Ceratopogonid	E	Bio.
Teen Doi, Mae Suai, Chiang Rai, 22. II. 1979					
	A	2181	12	144	
	B	3668	19	228	
	C	1544	10	120	
Teen Doi, Mae Suai, Chiang Rai, 27. III. 1979					
	A	1818	99	1188	
	B	872	39	468	
Kua Tae, Muang, Chiang Rai, 28. III. 1979					
	A	2068	58	696	
	B	1085	21	252	
	C	1520	25	300	
	D	1240	26	312	
Mae Kao Tom, Muang, Chiang Rai, 28. III. 1979					
	A	2900	3	36	
	B	10040	23	276	
	C	1440	6	72	
Mae Kao Tom, Muang, Chiang Rai, 22. II. 1979					
	A	2033	10	120	
	B	1858	2	24	
	C	328	2	24	
Phrae, 11. IX. 1979		340	80	960	Bio.
Phrae, 26. X. 1979					
	A	433	7	84	
	B	556	10	120	
	C	168	3	36	

Table 28. (Continued)

Place and date of research		Chironomid	Predaceous Ceratopogonid	E	Bio.
Mae Jo, Chiang Mai, 6. IX. 1978					
	A	1096	211	2532	Bio.
	B	1120	158	1896	Bio.
Doi Saket, Chiang Mai, 28. IX. 1978		150	5	60	
Mae Yai, San Sai, Chiang Mai, 24. VI. 1979					
	A	103	5	60	
	B	868	5	60	
Hang Dong, Chiang Mai, 19. II. 1979					
	A	345	2	24	
	B	398	13	144	
	C	147	2	24	
Hang Dong, Chaing Mai, 27. III. 1979					
	A	Several thousands	196	2352	
	B	Several thousands	68	816	
	C	Several thousands	69	828	
Thung Sieo, San Pa Tong, Chiang Mai, 19. II. 1979	A	1281	32	384	
	B	621	62	744	Bio.
San Pa Tong, Chiang Mai, 19. II. 1979		200	14	168	
Than Sieo, Chiang Mai, 27. III. 1979					
	A	2350	223	2676	Bio.
	B	5600	97	1164	
	C	770	343	4116	Bio.

Table 28. (Continued)

Place and date of research		Chironomid	Predaceous Ceratopogonid	E	Bio.
Rong Ku, Chiang Mai, 27. III. 1979					
	A	over 2000	47	564	
	B	1066	58	696	
	C	792	41	492	
Yu Wha, San Pa Tong, Chiang Mai, 7. V. 1978					
	A	750	201	2412	Bio.
	B	1230	325	3900	Bio.
San Kab Tong Nua, Saraphi, Chiang Mai,					
4. V. 1978	A	246	45	540	Bio.
	B	96	13	156	Bio.
Thung-ka-la, Chiang Dao, Chiang Mai,					
6. IX. 1978	A	7300	249	2988	
	B	3780	154	1848	
	C	73150	354	4248	
Sob-kab, Chiang Dao, Chiang Mai, 6. IX. 1978					
	A	Several thousands	60	720	
	B	920	157	1884	Bio.
Huai Nam Dib, Chom Thong, Chiang Mai,					
7. V. 1978	A	496	131	1572	Bio.
	B	432	343	4116	Bio.
Wang Nam Yard, Chom Thong, Chiang Mai,					
7. V. 1978	A	56	9	108	Bio.
	B	16	20	240	Bio.
	C	58	21	252	Bio.

Table 28. (Continued)

Place and date of research		Chironomid	Predaceous Ceratopogonid	B	Bio.
Doi Pa-Morn, Doi Inthanon, Chiang Mai,					
5. IX. 1978	A	1442	193	2316	Bio.
	B	455	39	468	Bio.
	C	1357	124	1488	Bio.
	D	230	56	672	Bio.
	E	641	67	804	Bio.
	F	818	99	1188	Bio.
	G	669	113	1356	Bio.
Doi Pa-Morn, Doi Inthanon, Chiang Mai,					
19. XI. 1978	A	?	48	576	
	B	?	54	648	
	C	?	55	660	
	D	336	92	1104	Bio.
Muang, Lamphun, 20. II. 1979					
	A	88	169	2028	Bio.
	B	128	211	2532	Bio.
Suk Sawadee, Muang, Lampang,					
20. II. 1979		119	8	96	
Phayuha Khiri, Nakhon Sawan, 3. V. 1978					
	A	1120	22	264	
	B	7950	75	900	
	C	1360	20	240	
Khlong Khlong, Kamhaeng Phet, 3. V. 1978					
	A	3210	11	132	
	B	1850	4	48	
	C	432	11	132	

Table 28. (Continued)

Place and date of research		Chironomid	Predaceous Ceratopogonid	E	Bio.
Khon Kaen, 12. VIII. 1978					
	A	281	30	360	Bio.
	B	189	27	324	Bio.
Maha Sarakham, 28. X. 1976					
	A	50	27	324	Bio.
	B	20	93	1116	Bio.
Pleuy, Yang Talat, Kalasin,					
27. X. 1976		30	9	108	Bio.
Na-Kham-Hai, Nong Bua Lampoo,					
Udon Thani,					
26. X. 1976	A	51	5	60	Bio.
	B	145	9	108	
Nong Nok Kiang, Phen,					
Udon Thani,					
8. IX. 1978	A	Several thousands	200	2400	
	B	Several thousands	194	2328	
	C	Several thousands	34	408	
Pone Thong, Renunakorn,					
Nakhon Phanom,					
10. IX. 1978	A	1022	349	4188	Bio.
	B	983	101	1212	Bio.
	C	678	72	864	Bio.
Khung Nai, Ubol Ratchathani,					
28. X. 1976					
	A	61	8	36	
	B	273	18	216	
	C	Several thousands	15	180	

Table 28. (Continued)

Place and date of research		Chironomid	Predaceous Ceratopogonid	E	Bio.
None Nam Tang, Amnarcharoen, Ubol Ratchathani,					
10. IX. 1978	A	381	281	3372	Bio.
	B	188	50	600	Bio.
	C	279	111	1332	Bio.
Thang Sai, Ubol Ratchathani,					
19. XI. 1977		46	3	36	
Phibun Mangsaharn, Ubol Ratchathani,					
29. X. 1976					
	A	350	112	1344	Bio.
	B	130	22	264	Bio.
	C	70	19	228	Bio.
	D	90	10	120	Bio.
Phibun Mangsaharn, Ubol Ratchathani					
5. IX. 1977		921	63	756	
Phibun Mangsaharn, Ubol Ratchathani					
6. IX. 1977		101	46	552	Bio.
Phibun Mangsaharn, Ubol Ratchathani					
25. IX. 1977		800	15	180	
Phibun Mangsaharn, Ubol Ratchathani					
18. X. 1977		23	41	492	Bio.
Phibun Mangsaharn, Ubol Ratchathani					
20. XI. 1977					
	A	28	4	48	Bio.
	B	31	5	60	Bio.
	C	22	0		
Muang, Ubol Ratchathani					
20. XI. 1977		39	1	12	
Sangka Talag, Surin,					
21. XI. 1977		17	5	60	Bio.

Table 28. (Continued)

Place and date of research		Chironomid	Predaceous Ceratopogonid	Ɛ	Bio.
Sangka Talag, Surin, 25. XI. 1977		39	11	132	Bio.
Non-Sung, Kantararom, Si Sa Ket, 30. X. 1976		82	10	120	Bio.
Kra Sang, Tamyae, Si Sa Ket, 30. X. 1976		70	8	36	
Boo-Song, Si Sa Ket, 21. XI. 1977					
	A	15	49	588	Bio.
	B	89	16	192	Bio.
Muang, Prachuap Khiri Khan, 1. IV. 1978					
	A	636	9	108	
	B	754	3	36	
Phatthalung, 29. IV. 1978					
	A	483	5	60	
	B	323	0		
	C	50	4	48	
Phatthalung, 25. I. 1979		193	6	72	

From the data indicated in the table we can easily recognize how important the females of predaceous Ceratopogoniddae are as a regulating factor of the Chironomid populations. Sometimes their biological control effect on the Chironomus populations may be perfect. In some rice paddies in certain times, the female populations of predaceous Ceratopogonids were much higher than that of the Chironomid species. But in case of the outbreak of Chironomids, the populations of Chironomids become extremely superior to that of the predaceous Ceratopogonids, and the females of predaceous Ceratopogonids cannot suppress the populations of Chironomids at all. As seen also from the table given above, the females of predaceous Ceratopogonids are usually very important in regulating the number of Chironomids in the rice paddies, being as common as the Chironomid species. There is no seasonal fluctuation in the population of predaceous Ceratopogonids in the rice paddies with water.

To prevent the outbreak of Chironomids in the rice paddies it is necessary to keep the paddy soil without full of dead organic matter. Fortunately, chemical control of weeds in the rice paddies simultaneously with the larvae of Chironomids seems possible and can be conveniently carried out. In regards to this possibility, Yasumatsu asked Dr. Nohara, Hagi Citrus Experiment Station, Yamaguchi Prefecture, Japan, to make preliminary pot test against *Orthocladius akamushi* larvae using 76 different formulations of various herbicides. The herbicides concerned are : Chlornitrofen,Chloroxuron, Molinate, Chloromethoxynil, Butachlor, Basagran, ACN, allylMCP, Dimethametryn, Simetryne, Prometryne, MCPB and Benthiocarb. The method of evaluation was based on the number of adult emergence from the herbicide treated pot of rice plants. The ratings were made on a scale of 0 to 5, 0 indicating the most effective or complete control and 5 not effective. The result shows great range of effectiveness; viz. 0 in 10 cases; 1 in

24 cases; 2 in 16 cases; 3 in 14 cases; 4 in 8 cases; and 5 in 4 cases. These data suggest that our idea to control both weeds and Chironomid larvae at the same time by herbicide is feasible.

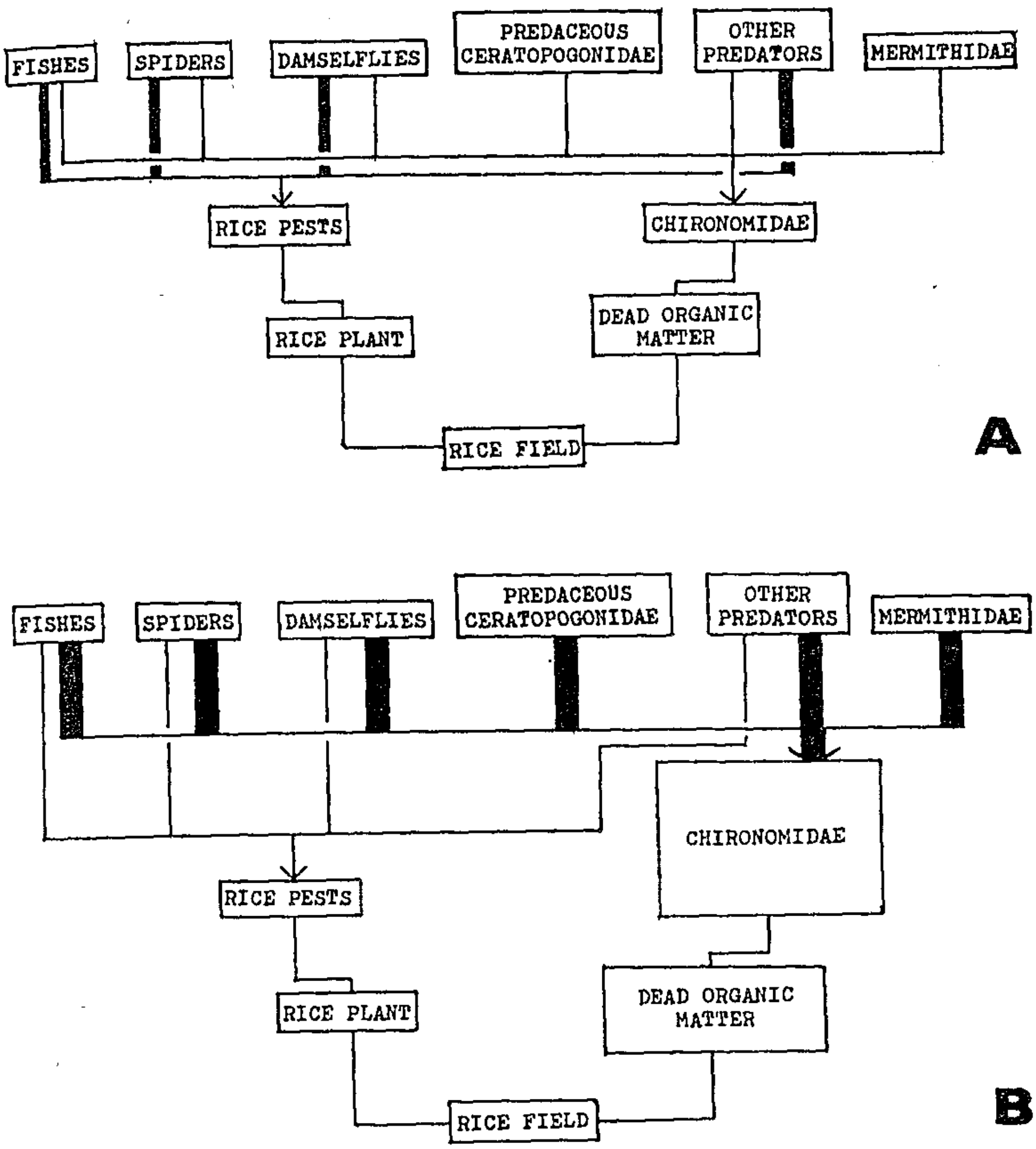

Figure 14. Diagram showing the relationship between Chironomidae and their predators. A: A case in which the population of Chironomidae is not high. B: A case in which the population of Chironomidae is very high. Width of arrow indicates intensity of attack.

REVIEW OF IMPORTANT LITERATURE CONCERNING THE MOTHS OF STEM-BORERS AND SOME CONSIDERATIONS ON THEIR CULTURAL CONTROL METHOD

Among a variety of factors affecting rice production water is by far the most important. In many parts of Thailand where irrigation water is not available during the dry season, the farmers cannot cultivate the second crop of rice or any other kinds of crops. But, if the irrigation system develops and sufficient water becomes available, the farmers can start the second crops. In some areas of north and northeast Thailand, the cultivation of second crop of rice have started in relatively recent years in the dry season. However, the stem-borer, especially *Tryporyza incertulas*, causes heavy damage on rice plant without exceptions. Therefore, in such rice paddies the use of insecticides is essential in controlling stem-borers.

In the dry season, the stem-borer larvae are usually in aestivation or diapause deep in the stubbles. Emergence of moths of the aestivating or diapausing generation may be governed by rain fall after the start of monsoon season. The direct contact of water either of irrigated one or rain break the diapause or aestivation of full-grown stem-borer larvae and stimulate to pupate, and the moths appear four to six weeks later. This almost simultaneous appearance of the first moth generation after the dry monsoon is called "stubbleflight."

Several entomologists in Japan, Indonesia, India, Pakistan, Australia and Surinam have suggested the manipulation of transplanting dates to avoid high stem-borer incidence. The delay of transplanting until after peak emergence of stem-borer moths may decrease heavy losses caused by the pest considerably. Theoretically, by the delay of transplanting until after the last emergence of moths, it is possible to cultivate the stem-borer free rice plant. Such method of delayed transplanting have been in practice in many places.

In this connection, the consideration on the correlation between rainfall in the dry season and the occurrence of the white rice borer (*Scirpophaga innotata* Wlk.) in Java by van der Laan (1959) is of great interest. His result is summarized as follows : "The amount of rain which falls sporadically in the relatively dry season at the time that the white rice borer is diapausing as a full grown larva in the rice stubble, has a very important influence on the size of population of the borers in the following wet season when rice is grown. If this dry season is wet or very wet (according to our standard, based on the figures of rainfall and borer damage over 26 years in five regions of Eastern Java), no damage can be expected in the following planting season. If the dry season is really dry or very dry, outbreaks of borers may occur (in the period under survey this occurred in nine out of fourteen years). We have tried to give an outline of a method of prediction of borer damage in the planting season, based on the rainfall dates of the foregoing dry season."

As early as in 1925, van der Goot published a very important paper in which he wrote his result as follows : "Mortality during the diapause was mainly caused by moisture. More or less regular rainfall in the first two months after the beginning of the diapause caused 100% mortality. Moistening at regular times in the third and fourth month of the diapause also caused the death of most caterpillars."

Studies on another rice stem-borer, *Rupela albinella* (Cr.), made by van Dinther in Surinam (1961) offers a significant result in establishing the control schedule. He wrote, "Diapausing larvae of this borer remain in the stubble after harvesting and carry the species over a period during which the hostplant may be scarce or absent. The influence of rainfall on the duration of diapause was experimentally analyzed. As a rule the higher the amount of precipitation, the sooner the moths make their appearance. This break of diapause is accelerated the longer the diapausing larvae stayed in the dry stubble. It is suggested that under the prevailing weather conditions stubble destruction within one month after harvest will prevent the appearance of the moths."

Areekul, Bhonuanypol and Ekapat (1973) showed that for *Tryporyza incertulas* humidity has a marked influence on the pupal development, and high percentage emergence of adult was obtained only when pupae were exposed to 95% RH.

From the review of literature together with our experiences the following considerations may be derived.

The cultivation of second crops such as corn, sugarcane, soybean, mungbean, peanut, tobacco, etc. in the dry season by the use of irrigation water may cause high mortality on the aestivating or diapausing larvae of stem-borers in the stubbles, because we use sufficient water to start the second crops and also use regular water supply to the crops during the crop growing season. By this method we can not only reduce the population of the first moths greatly at the beginning of the first crop of rice cultivation but also can conserve the population of natural enemies of rice pests.

The cultivation of second crop including rice and other crops at the same time or the cultivation of mixed crops will be worthy of consideration. In this case the rice paddies will be settled at random among the fields of other crops. This type of cultivation is seen in northern part of Thailand, Chiang Mai and Chiang Rai Provinces. This method may destroy the population of rice stem-borers to a greater extent on one hand and may serve to conserve natural enemies of rice pests on the other hand.

The cultivation of second crop of rice in the dry season in the paddies where water has become available in recent years must expect the heavy outbreak of rice stem-borers. But, if we consider the water relation to the emergence of moths of stem-borers and determine the date of transplanting, we can cultivate rice plants with free of infestation. In the areas where we can grow only rice plant in the dry season even if irrigation water is available, it is desirable to start flooding of rice paddies one or two months after harvesting in order to get the stubbleflight of emerging moths of stem-borers, or it is better to decide the approximate transplanting date first, and next the flooding date to the rice paddies is scheduled one or two months prior to the transplanting date. In any case, it may be more useful to monitor the moth emergence by using either of the two following supplementary measures. In the areas where electricity is available, the setting of light traps may be very helpful in observing continuously the trend of moth emergence. Comparatively later than the peak of stubbleflight of stem-borer moths or after the cease of stubbleflight we start transplanting. In the areas where electricity is not available, the settling of a small rice nursery is recommended. We can observe the number of stubbleflight moths which are attracted to the rice plants to oviposit their eggs. We must start transplanting after the cease of moth flight. Thus, we can grow the second crop of rice without any incidence of stem-borers and at the same time without the use of insecticides.

In the following two tables we offer diagrams showing several cases of possible farming schedules of cultivated land where irrigation water has become available in the dry season in recent years or irrigation system will be completed in the nearest future.

Table 29. Diagram showing several possible farming schedules of cultivated land of north, northeast and central areas in Thailand.

	Wet season					Dry season						
Month	6	7	8	9	10	11	12	1	2	3	4	5
							Water unavailable					
One crop (Rice)	R	R	R	R	R	RF	F	F	F	F	F	F
							Irrigation water available					
Two crops (Rice)	R	R	R	R	R	R	R	R	R	R	R	R
	R	R	R	R	R	RF	R	R	R	R	R	R
	R	R	R	R	R	RF	F	R	R	R	R	R
	R	R	R	R	R	RF	F	F	R	R	R	R
	R	R	R	R	R	RF	F	F	F	R	R	R
Two crops (Two kinds)	R	R	R	R	R	V	V	V	V	V	V	V
Two crops (Mixed with fallowing areas)												
	R	R	R	R	R	RF	VF	VF	VF	VF	VF	VF
	R	R	R	R	R	RV	VF	VF	VF	VF	VF	VF
	R	R	R	R	R	RF	VF	VF	VR	VR	VR	VR
	R	R	R	R	R	RF	VF	VF	VF	VR	VR	VR
	R	R	R	R	R	RF	VFR	VFR	VFR	VFR	VFR	VFR

R: Rice. V: Crops other than rice. F: Fallowing period.

Table 30. Diagram showing several possible farming schedules of cultivated land of peninsula areas in Thailand.

	Wet season			Dry season					Wet season			
Month	1	2	3	4	5	6	7	8	9	10	11	12
					Water unavailable							
One crop (Rice)	R	R	R	F	F	F	F	F.	F	R	R	R
					Irrigation water available							
Two crops (Rice)	R	R	R	R	R	R	R	R	R	R	R	R
	R	R	R	R	F	R	R	R	F	R	R	R
	R	R	R	R	F	F	R	R	R	F	R	R
	R	R	R	R	F	F	F	R	R	R	F	R
Two crops (Two kinds)	R	R	R	V	V	V	V	V	R	R	R	R
Two crops (Mixed with fallowing areas)												
	R	R	R	VF	VR	VR	VR	VR	F	R	R	R
	R	R	R	VF	VF	VR	VR	VR	VR	F	R	R
	R	R	R	VF	VF	VF	VR	VR	R	R	R	R
	R	R	R	VF	VF	VF	VR	VR	VR	F	F	F

R: Rice. V: Crops other than rice. F: Fallowing period.

Since the arrival of Yasumatsu in Thailand we have heard very often the severe attack of rice stem-borers to the second crop of rice during the dry season in paddies developed in large virgin areas. The damage has been so severe that it was impossible to get satisfactory yields without the use of insecticides. From time to time we have made questions about the interval between the date of flooding and the transplanting. Almost all cases transplanting was made around two weeks after the date of flooding. This is quite insufficient, and two or three weeks after transplanting the stubbleflight occurred, thus causing severe infestation of rice stem-borers. In addition, at that time the growth of rice plants is sufficient enough to supply nutrient to the larvae of stem-borers. As pointed out above the interval between the initial date of flooding and transplanting should be more than one month or less than two months.

APHIDS, MIRIDS AND THRIPS FOUND IN THE RICE PADDIES OF THAILAND

Very little has been known on the fauna of Aphids, Mirids and Thrips in the rice paddies of Thailand. During the course of our study the following species of these groups were found and collected.

Aphididae (Det. by Dr. Sorin)

1. *Aphis gossypii* Glover
2. *Aphis craccivora* Koch
3. *Myzus persicae* (Sulzer)
4. *Schizaphis graminum* (Rondani)
5. *Schizaphis minuta* (van der Goot)
6. *Sitobion avenae* (Fabricius)
7. *Rhopalosiphum rufiabdominalis* (Sasaki)
8. *Rhopalosiphum maidis* (Fitch)
9. *Rhopalosiphum nymphaeae* (Linné)
10. *Rhopalosiphum padi* (Linné)
11. *Hysteroneura setariae* (Thomas)
12. *Tetraneura yezoensis* (Matsumura)
13. *Brachycaudus helichrysi* (Kaltenbach)
14. *Brachysiphoniella montana* (van der Goot)
15. *Melanaphis formosana* (Takahashi)

Among these nos. 1, 2 and 3 cannot survive on rice plant. They are just temporary invaders from the outside. Host plants of the other eight species belong to the Graminae including rice plants, and these are recorded in the rice paddies of Thailand for the first time. But, aphids are not so important pests of rice plant. They have numbers of effective natural enemies and their populations are always under economic injury level by the activity of their natural enemies. The following table shows an example of the abundance of their natural enemies in the rice paddies of Thailand.

Table 31. Number of rice Aphids and their natural enemies collected by the sweep net method in several paddies of Thailand. Figures in table indicate number collected per 50 sweeps from paddies with rice from vegetative to heading stages.

P: Predator. Pa: Parasites.

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
Ban Srang Kaeo, Amphoe Chieng Yun, Maha Sarakham	22.X. 1976	None (0.00)	*Aphelinus* spp. 12 (0.03) Pa
Amphoe Phibun Mangsaharn, Ubol Ratchathani	29. X. 1976	None (0.00)	*Aphelinus* spp. 16 (0.05) Pa
Ban Boo Soong, Si Sa Ket	21. XI. 1977	None (0.00)	*Aphelinus* spp. B (0.05) Pa
Ban None Nam Tang, Amphoe Amnarcharoen, Ubol Ratchathani	10. IX. 1978	None (0.00)	*Aphelinus* spp. 43 (0.12) Pa
Ban Pone Thong, Amphoe Renunakorn, Nakhon Phanom	10. IX. 1978	108 (0.31)	*Aphelinus* spp. 35 (0.10) Pa
			Scymnus sp. 2 (0.01) P
			Scymnus larva 3 (0.01) P
			Harmonia octomaculata 1 (0.002) P
Doi Pa-Morn, Doi Inthanon, Chiang Mai	19. XI. 1978		
Paddy 1		90 (0.26)	*Aphelinus* spp. 63 (0.18) Pa
			Geocoris sp. 4 (0.01) P

Table 31. (Continued)

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
			Scymnus sp. 1 (0.003)
			Harmonia octomaculata 3 (0.01) P
Paddy 2		29 (0.08)	*Aphelinus* spp. 45 (0.13) Pa
			Aphidius sp. 1 (0.003) Pa
			Geocoris sp. 4 (0.01) P
			Harmonia octomaculata 2 (0.005) P
Paddy 3		36 (0.103)	*Aphelinus* spp. 84 (0.24) Pa
			Geocoris sp. 4 (0.01) P
Doi Saket, Chiang Mai	28. IX. 1978	1 (0.00)	*Aphelinus* spp. 12 (0.03) Pa
			Geocoris sp. 1 (0.002) P
Amphoe Khlong Khlong, Kamphaeng Phet	3. V. 1978		
Paddy 1		15 (0.04)	*Aphelinus* spp. 73 (0.21) Pa
			Scymnus larva 3 (0.01) P

Table 31. (Continued)

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
Paddy 2		7 (0.02)	*Aphelinus* spp. 186 (0.53) Pa
			Micraspis discolor 3 (0.01) P
Paddy 3		6 (0.02)	*Aphelinus* spp. 35 (0.10) Pa
			Micraspis discolor 1 (0.002) P
Ban San Kab Tong Nua, Amphoe Saraphi, Chiang Mai	4. V. 1978	2 (0.01)	*Aphelinus* spp. 85 (0.24) Pa
			Scymnus sp. 1 (0.002) P
			Micraspis discolor 7 (0.02) P
			Harmonia larva 1 (0.002) P
Amphoe Muang, Lamphun	4. V. 1978		
Paddy 1		7 (0.02)	*Aphelinus* spp. 70 (0.21) Pa
			Scymnus sp. 2 (0.005) P
			Harmonia octomaculata 2 (0.005) P
			Harmonia larva 6 (0.02) P
Paddy 2		10 (0.03)	*Scymnus* sp. 1 (0.002) P
			Micraspis vincta 21 (0.05) P

Table 31. (Continued)

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
			Brumoides lineata 1 (0.002) P
			Harmonia octomaculata 3 (0.001) P
Amphoe Mae Sariang, Mae Hong Son	5. V. 1978	None (0.00)	*Aphelinus* spp. 5 (0.01) Pa
			Geocoris sp. 1 (0.002) P
			Geocoris larva 1 (0.002) P
			Micraspis vincta 7 (0.02) P
			Micraspis larva 4 (0.01) P
Ban Wang Nam Yard, Amphoe Chom Thong, Chiang Mai	7. V. 1978	None (0.00)	*Aphelinus* spp. 94 (0.27) Pa
			Geocoris sp. 4 (0.01) P
			Micraspis vincta 10 (0.03) P
			Brumoides lineatus 2 (0.01) P
			Harmonia octomaculata 7 (0.02) P
Ban Teen Doi, Amphoe Mae Suai, Chiang Rai	22. II. 1979		
Paddy 1		9 (0.03)	Syrphid 1 (0.002) P

Table 31. (Continued)

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
			Micraspis vincta 1 (0.002) P
Paddy 2		34 (0.10)	Syrphid 18 (0.05 P
			Geocoris sp. 1 (0.002) P
			Micraspis vincta 6 (0.02) P
			Micraspis larva 1 (0.002) P
			Micraspis discolor 1
Ban Mae Kao Tom, Amphoe Muang, Chiang Rai	28. III. 1979		
Paddy 1		56 (0.16)	*Aphelinus* spp. 15 (0.04) Pa
			Micraspis vincta 1 (0.002) P
			Micraspis discolor 2 (0.01) P
			Harmonia octomaculata 2 (0.01) P
Paddy 2		170 (0.49)	*Aphelinus* spp. 31 (0.09) Pa
			Syrphid 4 (0.01) P
			Micraspis vincta 1 (0.002) P
			Harmonia octomaculata 1 (0.002) P

Table 31. (Continued)

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
			Harmonia larva 12 (0.03) P
Ban Kua Tae, Amphoe Muang, Chiang Rai	28. III. 1979		
Paddy 1		240 (0.69)	*Aphelinus* spp. 70 (0.2) Pa
			Syrphid 17 (0.05) P
			Geocoris sp. 3 (0.01) P
			Scymnus sp. 2 (0.01) P
			Harmonia octomaculata 20 (0.06) P
			Harmonia larva 96 (0.27)
Paddy 2		39	*Aphelinus* spp. 2 (0.01) Pa
			Harmonia octomaculata 1 (0.002) P
			Harmonia larva 2 (0.01) P
Ban Teen Doi, Chiang Rai	27. III. 1979		
Paddy 1		21 (0.05)	*Aphelinus* spp. 7 (0.02) Pa
			Syrphid 4 (0.01) P
			Scymnus sp. 1 (0.002) P

Table 31. (Continued)

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
			Micraspis vincta 2 (0.005) P
Paddy 2		24 (0.06)	*Aphelinus* spp. 16 (0.04) Pa
			Syrphid 26 (0.07)
			Scymnus sp. 1 (0.002) P
			Micraspis vincta 4 (0.01) P
			Harmonia octomaculata 3 (0.01) P
Ban Than Sieo, Chiang Mai	27. III. 1979		
Paddy 1		3 (0.01)	*Aphelinus* spp. 45 (0.13)
			Syrphid 6 (0.02) P
			Micraspis vincta 11 (0.03) P
			Harmonia octomaculata 7 (0.02) P
			Harmonia larva 5 (0.01) P
Paddy 2		745 (2.13)	*Aphelinus* spp. 72 (0.21) Pa
			Syrphid 7 (0.02) P
			Scymnus sp. 2 (0.01) P

Table 31. (Continued)

Rice Paddy	Date of Research	Aphid (No./hill)	Natural Enemy (No./hill)
			Micraspis vincta 8 (0.02) P
			Harmonia octomaculata 4 (0.01) P
			Harmonia larva 13 (0.04) P

As seen from the table given above, the presence of Aphids in the rice paddies of Thailand is negligible. This is apparently attributed to the presence and activity of natural enemies, especially of two or three species of parasites, *Aphelinus* spp.

Miridae (Det. by Dr. Carvalho)

1. *Campylomma annulata* Knight
2. *Paramixia samoanus* Knight
3. *Ernestinus mimicus* Distant
4. *Creontiades pallidifer* (Walker)
5. *Halticus minutus* Reuter
6. *Cyrtorhinus lividipennis* Reuter
7. *Tytthus parviceps* (Reuter)
8. *Cyrtopeltis tenuis* (Reuter)

Among these only *Cyrtorhinus lividipennis* has been recorded from Thailand.

Thrips (Det. by Dr. Haga)

Thripidae

1. *Organothrips bianchii* Hood
2. *Chirothrips* sp.
3. *Caliothrips* sp.
4. *Anaphothrips* sp.
5. *Scirtothrips* sp.
6. *Thrips* sp.
7. *Xylaplothrips* sp.

Aeolothripidae

8. *Aeolothrips* sp.

Phlaeothripidae

9. *Antillothrips cingulatus* (Hood)
10. *Antillothrips malabaricus* (Ananthakrishnan)
11. *Dexiothrips madrasensis* (Ananthakrishnan)
12. *Haplothrips ganglbaueri* Schmutz
13. *Haplothrips apicalis* Bagnall
14. *Haplothrips* sp.
15. *Haplothrips euphorbiae* Priesner
16. *Nesothrips* sp.
17. *Podothrips lucasseni* (Kruger)

Among these 17 species, *Aeolothrips* sp. and *Podothrips lucasseni* are predators, and *Antillothrips cingulatus*, *A. malabaricus*, *Dexiothrips madrasensis*, *Nesothrips* sp. and *Xylaplothrips* are fungivorous. The most dominant species on rice plant is *Haplothrips ganglbaueri* so far as our observation goes.

DISCUSSIONS AND SUMMARY

With the development of irrigation system in the near future in Thailand, the double cropping of rice plant and the use of fertilizer and chemicals is expected to increase. Even in such cases we must endeavor to reduce the use of chemicals in order to continue the rational integrated rice pest control. As was discussed in the previous chapters, the following methods of manipulation in field usage may be always necessary, and we must predominantly dependent on these four principal techniques.

1. Use of natural enemies.
2. Application of cultural method.
3. Use of selective chemical insecticides and herbicides only in case of need.
4. Development of resistant rice plants or avoidance of the use of very susceptible varieties against rice pests.

In the case of rice cultivation, utilization of natural enemies is divided into the following two ways.

1. Conservation of the indigenous existing species to improve or maintain their effectiveness through

   a. provision of missing or inadequate requisites such as alternate hosts, supplementary food or shelter or refuge area during the non-rice months or seasons, and

   b. elimination or reduction of hazards or adverse environmental factors such as poor cultural practices, indiscriminate use of insecticides and herbicides and other adverse physical or biotic factors.

2. Augmentation of already established natural enemies by periodic colonization or by genetic selection to improve fitness.

In this connection, studies on the artificial mass-rearing methods of such natural enemies as *Conocephalus* spp., *Micraspis* spp., *Harmonia octomaculatus*, *Formicomus braminus braminus*, *Hapalochrus rufofasciatus*, *Cyrtorhinus lividipennis*, *Amblyseius imbricatus*, *Telenomus rowani*, *Tetrastichus schoenobii*, *Paracentrobia* spp., *Oligosita yasumatsui*, *Anagrus optabilis*, *Tetrastichus formosanus*, *Gonatocerus* sp. and *Platygaster oryzae* are of urgent need.

The results of our long years extensive survey on the natural enemies of rice pests in Thailand reveal that her rice paddies have satisfactorily abundant natural enemies either in the number of species or in their quantity. One hill of rice plants is keeping high rate of natural enemies as compared to the number of rice pests. Usually, the population of pest insects on one hill of rice plants is very low, being far below the economic injury level. This has a closest relation with the population of natural enemies of the pest insects. The ratio between.the numbers of insect pest and its natural enemies is satisfactory to prevent the increase of pest population above the economic threshold level of the pest species. Each species of rice pests has several key species of natural enemies which are attacking the host pest insect together in the same paddy. The predominance of non-specific natural enemies is extremely significant. Throughout the rice areas of Thailand the farmers are making staggered cultivation. Staggered cultivation is also helping the conservation and increase of natural enemies of rice pests and has a strong impact on the effectiveness of indigenous natural enemies. In another word, this indicates that in certain cases, perhaps many, the cultural technique operates indirectly by conserving or enhancing natural enemies rather than decimating pest populations directly. In our present report, we showed only a few examples of our survey results, but this fact will be seen clearly if the readers examine the data in detail and make reasonable analyses on the figures.

One of the most important application of cultural methods to avoid the infestation of rice pests has a close relation to the precipitation or water problem. Shortage of rain during a certain critical months may cause a great influence on the emergence of rice gall-midge. Relatively early transplanting of rice plants in the rice paddy after the flooding of water may stimulate the break of diapausing full-grown larvae of stem-borers to emerge at the most appropriate time to infest the rice plant. Even in the rice paddy where one crop of rice is cultivated per year, the late transplanting of four weeks or more after the flooding of rain-fed water is recommended for a comparatively large acreage at the same time where the damage caused by rice stem-borers was severe in the previous year. There is an urgent need to study the relation between the occurrence or incidence of rice pests and the water or rainfall more extensively in the future to determine the planting date to avoid the pest attack. Irrigation or fertilization regimes may have a great impact on pest populations.

The use of granular-form insecticides is strictly necessary to save the population and not to disturb the activity of natural enemies. By this method the effect of natural enemies upon the pest population may be more strongly increased. Endeavor should be made to find less expensive new insecticides.

The breeding or utilization of resistant varieties of rice plant against rice pests has some of the same limitations as chemical control - shifting physiological races of the pest pose the same problem to the plant breeder that insecticide resistance poses to the entomologist. Also it may require an average of ten to fifteen years to develop a firmly fixed resistant variety. This means a relatively expensive and slow response to immediate problems. Further, we must bear in mind that even if the plant breeder can develop highly resistant plant against one insect, there is a high possibility of having a strongly susceptible characters to another pests. We have many examples of this kind. And there is also a high possibility that the highly resistant variety against several insect pests at the same time may have a very poor agricultural quality for the consumers. Some farmers cultivate a high yielding varieties of rice plant by using chemicals frequently even if it is highly susceptible to the pest insects. Such a trend of rice cultivation we cannot recommend from the standpoint of ecology of a rice agro-ecosystem. Without waiting a long period we must encounter the problems such as environmental pollution by chemicals, elimination of natural enemies of rice pests, cause and domination of insecticide resistant populations of rice pests, and finally the necessity of more frequent or heavy application of strong insecticides. We are confident that such a trend of farmers may cause socio-economic problems if we consider and analyze the process on a long term basis.

At the moment and in the future, we can perform the integrated rice pest control without any difficulty if we follow the diagrammatic model of the integrated rice pest control and other recommendations carefully.

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