Role of Natural Enemies in the Regulation of Stored-Product Insect Populations in Rice Storages in Thailand*

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Abstract

Food trap investigations on stored-product insects in rice storages, farmers' warehouses, seed storages and rice mills in Thailand, revealed two contrasting types of population change of stored-product insects : suppression and explosive outbreak. Frequently the infestation levels in the rice storages were very low. The analysis of the factors that influenced the insect populations indicated that the suppression was apparently caused by natural enemies, especially predators. Many ants were captured such as *Crematogaster* sp.,*Tapinoma indicum* and *Paratrichena longicornis*. *Xylocoris flavipes*, a predacious bug and *Withius niger*, a pseudoscorpion were also trapped. In addition, the occurrence of intruders like spiders, lizards, etc. was frequently observed in the storage facilities since common rice storage structures in Thailand are widely exposed to such predators from outside. Thus, insect pests, natural enemies, especially predators from outside and host grain form a very unique and balanced ecosystem.

Additional key words : predators, parasites, ants, spiders, pseudoscorpion

*This paper presents the results of a collaborative study between the Tropical Agriculture Research Center (TARC), Tsukuba, Japan and the Department of Agriculture, Bangkok, Thailand.

Introduction

Thailand, located in the wet monsoon zone where a large number of farmers are engaged in paddy production is the largest rice-exporting country in the world. The hot and humid climate which is favorable for rice cultivation, however, also is apt to bring about serious damage to rice after harvest due to the occurrence of stored-product insects which can complete their life cycle rapidly and cause explosive outbreaks[5,9].

To investigate the fauna of stored-product insects in rice through the marketing system, we set up food traps in farmers' warehouses, seed storages, rice mills and godowns of exporting companies in 11 provinces of Thailand and recorded data from 1988 to 1991[8]. The records showed that the frequency of insect pest populations did not fit to a single-modal Gaussian curve but rather tended to show a skewed distribution toward two opposite conditions, explosive outbreak and suppression. In fact, in many rice storage facilities the incidence of infestation was rather low although the level of hygiene and sanitation was substandard including contamination with broken rice, soil dust, etc. These findings suggested that some unknown factors may operate in regulating the insect pest populations.

One such regulating factor may be the fauna of natural enemies. The present study was conducted to analyze the role of natural enemies in the storage facilities of rice grain in Thailand.

Materials and methods

1) Experimental sites

Eleven farmers' warehouses, 11 seed storage facilities in rice research stations and 13 rice mills were selected in 4 different regions ; Chiang Mai and Chiang Rai in the North, Khon Kaen, Sakon Nakhon, Ubon Ratchathani and Surin in the Northeast, Phitsanulok and Khok Samrong in the Center and Pattani, Phatthalung and Krabi in the South.

2) Food traps

To collect insect pests and their natural enemies, a food trap was installed in each rice storage facility. The trap consisted of a wire-net (ca. 16 mesh) cage 10 cm high, 25 cm long and 18 cm wide. Five hundred grams of paddy, brown, and milled rice were separately packed in plastic netbags (ca. 30 mesh) which allowed insects to freely move in and out, and placed in the cage. The traps were installed at each test site and the bags were renewed every four months. The insect pests, parasites and predators were examined for taxa and numbers.

Results and discussion

1) Size of insect pest populations

Table 1 Average and ranges of the number of Coleopteran adults of stored-product insects found in three forms of rice grains in traps installed for 4 months

	Paddy			Brown rice			Milled rice		
Facilities	(n)*	$\bar{X}$	Range	(n)*	$\bar{X}$	Range	(n)*	$\bar{X}$	Range
Farmer	(33)	706.13	6-5802	(32)	1176.60	8-4379	(32)	1147.28	12-6156
Station**	(32)	383.81	37-2635	(27)	829.95	48-2707	(30)	461.15	12-1813
Rice mill	(37)	365.16	65-1490	(37)	1263.29	42-3443	(36)	898.20	36-2873

* number of traps ** seed storage

A remarkable variation was observed in the number of insect pests collected in traps installed in different storages even in a limited area of a region. The number ranged from less than 10 to more than 6,000 in the Northern part[8]. Table 1 shows the average as well as the range of the numbers of adult Coleopteran pests detected in paddy, brown and milled rice in the traps installed for four months at farmers' warehouses, seed storages and rice mills. Among these different forms of rice grains, paddy showed the smallest number of pests, followed by milled and brown rice. These results are consistent with the general observation that paddy is the most resistant of the three forms of grains to insect infestations[3,4,10,11] whereas brown rice is the most susceptible. Based on the distribution of the size of the insect pest populations, however, it is apparent that the populations of insect pests tended to show opposite trends, very small size (suppression) or explosive multiplication (outbreak) as indicated in Table 2. Size of less than 100 adults corresponded to suppression and more than 2,000 to outbreak. *Sitophilus* spp., *S. zeamais* and *S. oryzae*, were predominant in the populations in both rice mills and seed storage facilities, while *Lophocateres pusillus* predominated in farmers' warehouses[8].

Generally under humid tropical climates, stored-product insects can grow and reproduce very fast, causing explosive outbreaks[5,9]. Hence, the observed low frequency of pest occurrence indicates the existence of certain factors that suppress insect populations.

If we examine the factors involved in the population change of the insect pests in rice storages, four factors can be considered as shown in Fig.1. Among these factors, sanitation conditions including insecticide application and the presence of natural enemies exert a considerable impact on the suppression of population increase.

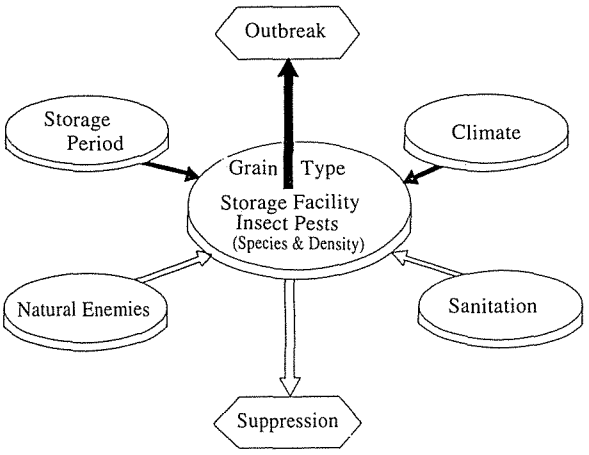

Fig.1. Factors influencing population fluctuations of insect pests in storage facilities

Table 2 Frequency of occurrence of suppression and outbreak of stored-product insects recorded in the traps installed for 4 months in storage facilities

	Paddy				Brown rice				Milled rice			
	Suppress.		Outbreak		Suppress.		Outbreak		Suppress.		Outbreak	
Facilities	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Farmer	9	(27.2)	4	(12.1)	5	(15.6)	8	(25.0)	8	(25.0)	9	(28.1)
Station	10	(31.2)	2	(6.2)	2	(7.4)	6	(22.2)	9	(30.0)	2	(6.6)
Rice mill	9	(24.3)	1	(2.7)	1	(2.7)	18	(48.6)	5	(13.8)	8	(22.2)

Suppression : samples which recorded less than 100 adults of Coleopteran pests.
Outbreak : samples which recorded more than 2,000 adults of Coleopteran pests.
n=number of traps

However, insect infestation in many facilities was rather low even though poor sanitation was a common sight and insecticidal treatment was absent. These observations strongly indicated that natural enemies may have played a significant role in regulating insect pest populations.

2) Natural enemies captured by the traps

The food traps installed in the storage facilities captured not only insect pests but also large number of natural enemies. The species and numbers of natural enemies recovered from the traps are shown in Fig.2,3 and 4. We found many parasites and predators. A parasitic wasp, *Choetospila elegans* that attacks weevils such as *Sitophilus* spp., was the dominant species found in rice mills. In contrast, a few ant species such as *Crematogaster* spp. *Tapinoma indicum, Paratrichena longicornis,* etc. were the most abundant species recorded in both farmers' warehouses and seed storages, although the ants were not specifically natural enemies of stored-product insects due to their otherwise omnivorous habit. As the second largest group, predators consisting of either a pseudoscorpion, *Withius niger* or a predacious bug, *Xylocoris flavipes* were recorded in farmers' warehouses and rice mills, respectively. The parasite, *C. elegans* found in rice mills was likewise recorded in seed storages. Judging from the counts and composition of the populations of natural enemies, they, especially predators, seemed to play a significant role in suppressing the pest populations in Thailand. The contribution of parasites to the control of the insect populations can be ruled out since the population fluctuation of common parasites appeared to be synchronized with that of host insects[2].

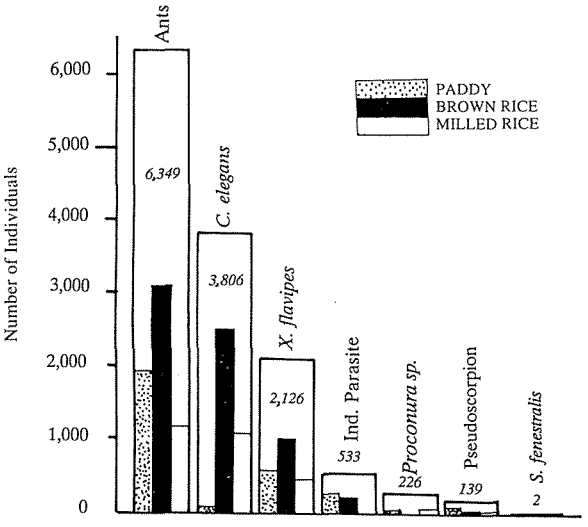

Fig.3. Species and number of natural enemies captured in food traps set-up in station seed storage facilities

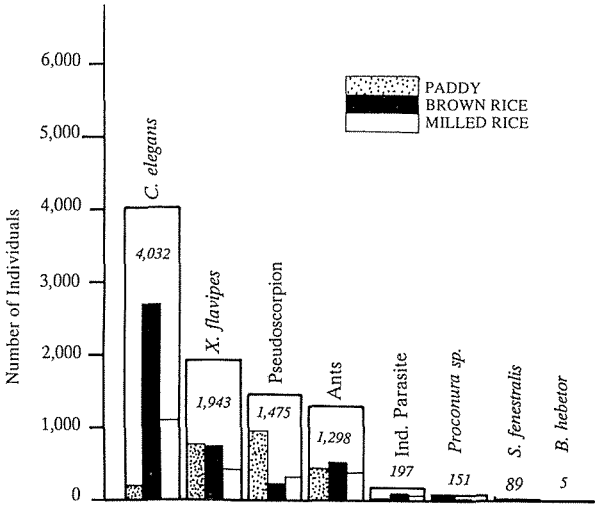

Fig.2. Species and number of natural enemies captured in food traps set-up in farmers' warehouses

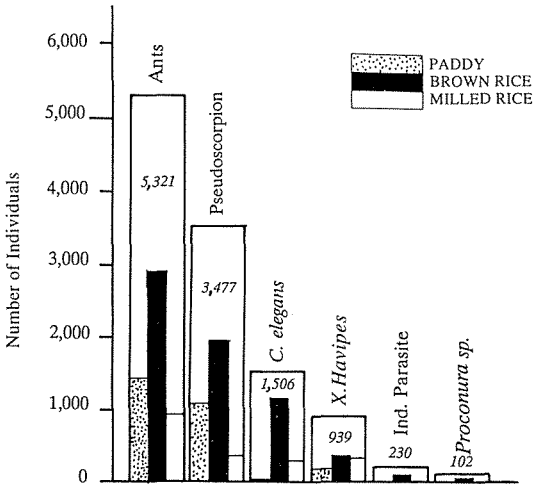

Fig.4. Species and number of natural enemies captured in food traps set-up in rice mills

3) Role of predators

Common predators specific to stored-product insects such as the bug, *X. flavipes* (Plate 1) and the pseudoscorpion, *Withius niger* (Plate 2) were detected as mentioned previously. The bug, *X. flavipes* is a well-known predator, since many researchers have extensively studies its role in the control of stored-product insects[1,2,6,7]. Since this bug has been considered to be a biological weapon for the control of various insect pests such as *Tribolium castaneum, T. confusum, Rhyzopertha dominica, Lasioderma serricorne, Oryzaephilus surinamensis, Sitotroga cerealella, Cadra cautella, Plodia interpunctella,* etc., it may also play an important role in Thailand.

Generally rice storage structures in Thailand are not hermetically closed to external predators, which have not been recognized as natural enemies to stored-product insect pests in temperate areas like U.S.A., Japan, etc. Thus, the ants which behave as carnivorous scavengers and occurred abundantly in the surveys are likely to play a major role in the control of insect pests. Long lines of ants carrying insect pests (Plate 3) were frequently observed, e.g., larvae of *Tribolium castaneum,* adults of *Tenebroides mauritanicus* and *Sitotroga cerealella* although their real effectiveness has not been verified. In addition to ants, spiders were also captured at times, although their exact numbers in the traps were not counted. Spider's webs capturing flying insect pests like moth *S. cerealella* were frequently encountered

Plate 1. Predatory bug : *Xylocoris flavipes*

Plate 2. Pseudoscopion : *Whithius niger*

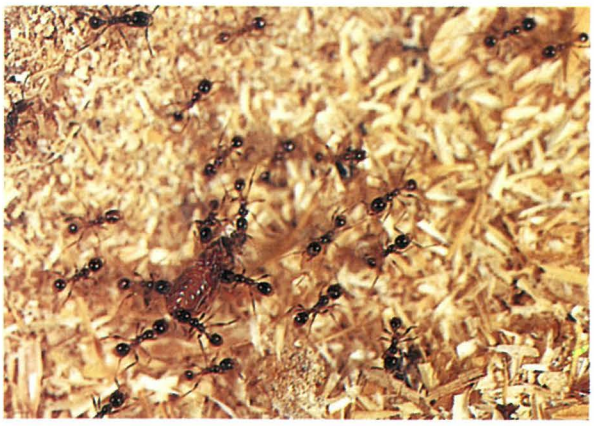

Plate 3. Ants carried an insect pest

Plate 4. Spiders captured moths

(Plate 4). Regarding spiders' role, Yoshida and Takahashi, based on a recent release experiment in Indonesia[12], reported that spiders are useful natural enemies of insect pests in tropical countries. Moreover, several predacious mites and house lizards were sometimes captured in the traps, suggesting that they may play some role in the regulation of the pest populations in the rice storages in Thailand.

In the temperate zone, it is commonly recognized that natural enemies specific to stored ecosystems do not contribute significantly to the regulation of insect pests because the populations of natural enemies fluctuate, following those of the host insects. However, it is unlikely that predators intruding from external habitats, such as ants, spiders, lizards depend on the pest populations for their primary source of food, as they thrive through their omnivorous habits. Thus external predators are considered to be the regulatory component that makes up the unique ecosystems in the rice storage environment in Thailand, although further studies are needed to elucidate their exact role.

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タイ国の米貯蔵場所における貯穀害虫個体群制御に及ぼす天敵類の役割

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摘　要

タイ国11地域の米貯蔵場所（農家倉庫，種子貯蔵庫，精米工場）の貯穀害虫個体群の発生をフードトラップ（籾，玄米，精米500gづつを金属ケージにいれたもの）を用いて，４か月ごとに更新し，一年間調査した。その結果，貯穀害虫の発生の状況は，発生数の少ない制御型と大発生の見られた爆発型に二極化した。それ故，害虫による被害が意外に低レベルなケースが数多く見られた。害虫個体群の増減に対する作用因子の解析から，制御型は明らかに天敵類，特に補食者が起因していることが示唆された。すなわち，設置トラップには多くのアリ類（*Crematogaster spp., Tapinoma indicum, Paratrichena longicornis*），ハナカメムシの一種 *Xylocoris flavipes*, カニムシ（*Withius niger*）が捕獲された。これらに加えて，貯蔵場所の多くは密封性がないので，本来野外に生息しているクモ，ヤモリ等の侵入補食者も頻繁に観察された。トラップで得られた結果と観察された事象からタイの米貯蔵場所では，貯穀害虫ー天敵類（特に外部侵入補食者）ー貯蔵米の間で，非常にユニークなバランスのとれたエコシステムが形成されているものと考えられる。

キーワード：貯穀害虫，天敵，補食者，米貯蔵場所