

## Session 2 : Biology, Ecology and Behavior

### Insect pest status in stored rice in a rice mill in Thailand

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#### Abstract

Rice is an important stored crop in Thailand, and can be infested by several stored product insect species, depending on the stage of the milling process. The lesser grain borer (*Rhyzopertha dominica*), maize weevil (*Sitophilus zeamais*) and Angoumois grain moth (*Sitotroga cerealella*) are the dominant pests in rough rice storage, while sawtoothed grain beetle (*Oryzaephilus surinamensis*) and flat grain beetle (*Cryptolestes* sp.) are dominant in white rice and the packing and milling processes. *Sitophilus zeamais* occasionally lays the egg plug on the embryo clef of white rice and thus causes contamination issues, although it usually lays an egg in the middle of rice kernels. Egg plugs laid on brown rice are able survive through the milling process. Finished milled rice in retail stores can be infested by *O. surinamensis* and also the red flour beetle (*Tribolium castaneum*). Certain species can penetrate through openings in packaged products. Rice products can be stored for up to two years, and the climate of Thailand is conducive to rapid population growth and development of stored product insects, with multiple generations occurring during a calendar year.

Keywords: rice mill , stored-product insects, rice quality, milled rice, paddy rice

#### 1. Introduction

##### 1.1. General condition of rice mills

Thailand was the second largest of rice in the world in 2013. Eight million tons of milled rice was exported while the biggest rice exporter was India (9.3 million tons). There are many rice mills around the country located close to rice production areas, which is about 10.3 million ha. After harvesting, paddy rice at 15% moisture content (MC) is brought to a rice mill to be processed. Paddy rice is held in storage until milled. The rice husk can be removed in one mill and then sent to different mills for further processing into different milled rice products. Thus, the dominant pests vary according to milling location. The limit for of incoming paddy is set at 15% MC and less than 14% for milled rice (National Bureau of Agricultural Community and Food Standard, 2012). Insect pests are always a problem due the favorable temperatures ranging from 30-36°C in summer and 20-26°C during winter, with r.h. of 70-80% year-round. Paddy storage in bulk is from 1 month to a year while the milled rice is packed in jute sack and can be stored for several years. Rice us usually stored by itself away from other commodities.

Incoming rough rice with appropriate MC (< 14%) can generally be held for several months, but rice with higher moisture content usually will experience damage from internal feeders

such as *Sitotroga cerealella*, the Angoumois grain moth, *Rhyzopertha dominica*, the lesser grain borer, and *Sitophilus zeamais*, the maize weevil. Those three species are the major causes of damage to rice stored in Thailand. Although the husk of rough rice storage provides protection the rice milling industry prefers to hold rice as milled rice due space limitation for rough rice storage. *Oryzaephilus surinamensis*, the sawtoothed grain beetle, and *Cryptolestes pusillus*, the flat grain beetle, are also important pests in milled rice in Thailand. *Oryzaephilus surinamensis* has a short life cycle (as low as 19 days depending on temperature, and seems to be the predominant insect pest found in white rice and in commercial retail packages (Hagstrum and Subramanyam, 2006).

Storage temperature was considered as the major insect growth factor. An inside bulk storage temperature depended up on environment temperature and its difference was about 2-3°C. In this case, temperature range had not only direct effects on insect growth but also affected milled rice quality, color and milling quality.

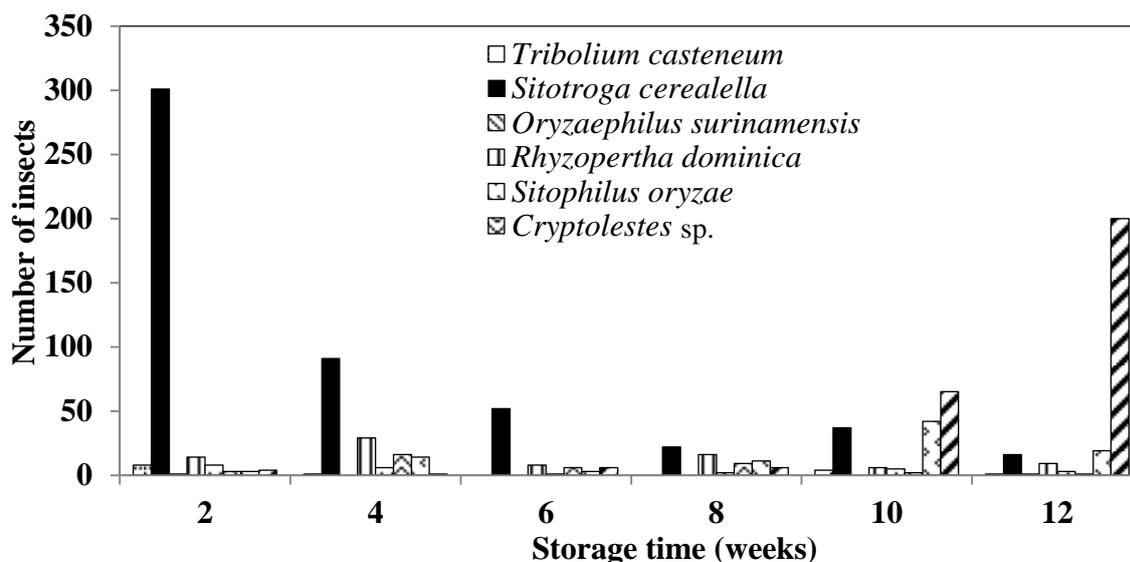
### 1.2. Rice storage system

There are 4 rice storage systems in Thailand consisting of: 1) rice stored in an uncontrolled environment, which is the common way of storing rice in a large scale; 2) low temperature storage using fans for cooling, 3) Rice stored in polyethylene bags; 4) seed banks in cold storage. Moisture control of stored seed is difficult because it hard to lower MC to 12% or less. Rough rice storage condition in Thailand is the weak point for insect pest infestation. After harvesting small rice growers sometimes store rice themselves but usually the sell to larger aggregators.

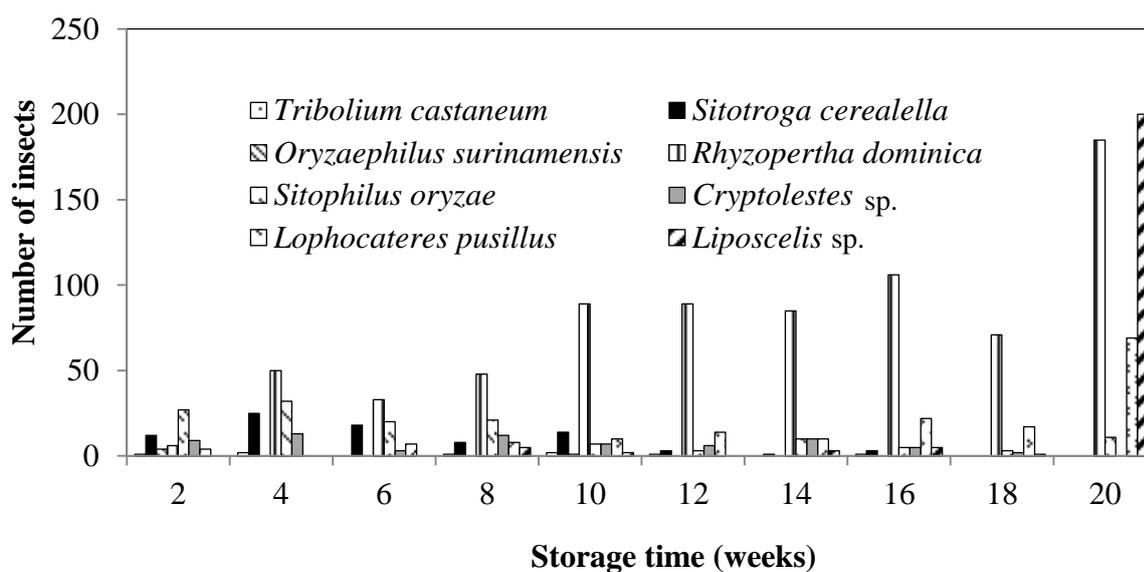
Rice production in 2013 decreased due drought conditions and field insect infestations. However, storage time increased due to changes in economics of storing rice, which led to poor storage conditions and increased losses due to stored product insects. A survey of insect pests in a rice mill in Chiang Mai was conducted from February to May 2013. *Tribolium castaneum*, the red flour beetle, was found at the beginning of storage, even in the new harvested rough rice, followed by *Cryptolestes* sp. and *O. surinamensis*. In contrast, *S. zeamais* was found at the end of storage of ten months. However the common insects found in rough rice bulk was *S. cerealella*, followed by *T. castaneum*, *Cryptolestes* sp. and *O. surinamensis*.

## 2. Yield loss in paddy and milled rice

Romkaew et al. (2014) monitored insect pests in paddy rice at the rice mill in Chiang Mai by using a grain trier to collect rice from the bulk mass. Samples were also collected from jute bags. Moisture content varied more in bulk paddy than in the jute bags. Insects were found mostly in the top portion of the grain bulk and in the jute bags (Figures 1 and 2). *S. cerealella* was more prominent in paddy rice bulk than in the jute bags. *R. dominica* were commonly found in both bulk and jute bags. Loss of paddy rice from those insects were determined by sampling and counting damaged kernels from a 1,000 kernel sample and also weighing the damaged rice and comparing it to undamaged rice. The result show that damage caused by *S. cerealella*, *S. zeamais* and *R. dominica* in four months caused a 0.217 and 0.102 % loss (Table 1) in paddy rice in bulk and jute bags, which translated to 2,000 ton n capacity results in losses of 4.34 and 2.04 ton in bulk and jute bag storage respectively .



**Figure 1** Number of stored product pests per 200 g of rough rice sampled by 4- meter grain trier in bulk of rough rice in every two weeks.

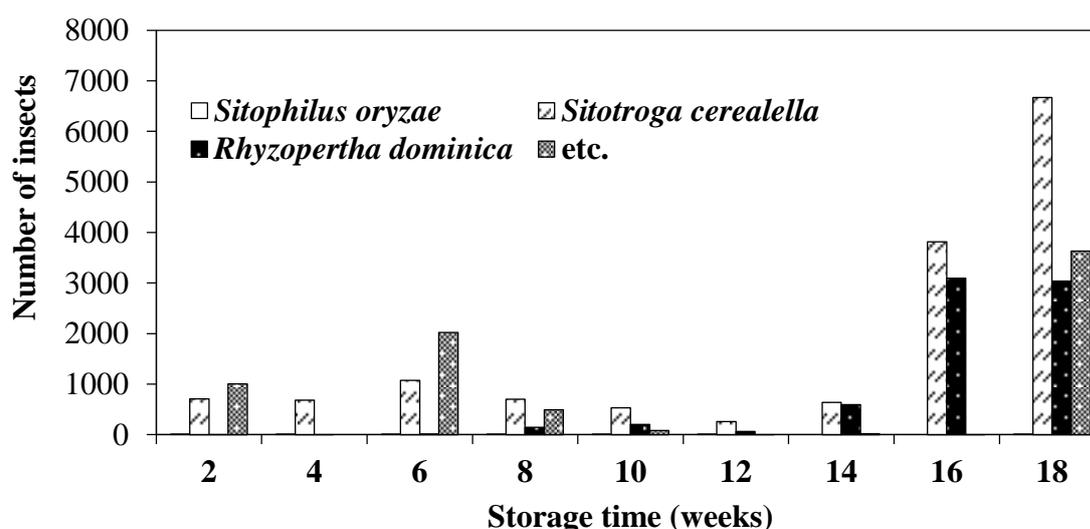


**Figure 2** The number of stored product pests per 200 g of rough rice sampled by 4- meter grain trier in jute bags of rough rice in every two weeks.

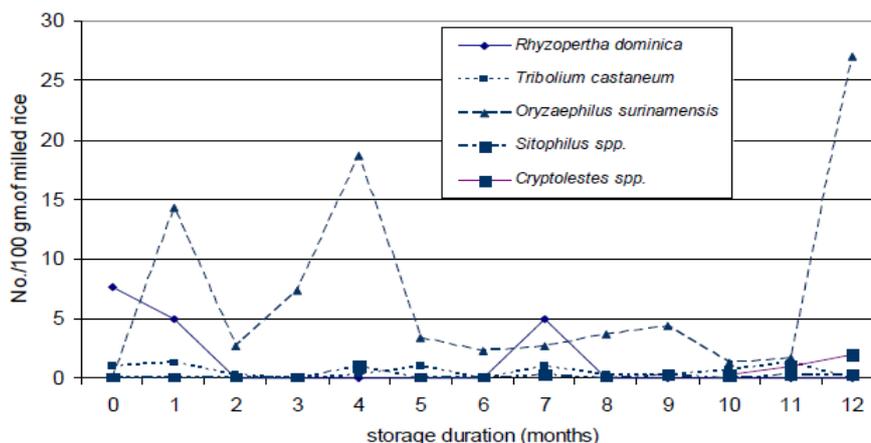
**Table 1** Rough rice damages caused by insect infestation in bulk and jute bag during 4-month storage.

| Rice storage | % damage of rough rice | Insect damage (ton)<br>based on 2,000 ton |
|--------------|------------------------|---|
| In bulk      | 0.217                  | 4.34                                      |
| In Jute bag  | 0.102                  | 2.04                                      |

Insect pests outside the storage areas were monitored in the same location. Ten white 20 by 20cm sticky traps made from corrugated plastic sheet covered with clear plastic bag and painted with liquid insect glue were used. *S. cerealella* and *R. dominica* were the major pests caught in sticky traps (Figure 3).

**Figure 3** Number of stored insect pests caught in 10 sticky traps in every 2 weeks. There were 4 species: 1) *Sitotroga cerealella* 2) *Rhyzopertha cerealella* 3) *Sitophilus zeamais* and 4) others.

In milled rice, Yanaso et al. (2014) reported that up to 100 *S. cerealella* per 250 g of rice were found at the beginning of harvesting and decreased down to 38.17 insects after 6 months. However, *T. castaneum* was found at the first month of storage (2.83 insects per 250g) and throughout the storage time (Figure 4) (Cheaupun et al., 2007). Residual infestations would occur in the rice storage area.



**Figure 4** Stored insect pest infestation (No./ 100 gm of grain) in milled rice storage.  
Source: Cheaupun et al. (2007)

### 3. Insect in light traps

In 2007-2008, researchers from Department of Agriculture, Postharvest and Processing Research and Development Office established light traps with suction devices to collect insects attracted by light in paddy storage in the central region of Thailand. *R. dominica* and *S. cerealella* were the most common species found in light traps in the dry season from September to October. The number of *R. dominica* was 798.33 insects per trap in 7 days while the number of *S. cerealella* was 171.66 insects per trap (Visaratanonth et al., 2008). From June to September *Cryptolestes* sp. and *O. surinamensis* were found in light traps near rice mills.

### 4. Insect biology

Life cycle of stored product insects in stored rice in Thailand was generally short due to favorable conditions (Table 2). Psocids are sometime confused with storage mites and were commonly found in milled rice. There is little research data on psocids in Thailand.

### 5. Milling process and its effects on *Sitophilus zeamais*

The loci of *S. zeamais* oviposition on rice kernels were also investigated. There was no egg plugs on the embryo of brown rice but we found that *S. zeamais* were able to lay eggs on the embryo of brown rice, and white rice with an embryo cleft. The survival rates of *S. zeamais* were  $45.64 \pm 15.4$  and  $3.57 \pm 7.1\%$  respectively (Kerdkong, 2004). As an observation, the embryo of brown rice seems to be flattened and shriveled. The same result was found by Campbell (2002), who showed that *S. oryzae* did not prefer to lay eggs on shriveled kernels. There was no egg oviposition found on shriveled embryo of brown rice. There were more egg plugs on the middle of white rice, brown rice and germinated brown rice and the survival rates at 75% r.h. and room temperature ranging from 25-32°C were  $29.4 \pm 4.6$ ,  $97.6 \pm 1.5$  and  $45.4 \pm 41.3\%$ , respectively while the survival rates of egg plug on edge of rice were  $46.9 \pm 7.8$ ,  $96.2 \pm 3.3$  and  $52.4 \pm 44.9\%$ . The results showed that more *S. zeamais* egg plugs were able to develop in brown rice and germinated brown rice compared to white rice and there was more survival of egg plugs at the middle and edge of kernel. There was less chance of *S. zeamais* of laying egg at the embryo of brown rice. *S. zeamais* egg plugs on the middle and at the edge of rice kernels were affected by the milling process. Survival rates of egg at the middle and the

edge of white kernels on white rice and brown rice were  $81.0 \pm 2.6$  and  $61.5 \pm 3.4\%$ . Brown rice with egg plugs were milled using the TVC rice miller for 20 sec; the survival rates were reduced as  $9.50 \pm 3.0\%$  but the egg laid on the edge of rice kernels was not able to survive. When the milling time was increased to be 30 sec (normal rate) and 40 sec, there was no survival in white and brown rice, indicating that the normal milling process would prevent egg plugs from developing to neonate larvae (Kerdkong, 2014).

**Table 2** Life cycle of stored rice pests in Thailand.

| species                          | Life cycle (days) | Longevity (days) |
|----------------------------------|-------------------|------------------|
| <i>Cryptolestes pusillus</i>     | 27-30             | nd               |
| <i>Liposcelis</i> spp.           | 24                | nd               |
| <i>Oryzaephilus surinamensis</i> | 24-30             | 180-300          |
| <i>Rhyzopertha dominica</i>      | 30                | 150 and more     |
| <i>Sitophilus oryzae</i>         | 30-40             | 30-60            |
| <i>Sitophilus zeamais</i>        | 30-45             | 30-240           |
| <i>Corcyra cephalonica</i>       | 30-40             | 7-14             |
| <i>Sitotrogra cerealella</i>     | 25-28             | 5-7              |
| <i>Tribolium castaneum</i>       | 26-40             | 180              |

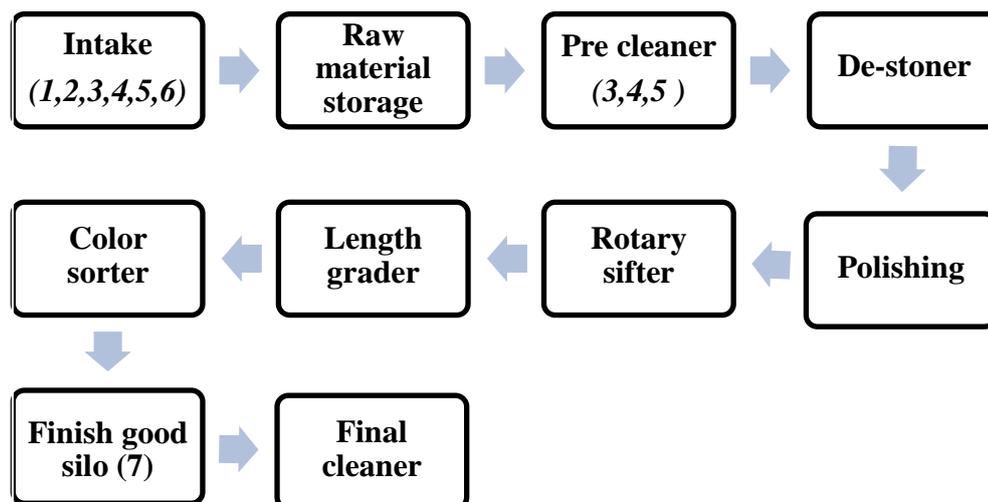
Source: Visarathanonth et al. (2008); Srikam et al. (2014) and Keatmaneerat et al. (2011) nd= no data

## 6. Insect pest of rice in transportation

Milled rice is packed and transported out of rice mill in small plastic bags to retail stores, and there were many cases where *T. castaneum* and *O. surinamensis* were found in or on rice bags. One possibility is those insects penetrated through the single wall corrugated sheet board which is used to protect rice bag. The gaps between papers may allow insects to enter through the length of corrugated sheet board. An experiment was conducted using the 117 cm length of single wall corrugated sheet board 21 cm wide. There was a space in the long tube along with the length of paper. Forty *T. castaneum* or *O. surinamensis* were released on the plastic bag and then the plastic bag with insects was connected to the long opening of corrugated sheet board for 5 days to allow insects to enter through the corrugated paper. The results showed that *T. castaneum* was able to enter the tube and remain inside corrugated sheet board (49.4%) while 9.4% were able to get through the tube of corrugated board to the other side. Fewer *O. surinamensis* (6.87%) penetrated inside corrugated sheet board and only 1.25% were able to get through the other side of corrugated sheet board. Protective packaging would reduce infestations.

## 7. Insect pests in rice milling processes

Incoming ingredients must show a good appearance to buyers or rice mills when brought to the loading site. Pre-cleaning provides good exclusion of foreign materials and insect parts also separates external feeders. A rice color sorter is an effective step to remove insects and other foreign materials (Figure 5).



**Figure 5** The rice milling process and insects found in the process.

- |                                     |                               |
|-------------------------------------|-------------------------------|
| 1. <i>Rhyzopertha dominica</i>      | 5. <i>Cryptolestes</i> sp.    |
| 2. <i>Sitophilus zeamais</i>        | 6. <i>Liposcelis</i> spp.     |
| 3. <i>Tribolium castaneum</i>       | 7. <i>Corcyra cephalonica</i> |
| 4. <i>Oryzaephilus surinamensis</i> |                               |

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