Inventory of Warehouse Pests on Grain Samples at the Plant Quarantine Laboratory of the Makassar Agricultural Quarantine Center

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ABSTRACT

This study aims to determine and record the types of warehouse pest insects found in several export grain commodities in the plant quarantine laboratory of the Makassar Agricultural Quarantine Center. Data on the types of warehouse pest insects on several grain commodities were obtained by sampling as much as 2 kg from each commodity. Grain commodities are taken in warehouses: rice, corn, green beans, coffee, and cocoa. Then take insects found on the surface or inside the grain. The types of warehouse pest insects found in grain samples were identified based on insect morphology. Then secondary data related to kinship relationships between insect species and data on optimal environmental factors for insect growth are taken from book and journal references. The number of warehouse pest insects found in several export grain commodities in the plant quarantine laboratory of BBPK Makassar is eight types. Insect pests are only found in rice, corn, and cocoa commodities. Types of insect pests found, namely *Sitophilus oryzae*, *Sitophilus zeamais*, *Tribolium castaneum*, *Cryptolestes ferrugineus*, *Araecerus fasciculatus*, *Ahasverus advena*, *Ephestia kuehniella*, and *Sitotroga cerealella*.

Keywords: Identification, warehouse pests, grain export

INTRODUCTION

Indonesia is one of the agricultural countries with various agricultural products. Agricultural products include grain, fruit, wood, and other materials. Grain is one of the abundant harvests and will usually be stored in warehouses or warehouse areas. In addition, agricultural products in the form of grains are one of the mainstay export products from Indonesia, such as cocoa beans, coffee, cereals, and oil-containing beans (BPS, 2022). Therefore, efforts to produce and store grain commodities are significant.

According to Rimbing (2015), various organisms can attack grains stored long enough in warehouses or warehouses. Organisms that attack grain commodities or other stored materials, in general, consist of insects, rodents, and birds. Insects are the organisms...
that damage the most stored materials in warehouses. Insects that attack stored materials are also called warehouse pest insects.

The most common insects found as barn pests are insects from the Orders Coleoptera, Lepidoptera, Hymenoptera, and Hemiptera. Of the four insect orders, Coleoptera is the group of insects that have the most species as warehouse pests (Ilato et al., 2012; Munro, 1986). Types of warehouse pest insects that attack seeds or other materials stored in warehouses include *Sitophilus oryzae*, *Tribolium castaneum*, *Rhyzopertha dominica*, *Carpophilus dimidiatus*, *Cryptolestes ferrugineus*, *Oryzaephilus surinamensis*, *Tenebroides mauritanicus*, *Sitotroga cerealella*, *Trogoderma granarium*, and *Ahasverus advena* (Rahman et al., 2012).

Various kinds of damage caused by warehouse pest insects to grain war the warehouses the occurrence of shrinkage or reduction in volume, deterioration in grain quality, and reduction in seed germination. In addition, other consequences of warehouse pest attacks can result in changes in the grain, such as changes in colour and taste and unpleasant odour or contamination with diseases carried by these insects (Nuraini et al., 2022).

Post-harvest grain damage has a significant economic value. It is because: (1) The material is ready for consumption, (2) Costs quite a lot of production costs ranging from seeding, tillage, planting, maintenance and harvesting. Therefore, minor damage to stored materials is already a significant loss compared to the attack of pests on agricultural land (Ilato et al., 2012). Exports of agricultural commodities, including grains, must also meet phytosanitary requirements and food safety standards set by trading partner countries. Insects found in exported grain can cause losses to the exporter due to the cost of reshipping (rejection) or re-fumigation at the destination (Budiman et al., 2020).

Export requirements and quarantine measures for plants and the plant products to be exported aim to ensure that the carrier media (plants and plant products) is free from the pest of the target destination country. The quarantine measures are adjusted to the policies imposed in the destination country. The phytosanitary certification system for the export of agricultural products is guided by a system based on in-line inspection through the application of risk mitigation of pest carry-on and contamination of hazardous contamination from the production site to the place of shipment as stated in the Decree of the Head of the Agricultural Quarantine Agency Number 2471/Kpts/KR.020/K/11/2018 concerning the Acceleration of Agricultural Quarantine Export Certification Services and Number 2523/Kpts/KR.020/K/11/2018 concerning Assessment and Determination In-Line Inspection Point (BKP, 2023).

Based on the description above, it is necessary to identify and inventory warehouse pest insects contained in several export grain commodities at the BBKP Makassar plant quarantine laboratory as inspection data to fulfil export requirements and provide policies
for managing these grains. This study aims to determine and record the types of warehouse pest insects found in several export grain commodities.

METHOD

This type of research is descriptive qualitative research. Data were obtained by directly observing and identifying warehouse pest insects in five export grain commodities: corn, rice, coffee, mung beans, and cocoa. This research was carried out from December 2022 to January 2023 at the Plant Quarantine Laboratory, Makassar Agricultural Quarantine Center, South Sulawesi. The observed population is all warehouse pest insects found in five export grain commodities at the Plant Quarantine Laboratory, BBKP Makassar. At the same time, the samples in this study were corn seeds, rice, coffee, green beans, and cocoa.

The method in this study refers to the IK Lab Method book. Entomology, Makassar Agricultural Quarantine Center (BBKP Makassar, 2023). The data collection technique in this study employs grain test samples taken as much as 2 kg each and put into the examination box. The examination is carried out on barn pest insects found on the surface of the seeds or inside the seeds. Insects outside the seeds are taken using an insect brush or aspirator and inserted into a petri dish containing 70% alcohol. Seeds that show damage symptoms are taken and solved, then insects are taken using a brush or aspirator, then put into a petri dish containing 70% alcohol. Each type of insect found is then identified based on morphology (colour, body shape, antennae, wing shape) which refers to the insect identification book, namely Insects of Stored Products (Rees, 2004) and Beetles Associated with Stored Products in Canada: An Identification Guide (Bosquet, 1990) and scientific articles. Insects that have been identified are put in vials/Petri dishes as archives of OPT (Plant Disturbing Organisms) or OPTK Quarantine Plant Disturbing Organisms) (BBKP Makassar, 2023). Then secondary data on kinship relationships between insect species are taken from scientific articles, and data related to environmental factors are taken from the book Insects of Stored Products (Rees, 2004).

RESULTS AND DISCUSSION

The results of observations made on several grain samples at the Plant Quarantine Laboratory BBKP Makassar obtained eight types of warehouse pest insects. The insects were found to belong to the Orders Coleoptera and Lepidoptera.

Table 1. Warehouse pest insects on some grain samples

<table>
<thead>
<tr>
<th>Number</th>
<th>Scientific Name</th>
<th>Local Name</th>
<th>Order</th>
<th>Family</th>
<th>Grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sitophilus oryzae</td>
<td>Kumbang beras</td>
<td>Coleoptera</td>
<td>Curculionidae</td>
<td>Rice and Corn</td>
</tr>
<tr>
<td>2</td>
<td>Sitophilus zeamais</td>
<td>Kumbang jagung</td>
<td></td>
<td>Curculionidae</td>
<td>Rice and Corn</td>
</tr>
<tr>
<td>3</td>
<td>Tribolium castaneum</td>
<td>Kumbang tepung merah</td>
<td>Tenebrionidae</td>
<td></td>
<td>Cocoa and</td>
</tr>
</tbody>
</table>
In this study, of the five-grain samples examined, only three contained warehouse pest insects: rice, corn, and cocoa. Samples of green bean beans and coffee found no invasion from insect pests. It is thought to be due to the maintained warehouse area condition, and fumigation has been carried out before being examined so that pest insects are not found in the two samples.

Table 2. Optimal environmental conditions and breeding

<table>
<thead>
<tr>
<th>Types of insects</th>
<th>Optimal breeding conditions (temperature, humidity)</th>
<th>Shortest Development Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitophilus oryzae</td>
<td>15-30°C, &gt; 40%</td>
<td>25 days, 30°C, 70%</td>
</tr>
<tr>
<td>Sitophilus zeamais</td>
<td>15-30°C, &gt; 40%</td>
<td>25 days, 30°C, 70%</td>
</tr>
<tr>
<td>Tribolium castaneum</td>
<td>22-40, &gt; 1%</td>
<td>20 days, 35-37,5°C, &gt;70%</td>
</tr>
<tr>
<td>Cryptolestes ferrugineus</td>
<td>20-42,5°C, 40-90%</td>
<td>21 days, 35°C, 90%</td>
</tr>
</tbody>
</table>
Members of the Order Coleoptera became the group with the most types of insects found in this study sample. Almost all grain commodities examined were found warehouse pest insects of the Order Coleoptera. In this study, 6 (six) insect species were included in the Order Coleoptera and divided into 5 (five) families: Curculionidae, Tenebrionidae, Laemophloeidae, Anthribidae, and Silvanidae.

The results also show that members of the Order Coleoptera are the order with the most significant number of species. It is supported by statements of Ilato et al. (2012) that Coleoptera is the largest group of insects with members as barn pests. In line with the statement of Stork et al. (2015), Coleoptera is the most significant insect order, with 400,000 species making up about 40% of all insect species described so far and about 25% of all animal species.

In addition to the Order Coleoptera, there are 2 (two) species of insects from the Order Lepidoptera divided into 2 (two) families, namely Pyralidae and Gelechiidae. These two species were found in different grain samples, as seen in Table 1. Lepidoptera occupies the second position after Coleoptera, which has the most members as a warehouse pest (Ilato et al., 2012). This order includes moths and butterflies with 180,000 species in 126 families and 46 superfamilies, or about 10% of the total living species described (Capinera, 2008).

Based on the phylogeny tree seen in Figure 1, it is known that the kinship grooves between the eight species found. All species found belong to the Superclass Hexapoda. Hidayat dan Sosromarsono (2015) said that Hexapoda is a group of Arthropods with three pairs of legs or feet, and most of their members are insects. However, many Hexapods have three pairs of limbs but do not include insects, namely Collembola, Diplura and Protura, which are called Parainsecta. In contrast, the Class Insecta is the group of insect Hexapods that do not belong to Parainsecta.

The eight insects then entered the Class of Insecta. Wardhani (2022) said that this class has unique characteristics; the body is divided into three main segments, namely the head (caput), chest (thorax) and abdomen (abdomen), has three pairs of limbs found on the chest, has compound eyes (facet eyes) and several other specific characteristics.

Furthermore, these insects are members of the Subclass Endopterygota (wings develop in the body). Hidayat dan Sasromarsono (2015) said that insects in the division Endopterygota are Superorders Neuropteroidea, Mecopteroidea, and Hymenopteroidea. Orders included in the superorder Neuropteroidea include the following; Order Megaloptera, Raphidioptera, Neuroptera, Coleoptera, and Strepsiptera. Orders included in

<table>
<thead>
<tr>
<th>Insect species</th>
<th>Temperature &amp; Humidity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Araecerus fasciculatus</em></td>
<td>&gt; 22°C, &gt; 60%</td>
<td>26-66 days</td>
</tr>
<tr>
<td><em>Ahasverus advena</em></td>
<td>&gt; 17.5°C, 65%</td>
<td>22.5 days</td>
</tr>
<tr>
<td><em>Ephestia kuehniella</em></td>
<td>12-30°C, &gt; 0%</td>
<td>40 days</td>
</tr>
<tr>
<td><em>Sitotroga cerealella</em></td>
<td>16-35°C, &gt; 30%</td>
<td>30 days</td>
</tr>
</tbody>
</table>

Source: Rees, 2004
The Superorder Mecopteroidea include Mecoptera, Diptera, Siphonaptera, Trichoptera, and Lepidoptera. The order included in the Superorder Hymenopteroidea is the order Hymenoptera.

As seen in Table 1 and Figure 1, it is known that the eight insect pests found consist of two orders, namely the Order Coleoptera and the Order Lepidoptera. The Order Coleoptera's characteristics are: (a) Have two pairs of wings. (b) The front wings are hard and thick and contain a substance called elytra, and the rear wings are membrane-like. (c) Undergoing complete metamorphosis and (d) Biting mouth type (Rahman, 2019). While according to Powell (2009), Order Lepidoptera has standard features: (a) Scales covering the body and wings, Scales are modified and flattened "hairs" that give butterflies and moths a variety of colours and patterns. (b) Almost all species have some form of membranous wing, except for a few whose wings have been reduced or wingless. (c) Undergo complete metamorphosis. (d) It has a cylindrical body with a well-developed head and three thoracic legs.

Based on Figure 1, insects in the Order Coleoptera are divided into five families. Antrhibidae and Curculionidae belong to the same superfamily, namely Curculionoidea, known as the snout beetle group because it has a snout as its characteristic (Mavaldi et al., 2014). Then the families Silvanidae and Laemophloeidae belong to the same superfamily, namely Cucujoidea. The morphology of Cucujoidea is varied, and no features unite all members of this superfamily (Robertson et al., 2015). Finally, the family Tenebrionidae belongs to the Superfamily Tenebrionoidea. Insects from Tenebrionoidea are known as the darkling beetle’s family because of the characteristic of this group, which is a dark body colour ranging from dark brown to black (Lillig et al., 2012). The insects found from the Order Lepidoptera belong to two different superfamilies. The family Pyralidae belongs to the Superfamily Pyraloidea. Pyraloidea is known as snout moths because they have a snout and overall body morphology of a triangular shape that progresses to the anterior end of the snout, and most of its members consist of slender-bodied and long-legged moths, often with narrow, elongated front wings (Alford, 2012; Regier et al., 2012; Solis, 1999). Then the family Gelechiidae is a member of the Superfamily Gelechinoidea, the curved horn moth. The name refers to one of the striking organs found in almost all Gelechinoidea, which is a labial palp that is well developed and forms more or less soft curved protrusions whose tips have pointed tips that are pulled out so that they look like horns (Kaila et al., 2011; Robinson et al., 1994).

### a. *Sitophilus oryzae* and *Sitophilus zeamais*

*S. oryzae* and *S. zeamais* is a barn pest insect that is both family members of Curculionidae. They are major pests on grains such as rice, corn and wheat. In nature, these two species are easier to distinguish with unique identification because the appearance of
both is very similar when viewed directly. However, the easiest way to identify it is to perform genital surgery to see the differences in genitalia between the two species (Haines, 1991; Ilato et al., 2012; Manueke et al., 2015; Rees, 2004; Setyaningrum et al., 2016).

*S. oryzae* and *S. zeamais* have several characteristics. The body of the imago *S. oryzae* is oval and measures 2-3.5 mm in length and 1.1-1.3 mm in width, while *S. zeamais* has a larger size ranging from 3.5-5 mm. Adult specimens or imago have a body of dark to black colour; two dull orange or yellow spots characterise each elytron. There are flying wings (under the elytra), and on the pronotum, there are circular spots. Differences between the two species are seen in genital dissection with the characteristics of the outer *aedeagus* surface, which serves as a penis on male *S. oryzae* smooth and convex in cross-section, whereas *S. zeamais* outer surface of male aedeagus has two notches in cross-section. In addition, the characteristic muzzle (rostrum) in adult specimens is also used to distinguish males and females. The male Sitophilus has a relatively short and broad muzzle; the pattern of holes along the muzzle is irregular, large, and rough. While the female Sitophilus has a relatively long and narrow snout, and the pattern of holes along the snout looks neat, regular, and petite, and does not touch each other to give a smooth appearance (Haines, 1991; Ilato et al., 2012; Manueke et al., 2015; Rahman et al., 2012; Rees, 2004; Setyaningrum et al., 2016).

Both species can be accurately identified through observations on adult insects based on the characteristics of male and female genitalia as previously described. In line with the identification results, Hong et al. (2018) said in particular, the median lobe of the aedeagus (sex organs) of *S. zeamais* has two longitudinal grooves on the dorsal, except in the apical part, and cross-section of the male genitals of *S. zeamais* appear to be torturous. However, there is no longitudinal groove on the dorsal on the median lobe of the aedeagus S. oryzae. Therefore, the male genitalia is finely convex in cross-section. Then the sex characteristics of *S. zeamais* females show a Y-shaped lateral sclerite lobe at the tapered end. The separation is more prominent than in the female genitals of *S. oryzae*, at the rounded end at the apex, and the separation is narrow.
S. oryzae and S. zeamais are almost cosmopolitan warehouse pests worldwide in warm and tropical regions. Usually, they dominate the competition with other warehouse pests in humid and warm conditions, such as in the tropics (Hong et al., 2018; Manueke et al., 2015). According to (Rees, 2004), The optimum conditions for growth and breeding of these two species tend to be the same, namely in environmental conditions with temperatures of 15-30°C and humidity > 40%. The shortest breeding period of both is the same, which is for 25 days at 30°C and 70% humidity. Adult insects will continue to feed on grain, live a long life of 3-6 months, and be longer in the cold months.

The type of damage and symptoms of an attack of both pests are very pronounced. The larvae feed on the seeds and leave large cavities on the seeds. Adult insects will cause further damage by eating grains and leaving large, uneven cavities. Investment in adult insects will encourage a broader decline in the quality of stored materials and create conditions that promote fungal growth and the growth of other insect populations (Ilato et al., 2012; Manueke et al., 2015; Nuraini et al., 2022; Rees, 2004; Setyaningrum et al., 2016).

The classification of S. oryzae and S. zeamais listed below (ITIS, 2023):

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Animalia</th>
<th>Order</th>
<th>Coleoptera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylum</td>
<td>Arthropoda</td>
<td>Family</td>
<td>Curculionidae</td>
</tr>
<tr>
<td>Subphylum</td>
<td>Hexapoda</td>
<td>Genus</td>
<td>Sitophilus</td>
</tr>
<tr>
<td>Class</td>
<td>Insecta</td>
<td>Species</td>
<td>S. oryzae, S. zeamais</td>
</tr>
</tbody>
</table>
b. *Tribolium castaneum*

*T. castaneum*, or red flour beetle, is known as a powder pest. The population of these insects will quickly increase in the warehouse material of the type of flour or on the condition that other types of insects have attacked the material. *T. castaneum* is a secondary pest that develops on material attacked by other insects (Ilato *et al.*, 2012). Heavily attacked food will be contaminated by benzoquinone, so it is unsuitable for consumption. Then mould will grow and produce metabolites such as aflatoxin, which are toxic and carcinogenic in humans (Astuti *et al.*, 2016). However, (Rees, 2004) said that in nature, they live under the bark of trees and in animal nests where they feed on other insects and detritus of animal and plant origin.

Based on the identification results, the species in the study sample was *T. castaneum*. This beetle has several distinctive characteristics that distinguish it from other species of the genus *Tribolium*. Adult beetles are small, about 2.3-6.5 mm long and 2 mm wide, with uniform rust or brown or black colour. The head and pronotum are sometimes darker than the rest of the body. On the head (dorsal), visible eyebrows are above the eyes. The adult has antennae shaped like a club and regularly widen towards the tip, and holes in the surface of the thorax are small. The gap between the eyes is relatively short on the ventral part of the side of the head (Haines, 1991; Ilato *et al.*, 2012; Rees, 2004; Setyaningrump *et al.*, 2016).

*T. castaneum* is one of the fastest-growing species under optimum conditions. *T. castaneum* is more dominant in the tropics. However, the species is also very tolerant of environments with low humidity. Based on Table 2, *T. castaneum* can grow and develop in an environment with a temperature of 22-40°C and humidity of 1%. Its shortest development period at optimum conditions is 20 days at a temperature of 35-37.5°C and humidity of > 70% (Rees, 2004).

![Figure 3. Tribolium castaneum. (A) Adult beetle, on the head (dorsal) visible eyebrow-like organs clearly above the eyes, the last three segments on the antennae enlarged, holes on the surface of the thorax are small, (B) The gap between the eyes is relatively short (Personal Documentation, 2022).](image-url)
By economic importance, *T. castaneum* is a significant pest on products in warehouse sites worldwide. This species almost attacks all dry matter of animal and plant origin, mainly as pests of cereals and cereal products. Several species may appear in one location, but one species will dominate in competition. *T. castaneum* is an efficient pest because it can fly. A considerable amount of its presence will significantly influence other insects in the warehouse site. The type of damage and symptoms resulting from this insect investment cannot be specifically identified. However, its invasion can cause an unpleasant odour that settles on the commodity due to the secretion of benzoquinone from the abdominal glands of these insects (Rees, 2004).

The classification of *T. castaneum* is as follows (ITIS, 2023):

- **Kingdom**: Animalia
- **Phylum**: Arthropoda
- **Subphylum**: Hexapoda
- **Class**: Insecta
- **Order**: Coleoptera
- **Family**: Tenebrionidae
- **Genus**: Tribolium
- **Species**: *T. castaneum*

### c. Cryptolestes ferrugineus

*C. ferrugineus* is a species of the Family Laemophloeidae. Generally, this family is flattened small beetles that mostly live under the bark of trees and are not so important economically. However, Cryptolestes constitute an important pest group of cereal products (Rees, 2004). *C. ferrugineus* appears after the attack of other pests on grain. In intact seeds, it is difficult to find populations of these insects (Setyaningrum *et al.*, 2016).

*C. ferrugineus* belongs to small beetles with an adult insect size of 1.5-2.5 mm and a width of 0.5 mm. The body is strongly flattened, bilaterally symmetrical, with antennae that look like long hairs. Antennae are long up to the length of the body of the insect. The body is brownish red. The head and prothorax together form half the length of the body. Adult beetles cannot climb glass but have a way of walking with a characteristic sway (Haines, 1991; Rahman *et al.*, 2012; Rees, 2004; Setyaningrum *et al.*, 2016).

![Figure 4. Cryptolestes ferrugineus](Personal Documentation, 2022)
**C. ferrugineus** is a secondary pest that attacks various commodities such as grains and grain products, nuts, vegetables, and dried tubers (Prabawadi et al., 2015). Table 2 shows these insects can grow and multiply optimally in an environment with 20-42.5°C and 40-90% humidity. The shortest development period is 21 days at 35°C and 90% humidity. Some species, including *C. ferrugineus*, *C. capensis* and *C. turcicus*, can tolerate cold environments even if they survive long in environments below 0°C. It allows this beetle to become a significant pest in cold climates (Rees, 2004).

Classification of *C. ferrugineus* is as follows (ITIS, 2023):

<table>
<thead>
<tr>
<th>Classification Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingdom</td>
<td>Animalia</td>
</tr>
<tr>
<td>Phylum</td>
<td>Arthropoda</td>
</tr>
<tr>
<td>Subphylum</td>
<td>Hexapoda</td>
</tr>
<tr>
<td>Class</td>
<td>Insecta</td>
</tr>
<tr>
<td>Order</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>Family</td>
<td>Laemophloeidae</td>
</tr>
<tr>
<td>Genus</td>
<td>Cryptolestes</td>
</tr>
<tr>
<td>Species</td>
<td><em>C. ferrugineus</em></td>
</tr>
</tbody>
</table>

d. **Araecerus fasciculatus**

*A. fasciculatus*, known as the cacao beetle, is a beetle of the Family Anthribidae. It is the only one in the family known as warehouse product pests because most of the members of Anthribidae feed on mould and dead wood (Rees, 2004).

*A. fasciculatus* is a spherical beetle 3–5 mm long with long legs and antennae, prothorax and elytra patterned with small patches of light dark brown light grey colour. The elytra are shorter than the abdomen, so the abdominal segment is open. Three thickened segments form a loose mace at the ends of the antennae. The larvae are scarabaeiform, hairy and legged (Nuraini et al., 2022; Rees, 2004).

![Araecerus fasciculatus](image)

Figure 5. *Araecerus fasciculatus* (Personal Documentation, 2022)

*A. fasciculatus* is an essential pest on stored products such as grains, coffee beans, and cassava. These insects can cause significant losses to post-harvest agricultural yields (Nuraini et al., 2022). Ress (2004) says that *A. fasciculatus* can attack a variety of
commodities but is most commonly known as a pest of coffee, cocoa, and spices such as nutmeg. However, this beetle will also attack nuts and dried roots such as yams and cassava and is sometimes also found attacking corn.

*A. fasciculatus* is distributed in tropical and subtropical countries. Table 2 shows adult beetles will perform optimum breeding under environmental conditions with a temperature of > 22°C and humidity > 60%. The shortest development period is 26-66 days at a temperature of 28-32°C and humidity of 60%. Therefore, *A. fasciculatus* will multiply most quickly and successfully in high humidity conditions. If commodity and environmental conditions are dry, it will increase mortality and the time it takes to mature. Therefore, this beetle will significantly impact when warehouse conditions and products are moist. The damage caused by adult beetles is the appearance of circular holes and large cavities inside the seeds (Haines, 1991; Rees, 2004).

The classification of *A. fasciculatus* is as follows (ITIS, 2023):

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Animalia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylum</td>
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</tr>
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<td>Subphylum</td>
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</tr>
<tr>
<td>Class</td>
<td>Insecta</td>
</tr>
<tr>
<td>Order</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>Family</td>
<td>Anthribidae</td>
</tr>
<tr>
<td>Genus</td>
<td>Araecerus</td>
</tr>
<tr>
<td>Species</td>
<td><em>A. fasciculatus</em></td>
</tr>
</tbody>
</table>

e. *Ahasverus advena*

*A. advena*, known as the migrant beetle, is a member of the family Silvanidae (Rees, 2004). These insects' presence indicates that the warehouse material has been severely damaged. *A. advena* are secondary pests that do not cause direct damage to stored materials. These insects attack stored material that has been damaged (damp and mouldy) because the leading food is fungi on insect carcasses and stored material that has been damaged (Anggara & Sudarmaji, 2009).

These beetles are generally small (figure 6), about 2.5-3.5 mm in size, very flattened and bilaterally symmetrical, and light brown. Prothorax without six tooth-like protrusions. Pronotum with slightly curved sides and protrusions clearly visible at each front corner and slightly curved ventral side. It has a pair of moderately long antennae with three segments at the end enlarged like a mace (Anggara & Sudarmaji, 2009; Haines, 1991; Rees, 2004).

*A. advena* attacks several commodities, including grains and cereal products, vegetable oils, nuts, herbs and spices, dried fruit and cocoa beans. This beetle has also been found all over the world. Based on Table 2, this beetle grows optimally and can breed in an environment with a temperature of > 17.5 °C and humidity of 65%. The shortest development period is 22.5 days, with optimum conditions at 27°C and humidity of 75%. These beetles are often found at harvest time and post-harvest but cannot survive on clean, dry grains. It will usually simultaneously appear in humid environmental conditions, and mouldy seeds are found (Rees, 2004).
Classification of A. advena is as follows (ITIS, 2023):

- **Kingdom**: Animalia
- **Phylum**: Arthropoda
- **Subphylum**: Hexapoda
- **Class**: Insecta
- **Order**: Coleoptera
- **Family**: Silvanidae
- **Genus**: Ahasverus
- **Species**: A. advena

**f. Ephesia kuehniella**

*E. kuehniella*, or Mediterranean flour moth, is a member of the Family Pyralidae and is a secondary pest on warehouse products. This moth is a significant pest on grains and cereals, especially flour (Rees, 2004). The attack of larvae from these insects poses a threat to warehouse materials. Although the intensity of feeding is small, nesting activities cause many grains to be damaged and contaminated with dirt (Anggara & Sudarmaji, 2009).

*E. kuehniella* adults have pale grey bodies (figure 7). The front wings are grey with black zigzag markings, while the hind wings are pale white. The front wings have a 7-14 mm length and a 1.5-2.6 cm wingspan. Labial palp curved upwards. The larvae (caterpillars) are white or pink with black spots and dark-coloured heads and hairs that appear respectively from points on the body's surface. Pupa reddish-brown (Anggara & Sudarmaji, 2009; Haines, 1991; Rees, 2004).

This moth can be found worldwide, especially in countries with a temperate climate. *E. kuehniella* prefers warm temperatures for faster development but can survive in environments with low temperatures ranging from 12-30°C and humidity of 0%. These moths do not survive well in environments with high temperatures because temperatures > 30°C will be barren. The shortest development period was 40 days at 25°C and 75% humidity (Table 2). This moth is often found in warm places like flour mills and bakeries. The place supports their breeding throughout the year (Rees, 2004).
Classification of *E. kuehniella* is as follows (ITIS, 2023):

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Hexapoda
Class: Insecta
Order: Lepidoptera
Family: Pyralidae
Genus: Ephestia
Species: *E. kuehniella*

### g. *Sitotroga cerealella*

*S. cerealella*, known as the rice moth, is a member of the family Gelechiidae. It is a primary pest on cereal commodities. The larval phase is their invasive phase, and when mature is short-lived, does not eat commodities and can fly. Moths of this family have very long, curved labial palps and differ from other moths of commodity warehouses (Haines, 1991; Rees, 2004).

*S. cerealella* adults are more petite than moths of other commonly encountered depository product pests (figure 8). The wings are pale greyish-brown, 5-6 mm long. One small black spot on the fresh specimen is in the centre of the front wing, 2/3 from the base. The wings have much fine hair. The front wings taper towards the ends, and when stretched, the rear wings are shaped like old-fashioned fingerboard road signs. Labial palp is long and curved upwards (Anggara & Sudarmaji, 2009; Haines, 1991; Nuraini et al., 2022; Rees, 2004).

*S. cerealella* many is distributed in tropical climates. This moth can survive cold environmental conditions in temperate or tropical climates. Table 2 shows these insects can grow and multiply in an environment with a temperature of 16-35°C and humidity of 30%. The shortest development period is 30 days in an environment with a temperature of 30°C and a humidity of 75%. Adults are short-lived, do not eat and are active at dusk and night (Rees, 2004).
Figure 8. *Cytotroga cerealella*, an adult moth, has a long, upward-curved labial palp (Personal Documentation, 2022)

*S. cerealella* is an essential pest in cereal commodities, especially barley, corn, rice, sorghum and wheat. The larvae develop inside the seeds so that the seeds become damaged. The field's investment often begins when the seeds mature, especially in tropical climates. These insects are the most severe pests on commodities stored in bags and traditional warehouses, such as corn and sorghum, kept open in fields when dried. However, its investments are limited to the surface layer only. The damage caused is mainly by larvae that feed on grains so that large cavities form inside the seeds (Anggara & Sudarmaji, 2009; Rees, 2004).

Classification of *S. cerealella* is as follows (ITIS, 2023):

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Animalia</th>
<th>Order</th>
<th>Lepidoptera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylum</td>
<td>Arthropoda</td>
<td>Family</td>
<td>Pyralidae</td>
</tr>
<tr>
<td>Subphylum</td>
<td>Hexapoda</td>
<td>Genus</td>
<td>Gelechiidae</td>
</tr>
<tr>
<td>Class</td>
<td>Insecta</td>
<td>Species</td>
<td><em>S. cerealella</em></td>
</tr>
</tbody>
</table>

**CONCLUSION**

Based on the results of research and discussions submitted, it can be concluded that warehouse pest insects found at the Makassar Agricultural Quarantine Center are only found in three commodities: rice, corn and cocoa. The warehouse pest insects found consisted of insects of the Order Coleoptera with species *Sitophilus oryzae*, *Sitophilus zeamais*, *Tribolium castaneum*, *Cryptolestes ferrugineus*, *Araecerus fasciculatus*, *Ahasverus advena* and two species of the Order Lepidoptera with species *Ephestia kuehniella* dan *Sitotroga cerealella*.

**REFERENCES**


ITIS. (2023), from the Integrated Taxonomic Information System (ITIS) online database, www.itis.gov CC0, https://doi.org/10.5066/F7KH0KBK


