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Stored grain pests of corn (*Zea mays* L.) in Mardin province, Türkiye

Mardin ilinde depolanmış dane mısır (Zea mays L.)*'larda zararlıların saptanması*

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ABSTRACT

Licensed warehousing has been steadily increasing in Kızıltepe, Nusaybin, Derik, Mazıdağı, and Artuklu districts of Mardin province, Türkiye. Nevertheless, the current knowledge of the stored grain pests is limited. This study determined insect species, their population densities, and extent of damage in stored corn grains during 2022–2023. Grain samples were taken from both traditional warehouses (reinforced concrete horizontal warehouse) and steel silos using the probe method. Insects were examined in 500 g composite samples prepared for each warehouse. Eleven species belonging to the order Coleoptera were identified from the samples. The most common species and the primary pest in ordinary warehouses was rice weevil, *Sitophilus oryzae* (L., 1758) (Coleoptera: Curculionidae) (48.24%), while the most common species in steel silos was *Tribolium castaneum* (Herbst, 1797) (Coleoptera: Tenebrionidae), with rate of %57.14, known as a secondary pest of stored grains. The number of alive individuals collected was higher than dead individuals (overall, the proportion of alive individuals was 90% in ordinary warehouses and 77% in steel silos). The damage caused by primary pests in corn grains ranged between 1–3%, indicating that the fumigation procedures in the sampled traditional warehouses and silos were not sufficiently successful.

Key Words: Corn grains, Coleoptera, damage, *Sitophilus oryzae,* warehouse

ÖZ

Lisanslı depoculuğun giderek arttığı Mardin İli Kızıltepe, Nusaybin, Derik, Mazıdağı ve Artuklu İlçelerinde depolanmış dane mısırlarda böcek türleri, yoğunlukları ve zarar durumları 2022-2023 yıllarında araştırılmıştır. Örnekler gerek betonarme yatay depo ve gerekse çelik silo depolardan sondalama yöntemiyle alınmıştır. Paçal yapılarak elde edilen 500 gramlık örneklerde böcekler incelenmiştir. Depolanmış dane buğdaylarda 11 tür saptanmış olup, tüm türler Coleoptera takımındandır. Adi depolarda en yaygın görülen ve tahılların primer zararlı olarak bilinen Ekin kambur biti, *Sitophilus oryzae* (L., 1758) (Coleoptera: Curculionidae) olurken, (%48.24), çelik silo depolarda ise, depolanmış tahılların sekonder zararlısı olarak bilinen, %57.14 oranla, *Tribolium castaneum* (Herbst, 1797) (Coleoptera: Tenebrionidae) bulunmuştur. Toplanan canlı birey sayısının ölü bireylere göre daha yüksek olduğu (genel olarak, adi depolarda canlı birey oranı %90, çelik silo depolarda %77) belirlenmiştir. Dane mısırlarda primer zararlıların neden olduğu zarar oranı %1-3 arasında değişmiştir.

Anahtar Kelimeler: Depo, dane mısır, Coleoptera, *Sitophilus oryzae*, zarar

Introduction

Corn (*Zea mays* L.) is one of the most important warm-climate cereals worldwide. It is widely utilized in starch, syrup, beer, and industrial alcohol production in addition to its use as human food and animal feed. Corn is native to Central America (Mexico–Guatemala), where it has been cultivated as a staple crop for thousands of years. (Anonymous, 2025a). Global corn production for 2023/2024 was 1.23 billion tons. The USA ranks first in production, while China ranks first in cultivation area (Anonymous, 2025b). Corn was cultivated on 9,119,000 ha in Türkiye during 2022/2023. Türkiye's corn production reached a record level of 9,000,000 tons during 2023/2024 (Anonymous, 2025b). The leading provinces in corn production are Konya, Adana, and Şanlıurfa in Türkiye.

Various problems occur in corn production from sowing to harvest, including diseases, pests, and weeds, all of which negatively affect yield (Anonymous, 2025b). Losses in grain storage caused by insects and mites fluctuate based on crop type, country, climatic conditions, storage duration, product circulation, storage conditions, storage type, and management measures (Rees, 2004). Generally, losses caused by insects in cereals are estimated to be 10% (Rees, 2004; Fox and Fimeche, 2013). Stored food products are economically valuable commodities; therefore, tolerance toward losses or quality and quantity deterioration caused by diseases and pests is very low. Harmful insects and mites in stored products are subject to quarantine regulations, and fumigation against pests is a mandatory practice in imports and exports (Özgür, 1990).

Several studies have been conducted in Türkiye on stored temperate-climate cereals (such as wheat, barley, and rye) and warm-climate cereals (such as corn, rice, and millet) (Yücel, 1982; Mert, 2012; Aydın, 2011; Bağcı et al., 2014; Işıkber et al., 2005, 2016; Zengin, 2019; Yetkin and Atakan, 2022). Mardin province is strategically located on major export routes, and licensed warehousing has gained importance in the province during recent years. However, there few studies have been conducted on stored cereals in this region. A study conducted in Mardin, Diyarbakır, and Urfa provinces in 1966 reported that Khapra beetle, *Trogoderma granarium* Everts, 1899 (Coleoptera: Dermestidae), was widespread and particularly abundant in Kızıltepe district of Mardin (Ergül et al., 1972).

Various factors influence the presence, species composition and infestation levels of pest insect species in stored products. Fumigation is the most commonly used chemical control method against harmful stored pest insect and acaries (Emekci and Ferizli, 2000). In Mardin, where licensed warehousing activities are steadily increasing and which lies on an important export route, there is currently no information on the pest insect species found in stored corn grains, their significance, or the damage caused by primary (key) pests. Therefore, determining the primary and secondary pest species, their densities in different storage types (traditional warehouses and steel silos), and the resulting damage is a fundamental priority. In addition, this study was designed to classify the collected insects as alive or dead, and aiming to roughly assess the effectiveness of fumigation.

Material and Methods

Properties of storages

This study was conducted in two different warehouse types. One of them traditional warehouses are constructed entirely of reinforced concrete, offering minimal fire hazards and suitable storage options, and it is widely used for storage in Türkiye. Some types have internal compartments. Flat and semi-mechanical types are available. The other storage type most commonly used by the Turkish Grain Board and the private sector is steel silos. Except for the foundation, all components are made of steel sheet metal. Inside the silo, there are steel tanks of various tonnages to hold the product. In these silos, manipulations such as receiving, cleaning, transfer, spraying, and loading are mechanical. It is less suitable for product storage than a

concrete silo. It conducts heat quickly.

Sampling sites

Sampling was conducted in corn warehouses located in Kızıltepe, Nusaybin, Derik, Mazıdağı, and Artuklu districts of Mardin province, Türkiye, where both cultivation and storage activities are intensive, to identify harmful insect species. Samplings were carried out during the period between October 3, 2022 and August 15, 2023. A total of 16 traditional warehouses (concrete horizontal warehouse) and steel silos were selected for samplings. In some of the warehouses or silos where sampling was conducted, pesticide applications (mostly fumigation with 57% aluminum phosphide) had been carried out, which was beyond our control.

The sampling process was conducted at 15–20 days interval throughout the storage period, and a total of 19 samplings were performed. Depending on the quantity of stored corn grains, 4–8 probings were conducted in both traditional warehouses and steel silos. From different points and depths of the corn grain stacks, 2–4 kg of corn was collected, bulked, and a 500 g sample was obtained. At each sampling site, information such as the condition of insects (alive or dead), sampling date, type of product, type of storage, and date of storage was recorded on labels.

Laboratory studies

The corn grain samples were brought to the Entomology Laboratory, Plant Protection Department, Faculty of Agriculture, University of Çukurova, Adana province, Türkiye, to determine insect infestations. The samples were passed through sieves with 2 mm openings, and insects retained beneath the sieves were separated according to species, with adults recorded. Immature stages (eggs, larvae, and pupae) present in the samples were placed, together with the same food material, into 500 g glass jars covered with tightly woven net to obtain adult insects. The jars were kept in a climate-controlled room in the Industrial Crop Pests Laboratory of the Department of Plant Protection, Faculty of Agriculture, Çukurova University, under suitable conditions (at least 25±2 °C and 60±10% relative humidity). The samples under culture were examined, and emerging adult insects were recorded and done ready for identification.

Identification of insects

The identification of insect species collected from stored corn in Mardin province at the species level was carried out by the first author, using the identification keys published by Özgür (1990) and Rees (2004).

Determination of insect damage in stored corn grains

From each sample, 100 grains were examined individually, and undamaged and damaged grains were recorded. Damaged grains were defined as those emptied due to feeding by primary insect pests and/or those with emergence holes of adults such as *Sitophilus* spp. The percentage of damaged grains was then calculated.

Evaluation of data

The number of individuals of the harmful insect species identified is given according to storage type and sampling date. For storages where samples were regularly taken, the damage rates (%) in grains were calculated based on the sampling dates following the method of Karman (1971) and were presented separately for traditional warehouses and steel silos. Since the physical properties, product turnover, spraying conditions (fumigation) and locations of the sampled traditional warehouses and steel silos were differed, no statistical comparison was therefore done in terms of insect numbers.

Results and Discussion

Insect species, number of individuals, and occurrence rates (%) in traditional and steel silo corn storages

Sitophilus oryzae (L. 1758) (Col., Curculionidae) ranked as the primary species, with both a high number of individuals (a total of 96 individuals) and the highest occurrence rate (48.24%) (Table 1). This species was followed by *Tribolium castaneum* (Herbst, 1797), (Col., Tenebrionidae) with a total of 40 individuals and an occurrence rate of 20.10%. A

total of 15 and 16 individuals of *Cryptolestes turcicus* (Grouvelle, 1876) (Col., Laemophloeidae) and *Oryzaephilus surinamensis* (L., 1758) (Col., Silvanidae), respectively, and their occurrence rates were 7.54% and 8.04% of total adults, respectively. Except for *Rhyzopertha dominica* (Fab., 1792) (Col., Bostrychidae) and *Sitophilus* spp., the other species detected in traditional corn storages are of secondary importance in stored grains.

Table 1. Insect species, their total numbers and percentage in total adults found in stored corn grains in traditional warehouses of Mardin province during 2022-2023

Family	Insects	Total number of insects	Percentage (%)
Bostrychidae	*Rhyzopertha dominica*	2	1.01
Curculionidae	*Sitophilus granarius*	6	3.02
	Sitophilus oryzae	96	48.24
Laemophloeidae	*Cryptolestes turcicus*	15	7.54
Nitidulidae	*Carpophilus hemipterus*	3	1.10
Silvanidae	*Ahasverus advena*	3	1.51
	Oryzaephilus surinamensis	16	8.04
Tenebrionidae	*Tribolium castaneum*	40	20.10
	Tribolium confusum	9	4.52
	Latheticus oryzae	9	4.52
	Total	199	100

In steel silos, a total of three insect species belonging to three families of the order Coleoptera were identified in corn grains stored in steel silos, with seven adult individuals recorded in total (Table 2). Contrary to the situation in traditional corn storages, primary pests with major economic importance such as *R. dominica* and *S. oryzae* (Rees, 2004) were not detected in silo storages. The most common (57.14%) and most abundant species (four individuals) was *T. castaneum*. The insect species *Litargus connexus* (Geoffroy, 1785) (Coleoptera: Mycetophagidae), which feeds on molds growing on decayed products in storages, was also identified. This species is recorded for the first time in stored products in Türkiye. It mainly feeds on fungi in storage environments (Hava, 2022).

Table 2. Insect species from order Coleoptera, their total numbers and percentage in corn grains stored in steel silos in Mardin, during 2022-2023

Family	Insects	Total number of insects	Percentage (%)
Tenebrionidae	*Tribolium castaneum*	4	57.14
	Latheticus oryzae	2	28.57
Mycetophagidae	*Litargus connexus*	1	14.29
	Total	7	100

Number of insect individuals according to sampling dates in traditional and steel silo corn storages

In Mardin province, during 2022 and 2023, the total number of insect individuals identified in 500 g samples of stored corn grains in traditional storages, according to sampling dates, is presented in Table 3. As shown in the table, insects were mostly recorded during the October–December period, when amount of corn grains was high. On October 17, 2023, 40 live individuals were recorded, and on December 12, 30 live individuals were recorded (Table 3). Of the total 199 individuals collected, 176 were live, with the proportion of live adults reaching 88%. During the October 2022–December 2022 period, the most abundant species collected from traditional storages was *S. oryzae*, with 86 individuals. In the same sampling period, the number of *T. castaneum* individuals was 36. *Tribolium confusum* du Val., 1863 (Col., Curculionidae), with a total of nine individuals was also recorded mainly during this period. The primary pest of cereal grains, *R. dominica* was recorded only once (July 29, 2023), with a very low number of individuals (two individuals). During the June–July period, *O. surinamensis* was collected in relatively higher number (16 individuals), compared to other insect species.

The numbers of the three insect species detected in corn grains stored in steel silos according to sampling dates are presented in Table 4. In total, only four samples were taken from these storages. The limited number of samples and irregular sampling intervals may have affected insect species composition and their densities. Of the seven individuals collected in total, six were alive (Table 4).

Table 3. Total numbers of insect species found in corn grains stored in traditional warehouses in Mardin, during 2022- 2023, according to sampling dates

Sampling date	n	*S.gr*	*S.or*	*T.ca*	*T.co*	*R.do*	*O.su*	*C.tu*	*C.he*	*L.or*	*A.ad*	Number of dead insect	Number of alive insect
4 Sep. 2022	2	-	5	5	2	-	-	-	-	-	-	-	12
17 Sep. 2022	3	-	23	9	1	-	2	-	-	5	-	-	40
12 Nov. 2022	4	-	28	12	3	-	-	3	-	1	-	23	24
4. Dec. 2022	1	-	8	5	3	-	-	3	-	-	-	-	19
20 Dec. 2022	3	-	9	2	-	-	2	1	-	-	-	-	14
4 Jan. 2023	3	6	13	3	-	-	1	5	-	2	-	-	30
4 Feb. 2023	1	-	-	-	-	-	-	-	-	-	-	-	-
21 Feb. 2023	1	-	-	-	-	-	-	-	-	-	-	-	-
6 Mar. 2023	1	-	-	-	-	-	-	-	-	-	-	-	-
9 Apr. 2023	1	-	-	-	-	-	-	-	-	-	-	-	-
14 May, 2023	2	-	-	-	-	-	-	-	1	-	-	-	1
26 May, 2023	1	-	-	2	-	-	-	2	-	-	-	-	4
14 Jun. 2023	1	-	-	-	-	-	-	-	-	-	2	-	4
24 Jun. 2023	2	-	3	2	-	-	1	-	-	-	1	-	2
14 Jul. 2023	1	-	4	-	-	-	3	-	2	-	-	-	7
29 Jul. 2023	3	-	-	-	-	-	4	-	-	-	-	-	9
16 Dec. 2023	1	-	3	-	-	2	3	1	-	1	-	-	10
Total	31	6	96	40	9	2	16	15	3	9	3	23	176

S.gr: *Sitophilous granarius*, *S.or*: *Sitophilus oryzae*, *T.ca*: *Tribolium castaneum*, *T.co*: *Tribolium confusum*, *R.do*: *Rhyzopertha dominica*, *O.su*: *Oryzaephilus surinamensis*, *C.tu*: *Cryptolestes turcicus*, *C.he*: *Carpophilus hemipterus*, *L.or*: *Latheticus oryzae, A.ad*: *Ahasverus advena;* n: number of sample

Table 4. Total numbers of insect species found in corn grains stored in steeel silos in Mardin, during 2022- 2023, according to sampling dates

Sampling date	Number of sample (n)	*T.ca*	*L.or*	*L.co*	Number of dead insect	Number of alive iinsect
5 Oct. 2022	1	2	-	-	-	2
4 Dec. 2022	1	-	-	-	-	-
28 Apr. 2023	1	-	-	1	1	-
14 May, 2023	1	2	2	-	-	4
Total	4	4	2	1	1	6

T.ca: *Tribolium castaneum*, *L.or*: *Latheticus oryzae*, *L.co*: *Litargus connexus*; (-) no insect found

Damaged grain condition in traditional and steel silo corn storages

The percentages of damaged corn grains due to primary pest insects in traditional storages in Mardin province during 2022 and 2023, based on sampling dates, are presented in Table 5. During the period of October–December in 2022, the percentage of damaged grains ranged between 1% and 2.50%. In June and July, on single sampling dates, the highest damage rate was 3%. By late June 2023, no grain damage was observed. However, on June 26 and July 29, the damage rate reached 3% (Table 5).

The percentages of damaged corn grains in steel silo storages in Mardin province during 2022 and 2023, based on sampling dates, are shown in Table 6. A total of 400 corn grains were examined across four sampling dates, and no damaged grains were detected. This may be attributed to the lower pest infestation levels in corn stored in steel silos and to the higher turnover rate of the stored product.

Table 5. Damaged corn grains due to insects in traditional warehouses of Mardin during 2022-2023, according to sampling dates

Sampling date	Number of sample (n)	Total number of grains	Total number of intact grains	Total number of damaged grains	Percentage of damaged grains
4 Sep. 2022	2	200	198	2	1.00
17 Sep. 2022	3	300	293	7	2.33
12 Nov. 2022	4	400	390	10	2.50
4. Dec. 2022	3	300	293	7	2.33
20 Dec. 2022	3	300	294	6	2.00
4 Jan. 2023	1	100	100	-	-
4 Feb. 2023	1	100	100	-	-
21 Feb. 2023	1	100	100	-	-
6 Mar. 2023	1	100	100	-	-
9 Apr. 2023	2	200	200	-	-
14 May, 2023	1	100	100	-	-
26 May, 2023	1	100	100	-	-
14 Jun. 2023	2	200	200	-	-
24 Jun. 2023	1	100	97	3	3.00
14 Jul. 2023	3	300	300	-	-
29 Jul. 2023	1	100	97	3	3.00
16 Dec. 2023	1	100	100	-	-
Total	31	3100	3062	38	1.23

(-) no insect found

Table 6. Damaged corn grains due to insects in steel silos of Mardin during 2022-2023, according to sampling dates

Sampling date	Number of sample (n)	Total number of grain	Total number of undamaged grain	Total number of damaged grain	Percentage of damaged grain
5 Oct. 2022	1	100	100	-	-
4. Dec. 2022	1	100	100	-	-
28 Apr. 2023	1	100	100	-	-
14 May. 2023	1	100	100	-	-
Total	4	400	400	-	-

(-) no damaged grain found

Discussion

Species diversity and the number of individuals in stored corn grains from traditional warehouses were richer and higher compared to those from steel silos. The primary reason for this is that fewer samples were taken from silos. In Mardin province, the maize weevil (*S. oryzae*) was the most widespread and abundant species in stored corn grains. Similar results have been reported in survey studies conducted in other provinces of Türkiye. Mert (2012) identified 14 insect species from seven families in corn storages in Adana Province. In three different geographical regions of Türkiye, the southern provinces, Southeastern Anatolia (Şanlıurfa), and Central Anatolia (Konya),

S. oryzae and *T. castaneum* were found to be the most common species, with both recorded at equal proportions of 40% (Işıkber, 2016). In Mersin province, the most common species in stored corn grains were reported to be *S. oryzae* and *Sitophilus granarius* (L., 1875) (Col., Curculionidae) (Yetkin and Atakan, 2022). Among the primary pests of cereals, the granary weevil (*S. granarius*) was recorded in much smaller numbers compared to *S. oryzae*. This species is generally widespread in storages located in cooler climates and has low tolerance to high temperatures (Özgür, 1990). The fact that it was detected, albeit in small numbers, in Mardin province suggests that the species was introduced into the region through corn grains trade but has not been able to reproduce successfully.

In corn grains stored in both traditional and steel silo storages, mostly live individuals were recorded (88% and 85%, respectively). This situation might be due to the inability to adjust the fumigant (tablets or bags) dose, the failure to maintain a stable concentration of gas during fumigation, and in other words, gas leakage due to insufficient isolation of the storages sampled. In addition, the high number of living individuals also brings to mind the problem of resistance (Tingiş, 2017). However, to reach more reliable results, this study suggests that further studies on resistance be conducted on insects collected from storages in the region.

In corn stored in traditional warehouses, the highest grain damage rate was determined as 3%. Mert (2012) reported that in warehouses (silos and traditional storage facilities) where fumigation was carried out periodically, the damage rates of the corn grains was about 1% in autumn and winter months, but later increased to 4–8% during the summer in Adana province. The differences between studies may be related to product density and turnover, fumigation duration and frequency, crop variety, storage period, and product transfer between storages. Similar to the findings of the current study, corn grain damage rates of 1–2% in warehouses and silos were reported in Mersin province (Yetkin and Atakan, 2022).

Conclusion

This study revealed that the primary pest, *S. oryzae*, is prevalent in stored corn. *Tribolium castaneum* was frequently recorded in association with this main pest insect. *Sitophilus oryzae* was recorded in relatively higher numbers in the fall months, depending on the suitability of storage conditions (temperature and humidity), suggesting that storage cleaning and spraying of empty storage areas before storage are insufficient. In many sampling dates from January to May, pests were either absent or recorded in very low numbers. After June, with the increase in temperature and humidity inside the storages, pest population densities increased.

The fact that most insects collected from both storage facilities were alive suggests that fumigation practices were inadequate. This inadequacy may stem from several factors; first, the gas concentration inside the warehouse should remain as stable as possible throughout the fumigation process. For this reason, it is recommended to test whether there is a leak in the storages by measuring the gas density with a detector during gassing.

Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

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