**RESEARCH ARTICLE**

**Daniela Atanasova**

# First record of new food specialization of the maize weevil *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae) in Bulgaria

***Authors' addresses:***
Department of Entomology, Faculty of Plant Protection and Agroecology, Agricultural University of Plovdiv, Bulgaria.

***Correspondence:***
*Daniela Atanasova*
Department of Entomology, Faculty of Plant Protection and Agroecology, Agricultural University of Plovdiv, Bulgaria.
Tel.: +35932654246
e-mail: daniat88@abv.bg

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**ABSTRACT**

Inspections of warehouses were carried out in the South and Southeast of the Republic of Bulgaria, from September 2019 to February 2020. In the province of Yambol, in Galabinci village, chickpea (*Cicer arietinum* L), an annual legume was for the first time, found to be damaged by the maize weevil *Sitophilus zeamais* Motsch. This is a new host record, *Sitophilus zeamais* has never been recorded feeding on a leguminous host previously. The species was also found to attack maize in a warehouse in the region of Plovdiv, Trud village. The new data about the distribution of the species in the Republic of Bulgaria are presented.

**Key words:** Pest, food specialization, chickpea, damage, stored products, maize weevil, *Sitophilus zeamais* Motsch

## Introduction

The origin of the maize weevil *Sitophilus zeamais* Motsch. is not known but now it is found in all warm humid areas of the world, where corn is grown but also can be found in colder climates like Canada (Hagstrum, 2012). In the United States, it is known as the greater rice weevil and is a major pest of maize. This species attacks both standing crops and stored cereal products, including wheat, rice, sorghum, oats, barley, rye, buckwheat, peas, and cottonseed. *S. zeamais* feeds on cereals and starch grains including guinea corn, *Sorghum bicolor* (L) (Effraim, 1996; PaDIL, 2009). The maize weevil also infests other types of stored, processed cereal products including pasta, cassava, and various coarse, milled grains. It has even been known to attack fruit while in storage, such as apples (Pacheco and De Paula, 1995). The maize weevil can infest various stored agricultural products such as maize, sorghum, wheat, barley, rice, and paddy (rough rice). In stored maize, a heavy infestation of the weevil cause weight losses of 30-40% (Paneru et al., 1996). In Italy, Trematerra (2009) studied the preferences of *S. zeamais* to different types of commercially grown Italian rice and cereal pasta. The choice tests demonstrated that corn pasta was more attractive than the buckwheat pasta, durum wheat pasta and rice type. Barley pasta, kamut pasta, spelt pasta, and five kinds of cereal pasta were less attractive to maize weevil adults. Sharma *et al.* (2016) investigated the food preferences of maize weevil to different crops in Nepal and found that the highest weight loss was recorded in polished rice followed by wheat under storage condition.

The maize weevil *S. zeamais* has a host range similar to that of the rice weevil (*Sitophilus oryzae* L.) and the granary weevil (*Sitophilus granarius* L.), and prefers whole grains but have also been reported to feed on many processed grain products including pet food and pastas. They have a wider tolerance for host moisture content, even feeding on stored apples. Typically one egg is laid per kernel (Lathrop 1914; Gomez et al., 1982), but on occasion, more than one adult may emerge. If multiple eggs are laid, larvae compete aggressively among the seed occupants (Guedes et al., 2010). Immature survivorship is only 18% (Throne, 1994). Eggs are not laid if the relative humidity is below 60% (Arbogast, 1991). Infestations of immatures can be determined by staining the kernels which enable the oviposition plug placed in the egg cavity to protect the immature weevil to be clearly seen. The life cycle of the maize weevil averages 35 days at 27°C (80.6°F) (Sharifi & Mills, 1971) with a maximum development time of 110 days at 18°C (64.4°F). Survivorship of all immature life stages is highest at 25°C (77°F) (Throne 1994). The minimum temperature for development is 13°C (55.4°F). The egg, larva, and pupa stages are rarely seen because they are confined to the inside of the grain kernel. Eggs are creamy-white and barely visible to the naked eye. Hatchability is about 90%, and the first instar larval mortality can be as high as 30% at 50% RH (Arbogast, 1991). The legless larvae are creamy-white with a brown head. They pass through four instars before pupating within the kernel. During the four to five months of cold winter weather, the



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larva remains within the kernels. There are generally four to five generations per year in most grain storage facilities. Heated storage buildings may enable twice that many generations. Adults live from four to eight months. Adult maize weevils are slightly larger (2.5 to 4 mm) than rice weevils. They have circular punctures on the thorax compared with oval punctures on the rice weevil and more distinct colored spots on the forewings. Maize weevils are stronger fliers than rice weevils. The adults for this species are small 3-4 mm in length, dark brown colored, with four reddish stains on the elytra, visible after emergence. The larvae are light yellow in color with a darker head, and the pupas show a milky white color. Adult females lay on average 282.2 eggs in 104.3 days of oviposition; they can live on average 140.5 days. The egg incubation ranges from 3 to 6 days and the life cycle from egg to adult is approximately 34 days (Gallo et al., 2002).

*Sitophilus zeamais*, a quarantine species for Bulgaria was found for the first time in 1979 in maize imported from Vietnam in the holds of a ship at the port of the city of Burgas (Southeastern Bulgaria). The ship was fumigated with methyl bromide. In 1985 the maize weevil was found again in maize in a warehouse in Kardam village, near the town of Dobrich (Northeastern Bulgaria). The warehouse was fumigated with methyl bromide (Obretenchev et al., 1990). Since then there are no data about the distribution of the species in the country and its nutritional preferences.

## Materials and Methods

The study was carried out in the period from September 2019 to February 2020 in routine inspections of warehouses in the Southern and Southeastern Republic of Bulgaria. Samples of stored grains from legumes and cereals were collected. For this purpose, stage and cone probes were used. Average samples of 2 kg each were formed by the diagonal method. In the laboratory, the samples were screened and the insects were separated by species and the type of food on which they were found.

## Results and Discussion

During the inspections in warehouses in the Southern and Southeastern Republic of Bulgaria, the maize weevil *S. zeamais* was found. In a warehouse in the region of Yambol, Galabinci village, chickpea *Cicer arietinum*, grains were found to have been damaged by *S. zeamais*. This is the first time that *S. zeamais* has been recorded feeding on a leguminous host. There are no published data about the food preference of *Sitophilus* species towards stored grain from leguminous. The species was also found to attack maize in a warehouse in the region of Plovdiv, Trud village. These are new data about the distribution of the species in the Republic of Bulgaria (Figure 1).


**Figure 1.** *The provinces of Republic of Bulgaria № 13 and № 28, where the maize weevil Sitophilus zeamais was found in 2019-2020. Source of the map: https://en.wikipedia.org/wiki/Provinces_of_Bulgaria.*

In Bulgaria for first time in 1979 Obretenchev et al. (1990) found *S. zeamais* in maize imported from Vietnam in the holds of a ship at the port of the city of Burgas (Figure 1, № 2) and in maize in a warehouse in Kardam village, near the town of Dobrich in 1985 (Figure 1, № 3). Since then and until now there have been no data about the distribution of the species in the country and its nutritional preferences.

The nature of the damage caused by the maize weevil is very specific. The pest causes the hollowing of whole previously undamaged grains. In severe infestations only the grain hull is left along with powdery white frass (insect waste). The large emergence holes with irregular edges are characteristic (CABI, 2020).

Our observations confirm the type of severe damage, namely the irregular shape of the gnawed openings along the grain sheath and the large amount of separate dust. In severe infestations caused by the maize weevil to grains of chickpeas, only the grain hull is left along with powdery white frass (Figure 2).

The damage caused by the beetle is both direct and indirect. It causes weight loss of the grain and affects the germination of the grain and the nutritional qualities. The damaged grain from the adults and the larvae of the beetle and the accumulated flour dust create favorable conditions for the multiplication of secondary storage pests that cannot damage the whole grain.

Weevils develop inside the grain, the females digging a tunnel into the grain with their chewing mouthparts at the end of the elongated snout before laying an egg and cementing over the opening with a gelatinous plug that rapidly hardens. On completing development inside the grain, the mature beetle chews through the grain shell to mate and start the next generation, this often being the first sign of infestation. *S.*



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*zeamais* cause extensive losses in quantity and quality of the grain in the field as well as in storage (Sabbour, 2012).

**Figure 2.** *Type of damage to grains of chickpeas caused by maize weevil Sitophilus zeamais (original).*

The infestation elevates temperature and moisture content in the stored grain mass, which can lead to fungal growth, including toxigenic species such as Aspergillus favus Link. Numerous insect species have been implicated in facilitating the dispersal of A. favus and subsequent aflatoxin contamination (Beti et al., 1995; Mohale et al., 2010).

Bhusal and Khanal (2019) studied the role of maize weevil, Sitophilus zeamais Motsch. on spread of Aspergillus section flavi in different maize varieties. They found that in the presence of weevil, the infestation of the fungus increased and in their absence, the infestation was low which signifies the role of weevil in the fungal spread.

## Conclusions

The maize weevil *Sitophilus zeamais* Motsch. was found during the routine surveys in the period from September 2019 to February 2020 in warehouses in the Southern and Southeastern Republic of Bulgaria.

In the region of Yambol, Galabinci village, chickpea grains were found to have been damaged by the maize weevil *S. zeamais*. This is the first time that *Sitophilus* species has been recorded feeding on a leguminous host.

The species was also found to have attacked maize in a warehouse in the region of Plovdiv, Trud village. The new data about the distribution of the species in the Republic of Bulgaria is shown.

## Compliance with ethical standards

The author declares that there are no conflicts of interest regarding the publication of this paper.

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