Food Specialization of the Lesser Grain Borer, Rhyzopertha Dominica F. (*Coleoptera: Bostrichidae*)

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ABSTRACT

Observations of stored grain, products from its manufacture and materials from plant origin in the storage-silo bases in Bulgaria were conducted from 1990 till 2019 to establish the food specialization and trophic chains of *Rhyzopertha dominica* F. The insect was found mostly in wheat grain – 49,2% from all expected samples, followed by barley – 18,5% and maize – 15,2%. The infestation of oats, rye, rice, and sorghum was 7.3%, 5.7%, 2.6%, and 1.5%, respectively. R. *dominica* infested also seeds of sugar and technical cane, millet, buckwheat, ryegrass, and *Dactylis glomerata* L. It was established in roots and fruits of *Ecbalium elaterium* L., roots of wild pumpkin – *Bryonia alba* L., bark of *Frangula alnus* Mill., crashed fruits of *Aesculus hippocastanum* L., fruits of *Paleurus aculeatus* L., seeds of quinoa *Chenopodium quinoa*, seeds of *Trigonella foenum-grecum*, seeds of *Hibiscus cannabinus*, seeds of *Beta vulgaris* L. and also in grain foods like "Kus-Kus". R. *dominica* did not develop in dried beans, lentil, edible and forage peas, vetch, chick-peas, soy, alfalfa, and clover. It was not found in storages with sunflower, rape, and coriander, and kernels - peanuts, groundnuts, hazelnuts, almond, sesame and pumpkins seeds.

Keywords: *Food specialization, Damages, Stored grain, Bulgaria, Lesser grain borer, Rhyzopertha dominica F.*

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Highlights of this paper

- The lesser grain borer, *Rhyzopertha dominica* (F.), is one of the most destructive insect pests of stored grains worldwide. Many authors consider that the trophic relations of grain beetle are very diverse and they note that the species is polyphagous.
- The aim of present study is to establish which grain stocks, products of their processing and materials of plant origin are attacked by the lesser grain borer, *Rhyzopertha dominica* in Bulgaria.
- New trophic relationships of the species have been found during the surveys: sugar beet (*Beta vulgaris* L.) seeds, fiber cone seeds (*Hibiscus cannabinus*), dried roots and fruits of sea cucumber (*Ecbalium elaterium* (L.) *A. Rich.*), kernel bark (*Frangula alnus* Mill.), crushed horse chestnut fruit (*Aesculus hippocastanum* L.), dragon fruit (*Paleurus aculeatus* Lam.), dried wild cucumber roots (*Bryonia alba* L.), quinoa seeds (*Chenopodium quinoa*) and chimney seeds.
- In the country, R. dominica has not been found in stored grain from leguminous and fodder legumes (beans, lentils, parrots, garden and fodder peas, beans, chickpeas, soybeans, alfalfa, and clover seeds). The species has not been found either in sunflower seed and rapeseed, coriander and coriander seedlings, but also in nuts (peanuts, nuts, hazelnuts, almonds, peanut, cashew, sesame and pumpkin seeds).

1. INTRODUCTION

The lesser grain borer, *Rhyzopertha dominica* (F.), is one of the most destructive insect pests of stored grains worldwide [1]. The origin of the insect is uncertain, but it now has a cosmopolitan distribution. It is a serious pest of dried stored products throughout the tropics and it is also found in temperate countries. It has most likely spread as a result of the international trade in food products combined with its strong flying ability.

Zacher [2] gives information on the first food products to which the grain beetle *Rhizoperta dominica* F. has been found. He reports that the species was found in the Tut Ank Amon tomb in wheat dating from 1345 BC and that is also reported by Solomon [3] and Chaddick and Filce Leek [4].

Many authors consider that the trophic relations of grain beetle are very diverse and they note that the species is polyphagous. Potter [5] and Ebeling [6]; Ebeling [7] reported that *R. dominica* besides the different types of cereal foods developed in wood and paper products and books in libraries. According to Howe [8] the grain beetle was found in samples of barley, wheat, corn, rice, and peanuts. In India, an attack of this species of peanuts also reported Srivastava [9]. According to Zheltova [10] the species attacks mainly wheat, barley, rice, maize, oats, buckwheat, and flour. According to them, oil and leguminous crops are not good food for the grain beetle. Teriaki and Verner [11] reported that *R.dominica* was found mainly in samples of barley in Syria. According to Giles [12] in Nicaragua samples of beans are attacked by bean weevil and other storage pests including *R. dominica.* Iordanu [13] found that in the warehouses in six regions of Cyprus the beetle was found mainly in barley. According to Buchelos [14] the species mainly damage stored cereal grains and cereal products. Cline and Highland [15] reported that in the USA the species also attacks the seeds of *Hibiscus cannabinus.* In Kenya, Päts [16] found that the species damages stored corn and stored potatoes. Johnson [17] reports that the grain beetle attacks wheat, corn, rice, and millet. The publication of Saffestore: Factsheet Lesser Grain Borer [18] noted that besides cereal stocks *R. dominica* can attack and other food products and raw materials such as tobacco, nuts, beans, biscuits, cassava, cocoa beans, dried fruits, peanuts, spices, dried meat, and fish.

Koehler and Pereira [19] identified *R. dominica* as an important pest of stored wheat and corn, but the authors note that he can attack tobacco, walnuts, beans, cowpea, biscuits, cocoa beans, dried fruit, peanuts, rodenticide baits, and others. Domar [20] reports that the species develops in various foods, rice, pistachios, beans, wheat, corn, sweet potatoes, and wood. According to Mason [21] besides wheat, rye, corn, rice, and millet cereals, the species attacks products from their processing - flour, macaroni, and others. It also attacks dried potatoes, dried edible bulbs, lentils, beans, cowpea, herbs, and wood products. Oily seeds and spices are not suitable for the development of the larvae of the species.

Mahdi [22] investigating coffee warehouses in Yemen, found that *R. dominica* attacks residual fractions and bran from the processing of coffee. Klys [23] notes that this species in laboratory conditions have been successfully developed on wheat, oats, barley, and semolina. Nansen, et al. [24] and Jia, et al. [25] found that *R. dominica* can reproduce on stored acorns of oak-tree *Quercus muchlenbergii*, fruits of North American wild cherry (*Prunus angustifolia*) and fruits of black walnut-tree *Juglans nigra* and *Symphricarpus orbiculatus*. The authors report that at a distance of several kilometers from the storehouses the beetle can also be reproduced on seeds of weed plants, trees, and shrubs in the Kansas prairie. The species successfully develops on seeds of *Elymus kanadensis*, *Triticum aestivum*, *Gleditsia triacanthos* (meadows).

According to data published by the Canadian Grain Commission [26] the beetle attacked a wide range of stored foods including cereal grains, dried fruit, sorghum, rice, drugs, cork, wood and paper products.

In Bulgaria [27] found that the species attacked mainly barley, wheat, oats, rye, maize. The author has found the species in the warehouse of "Herbalcoop" in batches of imported manioc. The damage caused by the larvae and adults of the species is very characteristic and easily identifies the infection by *R. dominica*. They gnaw on irregularly shaped nipples, gnaw the entire contents of the endosperm, leaving only the shell. This activity produces a creamy powder that the larvae and adults make through the openings outwards and it fills the space between the nipples. These wastes have an unpleasant sweet smell and are not suitable for food even for animals.

In terms of the nature of the damage, Johnson [17] reports that larval and adult individuals of *R. dominica* are primary pests. They pierce roughly shaped holes in the entire non-damaged grains, and the larvae develop within the endosperm of the grain. According to the author, the larvae and the adults develop, feeding inside and on the grain, and from it can remain unevenly cracked only the scales. Eating adults and larvae is accompanied by the release of a lot of dust and the presence of a sweet and unpleasant odor.

Golebiowska [28] notes that during the feeding of the adults and larvae of *R. dominica*, many bran and powders are produced. The author finds that if rice and granary weevils in their lifetime produce 11 and 12 mg powder of one individual respectively, then in *R. dominica* this amount reaches about 54 mg.

Koehler and Pereira [19] report that the grain beetle feeds in and out of the grain, damages the germ and is a serious pest for both the grain and the cereal products.

The present study aimed to establish which grain stocks, products of their processing and materials of plant origin are attacked by the lesser grain borer, *Rhyzopertha dominica* in Bulgaria.

2. MATERIALS AND METHODS

The study was carried out in the period 1990-2019 in route inspections of warehouses, silos, mills, factories, and workplaces in the Republic of Bulgaria.

Samples of stored grain from cereals, products of its processing and materials used to determine the type of attacked food were collected. For this purpose, stage and cone probes, thermal rods were used. Average samples of 2 kg each were formed by the diagonal method or the checkerboard pattern.

In the laboratory, the samples were screened through a set of sieves with a bottom and a lid, the insects were separated by species and their population density was taken into account, equating to 1 kg of sample and the type of food on which they were found.

3. RESULTS AND DISCUSSION

During the inspection of the storage-silo bases and factories in the Republic of Bulgaria, we found the grain beetle mainly in wheat, barley, oats, rye, maize, triticale, and sorghum.

We have encountered the species only once on the rice arp in a warehouse in the town of Rakovski in 2002, and on husked rice also once in a wholesale warehouse in Vidin in 2004.

R. dominica was also found to attack buckwheat and in baby food "Kus-Kus" at a warehouse in Sofia in 2006.

During the period 2007 - 2010, we established in laboratory conditions that the grain beetle has developed successfully on husked millet.

The following Figure 1 shows the frequency of occurrence of the species in different types of food in samples of cereal collected from all over the country.

The figure shows that most often - 49.2% of the grain beetle is found on wheat grain, followed by barley - 18.5%, maize - 15.2% and on oats, rye, rice, and sorghum - 7.3%, 5.7%, 2.6% and 1.5%, respectively. We see that the frequency of occurrence in these stocks correlates with the degree of occurrence of these crops in the country's agriculture.

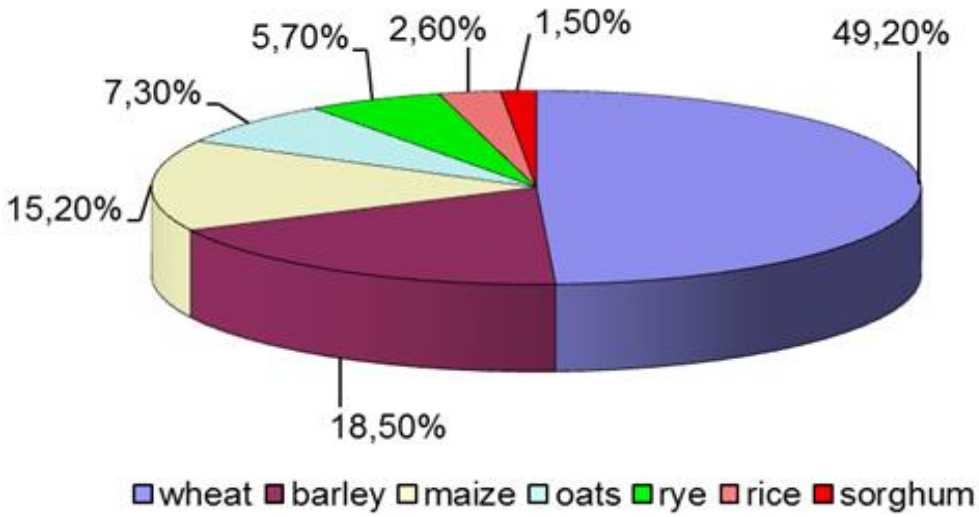

Figure-1. Frequency of occurrence of grain beetle *Rhyzopertha dominica* F. in grain from different cereal stocks.

In the period 1990-2019, in addition to cereals, we established the species in ryegrass and hedgehog (*Dactylis glomerata* L.) seeds in warehouses of "Variety seeds" in Sofia and on dried roots and fruits of sea cucumber (*Ecbalium elaterium* (L.) A. Rich.), the bark of a kernel (*Frangula alnus* Mill.) (imported from Russia) stored in the herbal warehouses in Pordim. In an herbal warehouse in Targovishte, it was found in crushed horse chestnut (*Aesculus hippocastanum* L), on the fruit of the dragonfly (*Paleurus aculeatus* Lam.) and dried roots of wild cucumber (*Bryonia alba* L).

In 1994, in a spice warehouse in Shumen, we established it in quinoa seeds (*Chenopodium quinoa*) - the plant is a cereal-like crop from the family *Chenopodiaceae*. In the same year, we found an attack of this species in the sugar beet seeds (*Beta vulgaris* L.) of the General Toshevo Institute, and in 1995 in the fiber hemp seed (*Hibiscus cannabinus*) at the Institute of Plant Resources in the town of Sadovo. We found the grain beetle in 1996 and 1998 in attacked sorghum seeds in the silos of the Kostinbrod Feed Factory. In 1999 the species was identified by *Trigonella foenum-grecum* seeds purchased from the market in Sofia. In 2019 at a chocolate factory "Nencho Iliev" in Sofia, the species was found in pieces of coconut eating the core.

In our multiple surveys of warehouses with stored grain from leguminous and fodder legumes (beans, lentils, parrots, garden and fodder peas, beans, chickpeas, soybeans, alfalfa, and clover seeds), an attack by *R. dominica* was not detected. The species was also not found in sunflower and rapeseed, radish and coriander seedlings, and also in nuts (peanuts, nuts, hazelnuts, almonds, peanuts, cashews, sesame seeds, and pumpkin seeds).

The nature of the damage caused by the grain beetle is specific and differs from that of the other two species grain beetles and moth, which also have a hidden lifestyle.

The type of severe damage to wheat, barley, maize, and the huge amount of dust released due to the nutrition and vital activity of the grain beetle is shown in Figure 2.

Figure-2. Type of damage caused by grain beetle *Rhyzopertha dominica* F.

Our observations confirm the nature of the damage noted by Tsvetkov [27] namely the irregular shape of the gnawed openings along the grain sheath, the large amount of separate dust and its specific sweet smell of urine.

The damage caused by the beetle is both direct and affects the weight loss of the grain and indirect. Damage affects the germination of the grain and the baking qualities of the flour obtained. 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.

4. CONCLUSIONS

In Bulgaria the grain beetle *Rhyzopertha dominica* is most often found on wheat grain - 49.2%, followed by barley - 18.5%, corn - 15.2% and on oats, rye, rice, and sorghum - 7.3%, 5.7%, 2.6%, and 1.5%, respectively.

In the period 1996 - 2011 we found cereal beetle in seeds of sugar and technical broom, millet, buckwheat and baby foods "Kus-Kus", in seeds of ryegrass and hedgehog.

New trophic relationships of the species have been found during the surveys: sugar beet (*Beta vulgaris* L.) seeds, fiber cone seeds (*Hibiscus cannabinus*), dried roots and fruits of sea cucumber (*Ecbalium elaterium* (L.) A. Rich.), kernel bark (*Frangula alnus* Mill.), crushed horse chestnut fruit (*Aesculus hippocastanum* L.), dragon fruit (*Paleurus aculeatus* Lam.), dried wild cucumber roots (*Bryonia alba* L.), quinoa seeds (*Chenopodium quinoa*) and chimney seeds.

In the country, *R. dominica* has not been found in stored grain from leguminous and fodder legumes (beans, lentils, parrots, garden and fodder peas, beans, chickpeas, soybeans, alfalfa, and clover seeds). The species has not been found either in sunflower seed and rapeseed, coriander and coriander seedlings, but also in nuts (peanuts, nuts, hazelnuts, almonds, peanut, cashew, sesame and pumpkin seeds).

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