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MONITORING OF THE INVASIVE SPECIES *RHAGOLETHIS COMPLETA* CRESSON AND THE HARMFULNESS OF FLIES THAT DAMAGES WALNUT FRUITS

Goal. The study aimed primarily at monitoring the walnut fly *Rhagoletis complete* Cresson and other fly species damaging the walnut tree *Juglans regia* L. **Methods.** Monitoring of the walnut fly *R. completa* was conducted using EC Firuț traps with food attractants and yellow Card Cue traps, placed 2.5 meters above the ground. The traps were installed at the end of May and the beginning of June, both in industrial walnut orchards and isolated walnut stands in urban areas. **Results.** Harvesting of damaged fruits began in mid-August, and the analysis involved removing the endocarp and examining the kernel to count the ontogenetic stages of pest species. During, the spring-summer period, no walnut flies were found in the traps, but a few specimens of *Rhagolethis cerasi* were observed. By the end of summer, two species of flies were identified. The first species, *Polyodaspis ruficornis*, the second species, *Odinia meijerei*. They can be taxonomically differentiated by pupae and adults. **Conclusions:** Monitoring with food pheromones did not indicate the presence of *R. completa* in the central region of Moldova, but characteristic damage of this species was observed. Fruit analysis showed that the damage was caused by the cereal fly *P. ruficornis*. Maximally, up to 97 pupae and larvae were found in a single fruit. In the stations, an average number of 0.01 to 18.4 per 50 analyzed fruits was recorded, which constituted 68% of affected fruits. Additionally, parasitism of the pupae by more than two species of parasites and from the Pteromalidae, Eulophidae families was observed. The results underscore the importance of ongoing monitoring and research of local pests, as well as their significant impact on walnut production in Moldo-

va. The study highlights the need for effective pest management measures to protect walnut crops and maintain sustainable production.

***Rhagoletis completa; Polyodaspis ruficornis; Odinia meijerei flies;* walnuts fruit damage; pheromone traps; parasitoids; insect larvae and pupae**

Introduction. Global climate change, anthropogenic economic activities, and commodity transport movements lead to the direct or indirect movement of various species of arthropod pests of agricultural crops and their natural enemies from one area to another. This includes the production of nut crops. According to statistical data, the Republic of Moldova accounts for more than 4% of global nut production and exports over 10.000 tons of walnut kernels annually, with the participation of around 40 companies.

For plant protection specialists, it is important to monitor the movement of these species, the quarantine measures of neighbouring countries, and to timely implement appropriate internal quarantine measures for these species. An example is the research conducted by Ukrainian scientists, where the quarantine service published results on many pests and the likelihood of their appearance, acclimatization risks, and spread depending on climatic conditions. It has been noted that 8 species of fruit fly pests are on the quarantine pest list [1], [2].

The list of organisms with restrictions on entry into the Republic of Moldova includes 23 species of fruit flies (Tephritidae). Of these, 15 species (*Anastrepha fraterculus* Wied., *A. ludens* (Loew), *A. suspensa* (Loew), *Bactocera dorsalis* Hend., *B. tryoni* Frogg., *B. zonata* Saund., *Ceratitis quinaria* Bezzi, *C. rosa* (Karsch), *Euphranta japonica* Ito, *Rhagoletis cingulata* (Loew), *R. fausta* (Osten-Sacken), *R. indifferens* Curran, *R. pomonella* Walsh, *R. suavis* (Loew), and *R. completa* Cresson) attack fruit crops. Of these, 7 species affect peaches and pears, 6 species affect apples and plums, 4 species affect apricots, 2 species affect cherries and sweet cherries, and one species each affects quinces, nectarines, mulberries, and chestnuts [3]. The list does not include two species that damage peaches, namely *Ceratitis capitata* Wied. and *C. cosyra* Walk.

In international practice, walnut cultivation is affected by 4 species of flies from the Tephritidae family (*A. fraterculus*, *B. dorsalis*, *R. suavis*, and *R. completa*). Natural enemies that limit their numbers are fewer in number, but several species of parasitoids are known to limit the population of Tephritidae pests. These parasitoids belong to the families Ichneumonidae (*Phygadeon*), Braconidae (*Rhysipolis* and 12 species of the *Bracon* genus), Pteromalidae (*Spalanga*, *Halticoptera*, *Homoporius*, *Habrocytus*, *Cyrtoptyx*), Eurytomidae (*Eurytoma*), Torymidae (*Torymus*, *Dimeromicrus*), and Eulophiidae (*Pnigalio*, *Achrysocharella*, *Tetrastichus*, *Crataepus*, and *Crataepiella*) [4], [5], [6], [7], [8], [9].

In the country's conditions, even at the end of the last century, the cereal fly *Polyodaspis ruficornis* Meq. was noted on walnuts [10], but under conditions of climatic imbalance, its numbers are becoming threatening to the crop.

The aim of our research was to monitor the walnut fly *Rhagoletis completa* and other fly species damaging walnuts.

Materials and Methods. Monitoring of the walnut fly *R. completa* was conducted by placing EC Firuț fly traps with food attractants and yellow Card Cue traps, set 2.5 m above the ground. The traps were installed at the end of May and the beginning of June in both a commercial walnut orchard and in an urban area. Harvesting of damaged fruits began in mid-August when damage characteristic of the walnut fly was observed. Subsequently, counts were conducted at 5 walnut sites, including 2 in the urban area, and one each in commercial orchards and on institute plots where trees were isolated from each other by 30—50 meters, as well as in the suburban area. One sample from a tree consisted of 50 damaged fruits. Fruit analysis was performed by removing the pericarp, opening the kernel, and counting the ontogenetic stages of the species. Damaged fruits were classified into two types: larvae and pupae of flies under the green or rotting pericarp, and larvae and pupae inside the kernel. Individuals were counted and exposed for individual incubation. Taxonomic identification was performed using classical keys: for flies of the families Chloripidae and Odiniidae [11], [12] and for parasitoids emerging from pupae of the families Pteromalidae and Eulophiidae [4], [6].

Results and Discussion. As a result of monitoring the walnut fly, it was not detected in traps with attractants or in yellow sticky traps during the spring-summer period, but single specimens of the cherry fruit fly *Rhagolethis cerasi* were observed.

In the second period, late summer, during the collection of fruits with symptoms resembling those of walnut fly damage and their analysis, two species of flies were identified. One of them, from the Chloripidae family, was described for the first time by G. F. Kyauka [13] as the cereal fly *Polyodaspis ruficornis* (Figure 2.1). Detailed bioecology is provided, noting that it appears in walnut fruits after damage from codling moth larvae. The larvae of this insect are phytophagous, primarily feeding on rotting tissues and the excrement of other plant inhabitants, occasionally attacking larvae of moths living on plants. *P. ruficornis* is found in corn stalks, rotting pears, safflower heads, and composites, including walnut fruits, but its significance is unclear [14], and further study of its biology through all fruit development phases and trophic interactions is needed.

Our observations indicated that this phytophage damages fruits without the presence of codling moth larvae. The adult fly makes a small depression on the surface of the pericarp with its mouthparts and deposits eggs around the perimeter of the depression (Figure 1.1). Upon hatching, larvae

feed on the pericarp tissues of the walnut, secreting tannins that provoke its decay (Figure 1.2). After feeding, larvae pupate both under the pericarp (Figure 1.3) and inside the kernel (Figure 1.4). Pupae of this species can be distinguished by the structure of their cuticle (Figure 2.3).

An important element in such research is observing the phases of fruit development and ripening, and determining the period when fly eggs first appear. We observed situations where eggs were laid in holes made by codling moths, but no development of the phytophage was observed. Thus, the presence of thistles *Cardus* sp. near a walnut tree, where the phytophage of the first generation can be found, and it will lead to the development of the second generation on the walnut. Biological material collected at the beginning and end of August from Station No. 3 showed a high abundance, as a thistle stand was located 20 meters away.

The second species of fly is from the family Odiniidae (*Odinia meijerei* Collin) (Figure 2.2). This family includes more than 15 genera and over 66 species. They live in the tunnels of larvae of wood-boring beetles (Coleop-

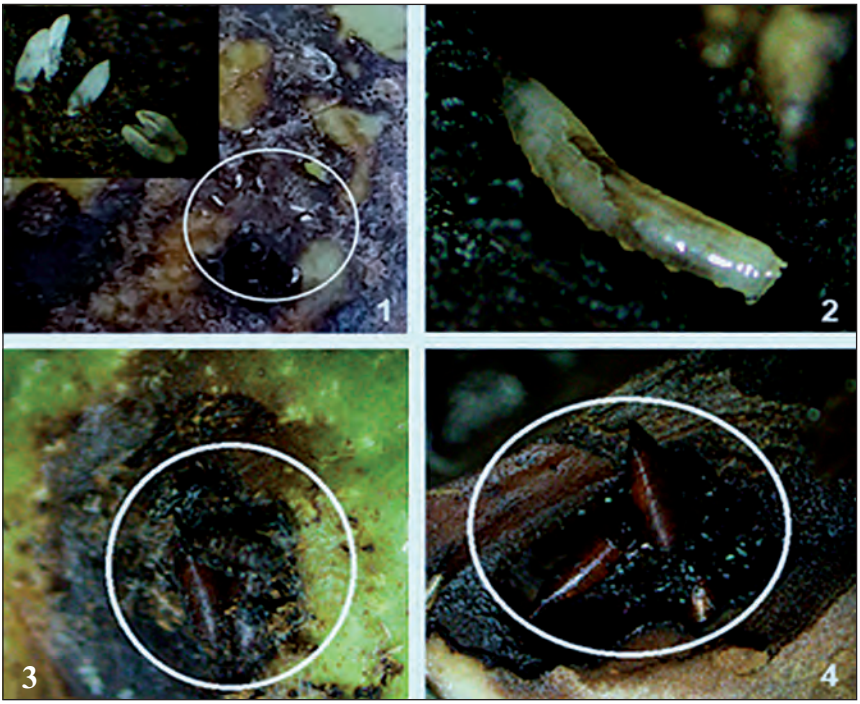

Figure 1. Damage to walnut fruits by flies: 1 — hole after larvae have emerged from eggs; 2 — last instar larva of the fly; 3 — fly pupae in the hole on the green pericarp; and 4 — pupae inside the kernel

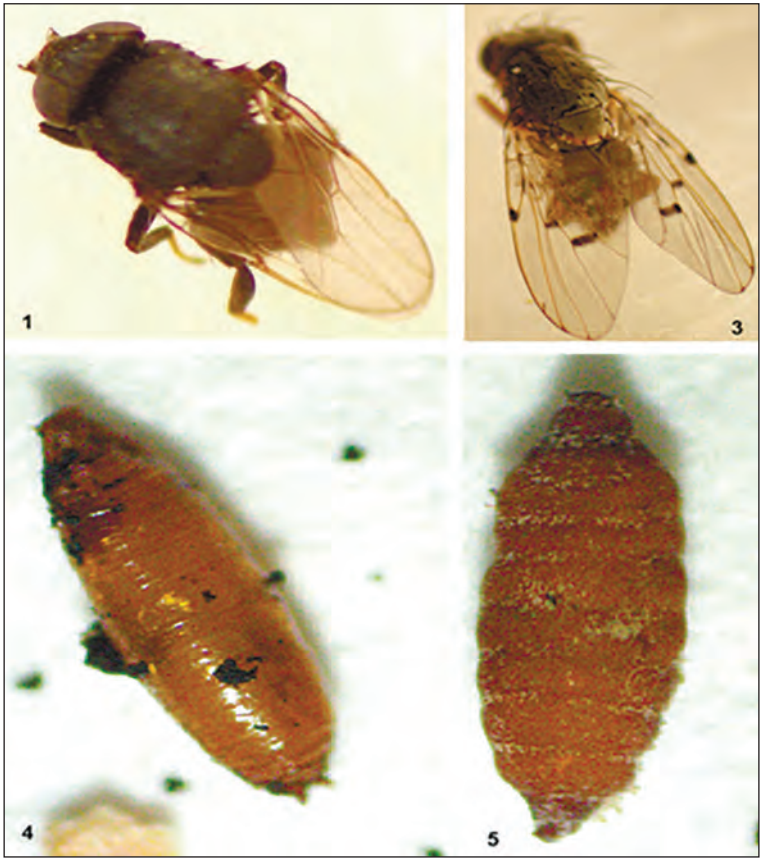

Figure 2. Distinguishing features of flies: 1 — adult *Polyodaspis ruficornis*; 2 — adult *Odinia meijerei* Collin of the last instar; 3 — fly pupae in the hole on the green pericarp; and 4 — pupae inside the kernel

tera), moths (Lepidoptera), and other flies (Diptera), and act as scavengers or predators of host larvae. In our case, this species is difficult to diagnose in the larval stage, but clear distinguishing features are visible in the pupal stage (Figure 2.5).

The analysis of fruits revealed that the fly develops and damages fruits in two ways. The first type of damage occurs under the green pericarp and inside the kernel, where both larvae and pupae are present. In both cases, the penetration of larvae under the pericarp and inside the kernel occurs independently, without causing damage and the infiltration of codling moth larvae. Data on the average number of flies per fruit are presented in Table.

Density of the grass fly *Polyodaspis ruficornis* in walnut fruits in the central zone

Stages of development of flies	Average number of individuals per nut fruit by stations				
	Station 1 (Sadova)	urban area of Chisinau			
		№ 1 (IGFPP)	№ 2 (Telecentru)	№ 3 (Metro 2)	№ 4 Dacia 58
Puparia and larvae	2.3	4	0.01	18.4	0.8

This way can be noted that cases of larvae penetrating independently occur 25 times more frequently, as observed at Station No. 3, where the number of codling moth larvae does not exceed 6 larvae per 50 fruits.

According to Table, the highest average number of fly pupae and larvae per fruit was found at Station No. 3 in the urban area, located 50 meters from a wheat field and near a fallow area after a sage plantation. This number is 8 times greater than at Station No. 1 in a commercial orchard, 5 times greater than at Station No. 1 in the urban area, and 23 times greater than at Station No. 4. In the station No. 2, out of 50 analyzed fruits, 75% were affected by diseases and no codling moth caterpillars were found, and flies were found in small quantities.

We observed that the maximum number of phytophage specimens from a single walnut fruit, where development occurred inside the kernel, reached up to 78, while under the pericarp, up to 115 pupae and larvae were found.

Damage to walnut fruits by this phytophage is very similar to the damage caused by larvae of the walnut fly *Rhagoletis completa* [15], which can sometimes lead to confusion in monitoring quarantine pests when using food pheromones and its identification and other tephritid flies damaging walnuts.

During individual rearing of flies, a small number of parasitoids from the families *Pteromalidae*, *Eulophiidae* and others were noted. The percentage of parasitism reached up to 27% per fruit.

In all other cases, the average percentage of fruit damage by flies was 68%, leading us to conclude that this insect is a serious walnut pest and the earlier reports of it being a potential pest are valid.

CONCLUSIONS

Monitoring with food pheromones did not reveal the presence of the quarantine pest *Rhagoletis completa* on walnuts in the central region of Moldova, although characteristic damage signs were present.

Fruit analysis indicated that the damage was caused by the previously mentioned phytophage, the cereal fly *Polyodaspis ruficornis*. On a single fruit, both under the pericarp and inside the kernel, the maximum number of pupae and larvae found was up to 97. On average, the number of larvae

and pupae per station ranged from 0.01 to 18.4. Damaged fruits at three stations amounted to up to 68%. Among the complex of parasitoids, pupae parasitism was observed by two species of parasitoids.

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Моніторинг інвазійного виду *Rhagoletis completa* Cresson та шкідливості мух, що пошкоджують плоди горіха

Мета. Дослідження спрямоване насамперед на моніторинг горіхової мухи *Rhagoletis complete* Cresson та інших видів мух, що пошкоджують дерево волоського горіха *Juglans regia* L. **Методи.** Моніторинг горіхової мухи *R. completa* проводили за допомогою пасток EC Firuţ з харчовими атрактантами та жовтих пасток Card Cue, розміщених на висоті 2,5 м

над землею. Пастки були встановлені наприкінці травня та на початку червня як у промислових садах волоського горіха, так і в ізольованих насадженнях волоського горіха в міській місцевості. **Результати.** Збір пошкоджених плодів розпочали в середині серпня, а аналіз включав видалення ендокарпу та дослідження ядра для підрахунку онтогенетичних стадій видів шкідників. Протягом весняно-літнього періоду в пастках не було виявлено жодної волоської горіхової мухи, але спостерігалось кілька особин *Rhagolethis cerasi*. Наприкінці літа виявлено два види мух. Перший вид — *Polyodaspis ruficornis*, другий вид — *Odinia meijerei*. Їх можна таксономічно диференціювати за лялечками та імаго. **Висновки.** Моніторинг за допомогою харчових феромонів не показав присутності *R. completa* в центральному регіоні Молдови, але на плодах були характерні для цього виду пошкодження. Аналіз плодів показав, що пошкодження спричинені злаковою мухою *P. ruficornis*. Максимально в одному плоді виявлено до 97 лялечок і личинок. На станціях зафіксовано в середньому від 0,01 до 18,4 на 50 проаналізованих плодів, що становило 68% уражених плодів. Крім того, виявлено паразитування на лялечках більше ніж двох видів паразитів з родин Pteromalidae, Eulophidae. Результати підкреслюють важливість постійного моніторингу та дослідження місцевих шкідників, а також їх значний вплив на виробництво волоського горіха в Молдові. Дослідження підкреслює необхідність ефективних заходів захисти від шкідників волоського горіха та підтримання сталого виробництва.

***Rhagoletis completa*; *Polyodaspis ruficornis*; *Odinia meijerei*; пошкодження плодів волоського горіха; феромонні пастки; паразитоїди; личинки та лялечки комах**

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