

UDC 632.9:634
AGRIS L20

<https://doi.org/10.33619/2414-2948/131/35>

**STUDY OF THE BIOECOLOGICAL CHARACTERISTICS
OF THE PEST *Grapholita molesta* (Lepidoptera: Tortricidae)
IN ALMOND ORCHARDS OF ABSHERON**

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**ИЗУЧЕНИЕ БИОЭКОЛОГИЧЕСКИХ ОСОБЕННОСТЕЙ ВОСТОЧНОЙ
ПЛОДОЖОРКИ *Grapholita molesta* (Lepidoptera: Tortricidae)
В МИНДАЛЬНЫХ САДАХ АБШЕРОНА**

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Abstract. This study investigates the distribution, bioecological characteristics, population density, and harmfulness of the Oriental fruit moth, *Grapholita molesta* (Busck, 1916), in almond orchards on the Absheron Peninsula during the 2024–2025 vegetation periods. The results indicate that, driven by regional climatic conditions, the pest completes four generations annually. The flight of the overwintered generation (initial adult emergence) commences during the third decade of March. Monitoring revealed that first- and second-generation larvae predominantly infest young, actively growing shoots (causing up to 22.1% damage), whereas the third and fourth generations directly attack the fruit, significantly compromising crop yield and quality. Peak fruit infestation reached 26.8% in September 2025, coinciding with the development period of the fourth generation. Based on the established dynamics of mass flight under the local conditions of the Absheron Peninsula, sustainable integrated pest management (IPM) strategies are proposed.

Аннотация. В данной работе представлены результаты исследования распространения, биоэкологических особенностей, плотности популяции и вредоносности восточной плодовой моли *Grapholita molesta* (Busck, 1916) в миндальных садах Абшеронского полуострова в течение вегетационных периодов 2024–2025 гг. Установлено, что под влиянием региональных климатических факторов вредитель развивается в четырех полных поколениях в год. Вылет бабочек перезимовавшего поколения (начало лёта имаго) начинается в третьей декаде марта. Результаты мониторинга показали, что гусеницы первого и второго поколений преимущественно повреждают молодые, активно растущие побеги (интенсивность повреждения — до 22,1%), в то время как третье и четвертое поколения наносят прямой вред плодам, существенно снижая урожайность и товарное качество продукции. Пик повреждения плодов был зафиксирован в сентябре 2025 года (период развития четвертого поколения) и составил 26,8%. На основе установленной динамики массового лёта вредителя в специфических условиях Абшерона предложены экологически безопасные методы интегрированной защиты растений (ИЗР).

Keywords: Absheron Peninsula, almond, *Grapholita molesta*, integrated pest management (IPM), pheromone traps, population density.

Ключевые слова: Абшеронский полуостров, миндаль, *Grapholita molesta*, интегрированная защита растений (ИЗР), феромонные ловушки, плотность популяции.

In recent years, targeted state programs and agricultural development strategies have significantly strengthened the agricultural sector and enhanced food security. Within this framework, expanding the cultivation of almond (*Prunus dulcis*)—a crop highly valued for its economic returns, exceptional drought tolerance, and export potential—has emerged as a key strategic priority. The distinctive dry-subtropical climate, unique soil conditions, and favorable thermal regime of the Absheron Peninsula offer excellent ecological and agronomic opportunities for establishing intensive, industrial-scale almond orchards. However, achieving sustainable high yields and producing premium-quality fruit in these intensive agroecosystems is severely challenged by various biotic constraints, most notably the pressure from phytophagous insect pests. Among these biotic threats, the Oriental fruit moth, *Grapholita molesta* (Busck, 1916), stands out as one of the most destructive pests affecting both vegetative and generative organs of stone fruit trees (<https://www.bugguide.net/node/view/9524>).

The larval feeding activity of this polyphagous species causes the desiccation of young shoots and extensive damage to internal fruit tissues, leading to direct and substantial crop losses. Consequently, investigating the bioecological characteristics, seasonal phenology, and population dynamics of *G. molesta* within the almond orchards of the Absheron Peninsula — particularly under the influence of shifting regional climatic conditions—is of paramount scientific and practical importance for developing efficient agricultural entomology and pest management strategies [3, 4].

Materials and Methods

The research was carried out during the 2024–2025 vegetation periods in intensively cultivated, commercial almond (*Prunus dulcis*) orchards containing various cultivars on the Absheron Peninsula. Laboratory analyses and identification procedures were performed at the laboratories of the Research Institute on Living Systems under the Ministry of Science and Education of the Republic of Azerbaijan. Field monitoring and laboratory assessments were conducted using standard entomological methodologies. Synthetic pheromone traps were utilized to determine the flight dynamics, initial adult emergence dates, population density, and generation overlap periods of *Grapholita molesta*.

The traps were suspended within the middle canopy of the trees at a height of approximately 1.5–1.8 meters above ground level, positioned to avoid direct solar radiation. The traps were distributed at a density of 2–3 traps per hectare. Monitoring was conducted semi-weekly from March through November. To maintain trap efficiency, the adhesive inserts and pheromone dispensers (capsules) were replaced periodically in strict accordance with the manufacturer's specifications. To evaluate the infestation rate and the extent of damage caused by the larvae to the vegetative (young shoots) and generative (fruits) organs of the almond trees, systematic sampling was performed. Representative sample trees were selected along diagonal transects across the experimental orchards. From each selected tree, 100 young shoots and 100 fruits were randomly inspected across the four cardinal directions (North, South, East, West) [5, 6].

The percentage of pest damage (infestation rate) was calculated using the following standard formula: $P = (n / N) \times 100$, where: P represents the damage percentage (%), n is the number of damaged shoots or fruits, and N is the total number of examined samples (shoots or fruits).

Results and Discussion

The monitoring and field assessments conducted during the 2024–2025 vegetation periods demonstrated that *Grapholita molesta* exhibits high ecological adaptability and harmfulness within

the intensive almond (*Prunus dulcis*) agroecosystems of the Absheron Peninsula. As a highly polyphagous member of the Tortricidae family, this pest demonstrated rapid population growth, driven by the favorable microclimatic and thermal conditions characteristic of the region. Our field observations revealed that *G. molesta* larvae systematically infest young, actively growing almond shoots, causing rapid wilting and subsequent desiccation of the terminal growth points. Furthermore, the larvae directly tunnel into the fruit tissues, which severely compromises the qualitative and quantitative parameters of the yield. Concurrently, the entry holes and feeding galleries excavated by the larvae serve as critical infection pathways for secondary phytopathogenic invasions. Notably, these mechanical injuries facilitate the penetration of fungal pathogens, particularly *Monilinia fructigena*, leading to widespread fruit rot—a finding that aligns with the structural pathology dynamics described by Holb [1].

The bioecological traits, seasonal development, and generational cycles of *G. molesta* were found to be closely modulated by the specific dry-subtropical climatic profile and ambient temperature fluctuations of the Absheron Peninsula. Quantitative analysis of the pest's population dynamics and spatial distribution underscores the critical need for precisely timed phytosanitary interventions. Consequently, these established developmental patterns under local conditions provide a robust scientific foundation for integrating targeted, sustainable Integrated Pest Management (IPM) strategies into regional almond cultivation [7, 8].

Grapholita molesta is recognized globally as one of the most important pests affecting stone fruits, including almonds. Research by Rothschild and Vickers (1991) notes that although *Grapholita molesta* originated in East Asia, global trade and the movement of plant materials have enabled it to establish well-developed populations across extensive fruit-growing regions in Europe, North America, and Australia. Because the insect adapts rapidly and easily to new climatic conditions, it rapidly colonizes new orchards and expands its distribution [2, 10].

In general, the pest's bioecological characteristics depend directly on climatic factors (temperature and relative humidity) and phenological stages. First-generation larvae feed on young, actively growing shoots during the spring, as fruits have not yet fully developed at this stage. Studies on almond trees demonstrate that larval boring into the internal tissues of shoots destroys apical dominance, halts growth, and causes abnormal development (bushy growth) of lateral buds.

Under the dry subtropical climatic conditions of the Absheron Peninsula, the phenological development of *Grapholita molesta* extends from early April to mid-October. High temperatures enable the pest to complete 4–5 generations during the growing season; the first generation causes significant damage to shoots, while subsequent generations directly damage almond fruits [9].

The pest overwinters as a mature larva enclosed in a silken cocoon, primarily within bark crevices on the trunk, at pruning cuts on branches, and under fallen leaves. In spring, when the average daily air temperature reaches 15–17°C (usually late March to early April), the overwintering caterpillars pupate. The flight period of the first-generation moths begins during the second ten-day period of April. Under Absheron conditions, generations overlap (their developmental cycles coincide); consequently, all developmental stages of the pest may occur simultaneously in the orchard during the summer months. During April and May, first-generation moths lay their eggs on the undersides of newly developed almond leaves and on young green shoots. After hatching, the caterpillars bore into young green shoots and tunnel downward. During this period, the loss of apical dominance and the resulting bushy growth habit are observed in the plant. The activity of the second and third generations (June–July) coincides with the fruit formation and kernel hardening stages. In addition to shoots, the caterpillars now penetrate the green fruit hull and feed on the kernel (seed), which has not yet hardened. Resin (gum) droplets exude from damaged fruits. During the activity of the fourth and fifth generations (August–September), the outer green hulls of the almonds begin to

crack. Larvae developing during this period enter through these cracks and feed directly on the kernel. With the drop in temperature in late September and early October, the mature caterpillars of the final generation retreat beneath the tree bark to overwinter. (Table 1)

Table 1

PHENOLOGICAL DIAGRAM OF *Grapholita molesta* DEVELOPMENTAL STAGES IN ALMOND ORCHARDS UNDER ABSHERON PENINSULA CONDITIONS (2024-2025)

Development stage	March	April	May	June	July	August	September	October
Butterfly(B)		— —	— — —	— — —	— — —	— — —	— — —	—
Egg(E)		• •	• • •	• • •	• • •	• • •	• • •	
Caterpillar (C)	x x x	+	+	+	+	+	+	x x x
Pupa (P)	[	[[	[[[	[[[	[[[	[[[	[[	

Note: The three symbols within each month represent the first, second, and third decades (ten-day periods) of that month, respectively. — Adult moth flight and oviposition (egg-laying) period; • Egg stage (embryonic development period); + Active larval feeding and infestation period; [Pupation period; x Larval overwintering (diapause) stage; Empty cell (): Stage not actively recorded during the respective decade

The phenological data clearly demonstrate that from May through late September, all developmental stages (adults, eggs, larvae, and pupae) occur concurrently and continuously within the orchards. This continuous presence provides robust evidence of pronounced generational overlap (multivoltine population overlap) under the dry subtropical climatic conditions of the Absheron Peninsula.

Analysis of phytosanitary monitoring data and pheromone trap readings conducted on the Absheron Peninsula during 2024–2025—under its distinctive dry subtropical and intensely windy climate—has determined that *Grapholita molesta* produces four complete generations annually in almond agro-ecosystems. In the Absheron environment, mild winters and early springs accelerate the pest's transition from overwintering caterpillars to the pupal stage and subsequently to the adult form. In both years of the study, the first flight of the butterflies was recorded during the third ten-day period of March, when the stable air temperature reached 12–14°C (coinciding with the end of the mass almond flowering phase—the period of petal fall). The percentage of shoot and fruit infestation across generations showed significant fluctuations. The results of the observations are presented in Table 2.

Table 2

INFESTATION RATES (%) OF YOUNG SHOOTS AND FRUITS BY SUCCESSIVE GENERATIONS OF *Grapholita molesta* IN ALMOND ORCHARDS OF THE ABSHERON PENINSULA (2024–2025)

Research Year	Observation Period (By Generations)	Average damage to the hooves (%)	Average fruit damage (%)
2024	Generation I (May)	12.4	—
	Generation II (June-July)	18.5	4.2
	Generation III (August)	6.1	14.8
	Generation IV (September)	—	22.3
2025	Generation I (May)	14.8	—
	Generation II (June-July)	22.1	6.5
	Generation III (August)	8.3	19.4
	Generation IV (September)	—	26.8

As shown in Table 2, the activity of the pest during the growing season of 2025 was higher than in 2024. The main reason for this is that weather conditions were dry and temperatures were above

average in the summer months of 2025, which shortened the developmental period of the pest. Caterpillars of the I and II generations bore into the internal tissues of young green shoots that grow intensively in May and June, forming downward tunnels. As a result, damaged shoots, also under the influence of the strong Khazri winds of Absheron, easily break and dry out. This disrupts the normal formation of the canopy in trees and reduces the number of productive shoots in the following year. The III and IV generations, which develop in August and September, exhibit a different feeding behavior. During the study, it was determined that green almond fruits are the primary site of larval entry. In particular, the percentage of fruit infestation in almond varieties with genetically delayed kernel hardening reached a maximum in September—26.8%. Larval feeding inside the fruit and the accumulation of frass create conditions for severe gummosis (gum formation) in the fruit and the spread of brown rot infection. This directly leads to losses in both yield and market quality.

Conclusion

Under the specific dry subtropical climatic conditions of the Absheron Peninsula, *Grapholita molesta* completes four generations annually in almond agroecosystems. The first flight of adult moths begins in the third ten-day period of March, when the average air temperature reaches 12–14°C. A comparative analysis of two-year studies shows that in the spring, the pest mainly damages young shoots (maximum 22.1% during the second generation in 2025), while in the summer and autumn, it shifts to feeding on reproductive organs (fruits), resulting in significant yield losses (maximum 26.8%). Monitoring of *Grapholita molesta* populations in almond orchards should be carried out using pheromone traps, and integrated chemical and biological control measures should be applied during periods of peak adult flight.

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Поступила в редакцию
16.07.2026 г.

Принята к публикации
29.07.2026 г.

Ссылка для цитирования:

Rzayeva G. Study of the Bioecological Characteristics of the Pest *Grapholita molesta* (Lepidoptera: Tortricidae) in Almond Orchards of Absheron // *Бюллетень науки и практики*. 2026. Т. 12. №10. С. 337-342. <https://doi.org/10.33619/2414-2948/131/35>

Cite as (APA):

Rzayeva, G. (2026). Study of the Bioecological Characteristics of the Pest *Grapholita molesta* (Lepidoptera: Tortricidae) in Almond Orchards of Absheron. *Bulletin of Science and Practice*, 12(10), 337-342. <https://doi.org/10.33619/2414-2948/131/35>