## БИОИНДИКАЦИЯ И МОНИТОРИНГ СОСТОЯНИЯ ЛЕСНЫХ ЭКОСИСТЕМ

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# IMPACTS OF *EUPROCTIS CHRYSORRHOEA* ON OAK FORESTS IN ARMENIA. FEEDING BEHAVIOR, DEFOLIATION PATTERNS, AND IMPLICATIONS FOR FOREST VULNERABILITY

M.A. Tigranyan[1], Y.A. Yanbaev[2], G.Yu. Pogosyan[1], A.M. Karapetyan[1]
[1]Institute of Botany after A.L. Takhtajyan National Academy of Sciences of the Republic of Armenia, Yerevan, Armenia. margarita.tigranyan03.08.92@gmail.com
[2]Bashkir State Agrarian University, Ufa, RU, yanbaev_ua@mail.ru

**Abstract.** Defoliation caused by larvae of the brown-tail moth (*Euproctis chrysorrhoea*) poses a significant threat to oak-dominated ecosystems in Armenia, particularly under the influence of escalating climatic stressors. This study investigates the species' feeding behavior, defoliation dynamics, and phenological shifts on degraded oak stands by integrating systematic field monitoring with historical climate data. A key finding of the research is the delayed emergence of adult moths (imagines), which appears to be strongly correlated with area's dryness.

**Keywords.** Oak forests, infestation, brown-tail moth, dendro entomology, Armenia.

# ВОЗДЕЙСТВИЕ *EUPROCTIS CHRYSORRHOEA* НА ДУБРАВЫ АРМЕНИИ. ПИЩЕВОЕ ПОВЕДЕНИЕ, ХАРАКТЕР ДЕФОЛИАЦИИ И ВЛИЯНИЕ НА УЯЗВИМОСТЬ ЛЕСОВ

М.А. Тигранян[1], Ю.А. Янбаев[2], Г.Ю. Погосян[1], А.М. Карапетян[1]
[1]Институт ботаники им. А.Л. Тахтаджяна Национальной академии наук Республики Армения, г. Ереван, Армения, margarita.tigranyan03.08.92@gmail.com
[2]Башкирский государственный университет, г. Уфа, Россия, yanbaev_ua@mail.ru

**Аннотация.** Дефолиация, вызванная личинками златогузки (*Euproctis chrysorrhoea*), представляет значительную угрозу для экосистем с преобладанием дуба в Армении, особенно под влиянием усиливающихся климатических стрессоров. В этом исследовании изучается пищевое поведение вида, динамика дефолиации и фенологические изменения в деградированных дубравах путем интеграции систематического полевого мониторинга с историческими климатическими данными. Ключевым выводом исследования является задержка появления взрослых особей, что, по-видимому, тесно связано с сухостью местности.

**Ключевые слова.** дубравы, заражение, златогузка, дендроэнтомология, Армения.

This study aims to: investigate the feeding behavior of *E. chrysorrhoea* larvae during peak activity periods; finalize phenological changes in adult moth emergence compared to historical data; evaluate the influence of environmental factors, including climate change and forest degradation, on larval population dynamics. We hypothesized that larval feeding behavior and defoliation severity are closely linked to seasonal leaf quality and that recent climatic changes have shifted the phenology of *E. chrysorrhoea*, potentially intensifying its impact on oak forest health. Oak forests of Armenia provide a unique habitat for the spring and summer larvae outbreaks of *Euproctis chrysorrhoea* (Linnaeus), commonly known as the brown-tail moth. The brown-tail moth's larvae exhibit remarkable adaptations to thrive in the oak (*Quercus macranthera* H.) forests of Armenia [2]. Similar to other Lepidopteran species, these larvae are generalist feeders, consuming the leaves of various tree species. However, in Armenia, they demonstrate a strong preference for oak foliage [4]. This selective feeding behavior likely stems from the abundant availability of oak trees in the local ecosystems, as well as the nutritional suitability of oak leaves for the larvae's growth and development. Defoliation caused by insects is a major disturbance that affects tree growth. Its effects can range from altered canopy habitats and their climatic conditions to decreased forest productivity [1]. Although larvae are capable of severely scalarizing oak trees, nothing is known about how they affect the general health of the oak forests of Armenia. Since the material on previous research conducted in Armenia only covers 1977, a comparable example from other countries was chosen to identify any phenological parallels or discrepancies. A comparative analysis of studies conducted between Czech Republic, 1974 [5]; Armenia, 1977 [4]; Spain, 2010 [3]; USA, 2023, and our study on 2024 reveals notable shifts in the phenology (Table) of the insect under investigation, particularly in the timing of adult emergence as well as other life stages due to climate change, among other factors, such as forest degradation and natural enemies. When comparing adult emergence on 2024 with the data of 1977 and with the data of other countries a difference of 1-7 weeks is observed. In this work, we are providing the results of our one-year full monitoring program for *E. chrysorrhoea* development, along with a comprehensive data analysis package covering the last ten years of the forest ecosystem changes (climate change, pest epidemics, aerial sprayings).

The study was conducted in the Aragatsotn region of Armenia, encompassing parts of the Aragats, Aparan, Yerevan, and Shirak floristic regions. These forests serve protective functions and are primarily composed of low-growing oak (*Quercus macranthera* H.) and dry juniper (*Juniperus oblonga*, *J. excelsa* subsp. *polycarpos*) stands, along with other species like pear (*Pyrus salicifolia* P.), ash (*Fraxinus excelsior* L., *F. angustifolia* subsp. *oxycarpa*), barberry (*Berberis orientalis* L.), spirea (*Spiraea crenata* L.). Oak regeneration is limited, and overall forest productivity is low. The Aragats floristic region (1400–4095 m altitude) hosts 10 endemic plant species and 19 species listed in Armenia's Red Book of Plants, while the Aparan region contains 17 endemic species and 26 protected species. Compared to Shirak and Yerevan, Aragats has a lower species diversity. According to Armenia's forest growth classification, the southern slopes of Mount Aragats fall within the semi-desert and arid sparse forest zones, which are generally unfavorable for forest development. As a result, xerophytic vegetation dominates [1].

Fieldwork was conducted at a permanent monitoring site in Byurakan. A permanent plot was selected due to *E. chrysorrhoea* high activity and damage to the oak tree during the previous ten

years, as well as human availability for monitoring and checks. GPS was used for precise location tracking.

Field surveys included the following steps:

1) Winter Web Surveys (October–April): Visual inspections for silken nests in oak canopies to estimate larval overwintering density. Trees with ≥5 webs were classified as high-risk zones requiring intervention.

2) Larval density assessments (April–July): Weekly counts of larval density per leaf cluster and defoliation percentage were recorded using standardized scales. "Skeletonized" leaves (veins remaining) were identified as feeding evidence.

Data collection

1) Climate Data: Historical temperature and precipitation data for Amberd climate station (1938–2023) were obtained from the Hydrometeorology and Monitoring Center database.

2) Literature survey for insect phenology.

Overwintered larvae began hatching in early May 2024. Initial observations revealed several webs with some dead larvae, possibly due to cold and wet nights. Early feeding was concentrated on newly produced oak leaves (4–5 cm diameter), with 4–6 larvae per twig observed in 2nd–3rd instars. Weekly monitoring indicated staggered hatching phases with approximately 7–9 day intervals, suggesting asynchronous larval emergence. Defoliation was first detected on May 10, with larvae progressively skeletonizing leaves. Trees with ≥5 webs per tree showed defoliation levels exceeding 40%, confirming the threshold for high-risk classification.

The differences between delayed adult emergence in our data and those in the literature (Table) may be due to significant climate changes in the last few decades, in particular, a decrease in precipitation (Figure). According to Mirzoian [4], adult flight activity was observed from early June to late August. In contrast, studies conducted in Spain reported adult emergence occurring within a much narrower window, from late June to mid-July [3]. Our 2024 monitoring results further highlight a shift, with adult flight activity recorded from late July to early August, indicating a delayed and condensed emergence period. These findings suggest a potential influence of environmental or climatic factors driving changes in the developmental dynamics of the species.

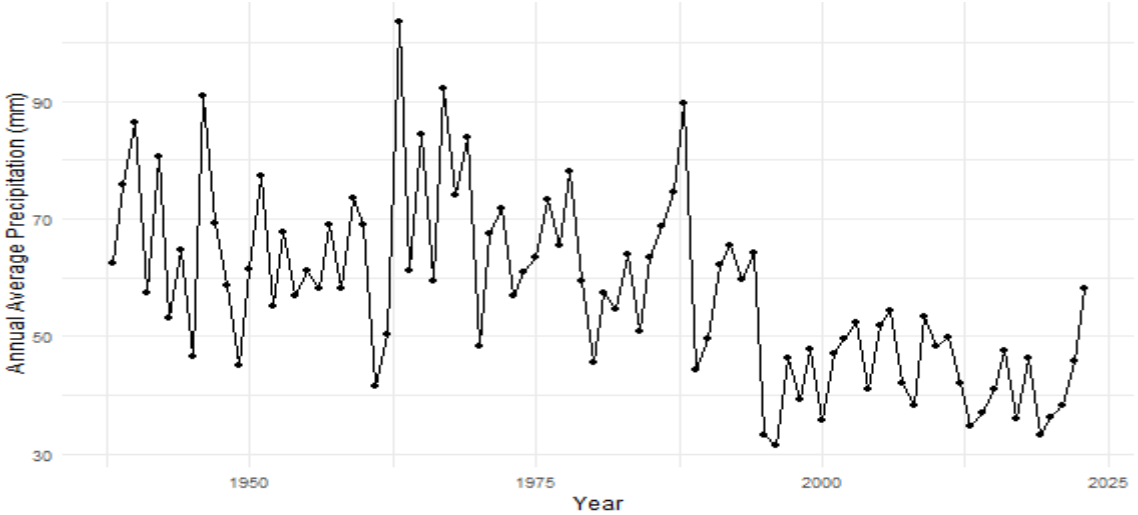


Figure- Annual average precipitation over the years in Byurakan (Amberd meteostation, Hydrometeorology and Monitoring Center data)

| Months | Weeks | Armenia | | | | | | | | | | | | USA | | | | | | Spain | | | | | | Czech Republic | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Current study, 2024 | | | | | | Mirzoian, 1977 | | | | | | Crosby, 2023 | | | | | | Frago, 2010 | | | | | | Novak, 1974 | | | | | |
| | | L1-3 | L4-5 | L6 | Pupae | Imago | Egg | L1-3 | L4-5 | L6 | Pupae | Imago | Egg | L1-3 | L4-5 | L6 | Pupae | Imago | Egg | L1-3 | L4-5 | L6 | Pupae | Imago | Egg | L1-3 | L4-5 | L6 | Pupae | Imago | Egg |
| 5 | 1 | | | | | | | | | | | | | ■ | | | | | | | | | | | | | | | | | |
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| | 4 | ■ | ■ | | | | | | ■ | ■ | ■ | | | | ■ | ■ | | | | | | | | | | | | | | | |
| 6 | 1 | | ■ | ■ | | | | | | | ■ | ■ | ■ | | ■ | ■ | | | | | | | ■ | | | | | | ■ | | |
| | 2 | | ■ | ■ | | | | | | | | ■ | ■ | | ■ | ■ | | | | | | | ■ | | | | | | ■ | | |
| | 3 | | ■ | ■ | ■ | | | | | | | ■ | ■ | | | ■ | | | | | | | ■ | | | | | | ■ | | |
| | 4 | | | ■ | ■ | | | | | | | ■ | ■ | | | ■ | | | | | | | ■ | ■ | | | | | | ■ | | |
| 7 | 1 | | | ■ | ■ | | | | | | | ■ | ■ | | | | ■ | | | | | | | ■ | | | | | | ■ | | |
| | 2 | | | | ■ | | | | | | | ■ | ■ | | | | | | | | | | | ■ | | | | | | ■ | | |
| | 3 | | | | ■ | | | | | | | ■ | ■ | | | | | | | | | | | ■ | ■ | | | | | ■ | | |
| | 4 | | | | ■ | ■ | ■ | ■ | | | | ■ | ■ | | | | | | | | | | | | ■ | | | | | ■ | ■ | |
| 8 | 1 | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | ■ | | | | | | ■ | |
| | 2 | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | ■ | | | | | | ■ | |
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| | 4 | ■ | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | ■ | |
| 9 | 1 | ■ | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | | |
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Table- Changes in *Euproctis chrysorrhoea* phenology over the years, showing adult late emergence in Armenia, in 2024, when comparing with data of 1977 and with the data of other countries.

The larvae's feeding patterns undergo distinct seasonal changes. During the spring, the newly hatched larvae consume young, tender oak leaves, taking advantage of the nutrient-rich foliage. As the summer progresses, the larvae transition to feeding on more mature, tougher oak leaves, exhibiting a remarkable ability to adapt their digestive systems to handle the changes in leaf quality and composition. This indicates a delayed and condensed adult emergence period, likely influenced by climatic changes.

Other Herbivores. Other oak-associated herbivores register in the result of the survey: European oak leafroller (*Tortrix viridana*), oak leaf-rolling weevil (*Attelabus nitens*), cicadas, psyllids, and geometer moth's species, contributing to overall canopy stress.

Key findings of the study include: larvae exhibit seasonal feeding adaptations, consuming young, nutrient-rich oak leaves in spring and transitioning to tougher mature leaves in summer; adult moth emergence has shifted later and become more condensed compared to historical data, with emergence now occurring from late July to early August, likely driven by climatic factors; co-

occurring herbivorous insects such as the European oak leafroller (*Tortrix viridana*) and oak leaf-rolling weevil (*Attelabus nitens*) contribute to cumulative defoliation pressures; forest degradation factors, including climate change-induced stress, exacerbate the vulnerability of oak stands.

This study provides critical insights into the feeding behavior, phenology, and defoliation impact of *Euproctis chrysorrhoea* in Armenia's oak forests. The demonstrated phenological shifts and high defoliation rates highlight the compounded threats of insect herbivory and climate change on these mountain ecosystems. Effective management integrating pest control and climate resilience measures is essential to preserve the ecological integrity and productivity of oak forests of Armenia. The high defoliation levels in areas with dense larval webs underscore the need for active management. The presence of multiple herbivorous species further complicates forest health, emphasizing the importance of integrated pest and ecosystem management.

Based on the present findings and relevant literature, the following key strategies are recommended for effective forest pest management: Monitoring: Sustained and systematic phenological observation combined with larval density assessments is essential for early detection of population increases. This enables timely and targeted interventions, thereby reducing ecological and economic damage. Integrated Pest Management (IPM): A multi-faceted approach that integrates mechanical methods, such as manual removal of infested material, with precision aerial spraying in heavily affected zones can significantly improve overall control effectiveness while minimizing environmental impact. Climate Adaptation: Forest management strategies must proactively integrate climate change projections to account for potential shifts in pest phenology, distribution, and outbreak severity. Adaptive planning will enhance the resilience of forest ecosystems and ensure long-term sustainability of pest management programs.

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