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OBSERVATIONS ON THE EVOLUTIONARY CYCLE OF THE EURYGASTER INTEGRICEPS SPECIES IN THE NORTHEASTERN REGION OF ROMANIA

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Abstract
Eurygaster integriceps, commonly known as the sunn pest, begins its biological activity in the second decade of April, when adults emerge from hibernation at temperatures of 12–16°C, with mass flights occurring on sunny days at temperatures above 18°C. Males appear a few days before females, and the migration to wheat fields is completed by May. After feeding, mating takes place, and females lay between 70 and 100 eggs, grouped in batches of 14, on leaves, stems, and preferably on emerging spikes. Egg hatching occurs within 7–15 days, from early May to mid-June. The larvae go through four instars and three molts, followed by the nymph stage. The full development cycle lasts 30–40 days, with new adults emerging between the second half of June and July. These adults feed intensively for about 10 days to accumulate fat reserves necessary for hibernation, after which they migrate to deciduous forests. Comparative studies between Gorban and Țuțora (2020–2024) reveal differences in the development rate, influenced by microclimatic conditions: maturation occurs faster in Gorban, while delays in hatching, larval development, and adult emergence are observed in Țuțora.

Keywords: *Eurygaster integriceps, evolutionary cycle, fat reserves.*

1. INTRODUCTION

Common wheat (*Triticum aestivum*) is one of the most important cereal crops globally, playing an essential role in ensuring food security. In the northeastern area of Romania, this crop is particularly relevant, but is constantly subject to pressure from a series of biotic and abiotic factors. Among the biotic factors, pest attacks are particularly notable, which can negatively influence both the quantity and quality of the harvest. Phytophagous insects, rodents and other pests contribute to the reduction of yield and the deterioration of grain quality (Popescu et al., 2020).

Among the most important wheat pest species in the northeastern region is *Eurygaster integriceps* (cereal bug), which directly affects wheat and barley crops. Its attack causes significant economic losses by reducing production and compromising the quality of the grains – especially by decreasing the gluten content, which makes them unsuitable for baking (Tudorache et al., 2019, Gündüz and Ölmez, 2021).

Within its evolutionary cycle, two key stages are of particular importance: diapause and seasonal migration. Diapause represents a survival strategy in adverse conditions, while migration allows adaptation to climatic variations and the availability of food resources (Kheradmand et al., 2019). Recent research shows that these processes are strongly influenced by climatic factors such as

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temperature, photoperiod and humidity. Climate change in recent years has led to changes in the biological rhythm, migratory behavior and population dynamics of the species (Tavakkoli et al., 2020).

In the current context, the Iași region – located in northeastern Romania – is facing an increasingly pronounced climate instability, marked by increases in average annual temperatures and changes in the rainfall regime (Dumitru et al., 2022). These changes can have a direct impact on the evolutionary cycle of pests and can influence the efficiency of control strategies.

This paper aims to analyze the evolution of the biological cycle of the *Eurygaster integriceps* species, with a focus on its diapause and migration during the period 2020–2024, in the Iași area. The main goal is to correlate these biological stages with local climatic factors, in order to identify recent trends and formulate effective phytosanitary protection measures. At the same time, this analysis aims to better understand the interaction between the evolution of the pest and local agroclimatic conditions, essential for maintaining sustainable agriculture in the region.

2. MATERIALS AND METHODS

The study on the biological cycle of *Eurygaster integriceps* in the North-Eastern area of Romania (Iași region) in the localities of Gorban and Tutora was carried out during the period 2020–2024, using a combined approach of field monitoring, entomological observations and analyses under controlled conditions.

Direct observations were carried out weekly, in plots cultivated with wheat, where the main developmental stages were identified and recorded: eggs, nymphs and adults.

To track the spring and autumn flight, adhesive and pheromone traps were used, strategically placed in the crop.

Also, collected specimens were morphologically analyzed to determine sexual maturity and the moment of entering diapause.

In parallel, experiments were carried out in the laboratory to evaluate the duration of the biological stages and the influence of environmental conditions on them.

To estimate the phenology of the species depending on air temperature, the degree-day model (GDD) was used, and local climate data were correlated with population dynamics to highlight the impact of meteorological changes on migratory behavior and diapause. This integrated approach allowed for the detailed characterization of the evolutionary cycle of grain bugs in the agroclimatic conditions of the Iași region..

3. RESULTS AND DISCUSSIONS

The hibernating adults of the *Eurygaster integriceps* species leave their hibernation sites during April, starting from the second decade (10 – 15 IV) at temperatures of 12 – 16°C, and the massive flight usually occurs on bright sunny days with temperatures above 18°C.

It has been observed that males precede the appearance of females by a few days. It has also been observed that if days with variable temperatures occur, lower or higher, the migration process can be accelerated or, on the contrary, delayed or staggered. However, this process ends in May, when all the bedbugs are present in the wheat fields (Figure 1).

Once in the wheat fields, the bedbugs mate, and after a period of feeding, the females begin to lay eggs, in clutches of 14 round, green eggs, arranged in two rows, on leaves, stems and preferably on the pods and on the ears that are beginning to appear.

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It has been found that a female can lay 70-100 eggs, which are usually laid in a proportion of 80% by the end of May.

The incubation of the eggs lasts 7-15 days, after which the larvae appear. They usually hatch at the end of the first decade of May and until the second decade of June. Due to the staggered hatching of the larvae, this determines the presence at a given time of the simultaneous appearance of larvae of different ages.

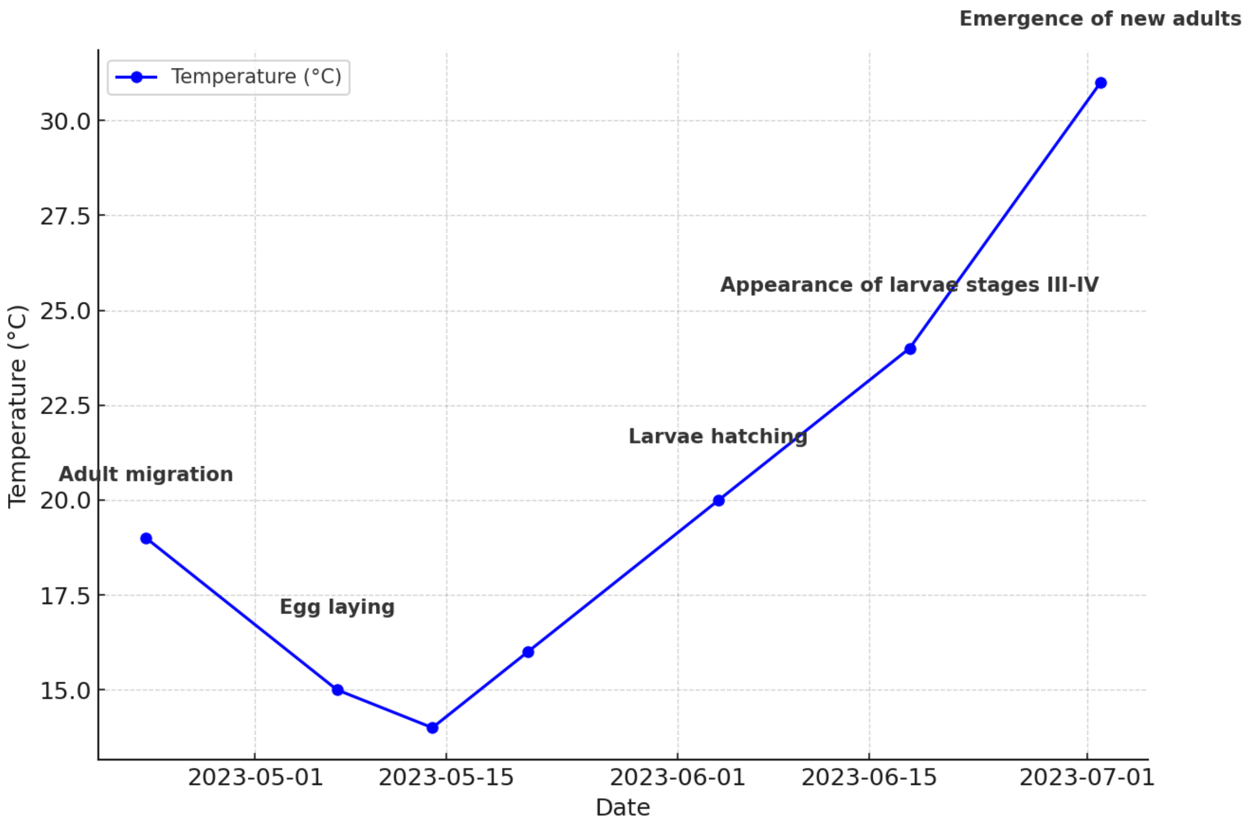

Figure 1. The evolutionary cycle of the species Eurygaster integriceps

During their development, the larvae go through four ages with three molts. After the fourth molt, the larvae pass into the nymph stage (according to some authors, the fifth-instar larva).

The nymph, in the case of the heterometabolous metamorphosis that characterizes the *Heteroptera*, is a stage in which the insect most resembles the adult (having reduced wings) moves and feeds, being a characteristic stage of this type of development. The evolution of the four larval ages and the nymph stage lasts in *Eurygaster integriceps* 30 - 40 days, so that new adults usually appear from the second half of June until the second decade of July.

Adults during this period feed intensively for approximately 10 days in order to accumulate reserve substances in the form of fats, absolutely necessary for the development of vital processes during the hiemal diapause and reproduction period. It should be noted that the period of intense feeding overlaps with the full ripening of the grains (caryopses) and therefore with the wheat harvest.

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After accumulating the necessary reserve substances, the bedbugs migrate for hibernation under the foliage in deciduous forests, entering diapause.

Although bedbugs can migrate over distances of over 100 km, under the conditions we investigated, the migration distance from the field to the deciduous forests, where they migrate for hibernation, does not exceed 10 – 15 km, often even less.

The biological cycle of the species *Eurygaster integriceps* in the Gorban – Iași area between 2020 and 2024

The biological cycle of the Eurygaster integriceps species was monitored over a five-year period in the Gorban – Iași area. During the research period, significant variations in the insect's phenology were observed, probably influenced by annual climatic conditions (table 1).

Table 1. ***The biological cycle of the species Eurygaster integriceps in the ecological conditions of the Gorban – Iași area in the period 2020 – 2024***

Specification	Year									
	2020		2021		2022		2023		2024	
	Data	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$
Beginning of migration and emergence of adults in wheat crops	18.04	19.8°	20.04	17.5°	27.04	19.1°	09.04	18.2°	25.04	20.5°
Copulation	17.05	131.4°	25.04	51.0°	08.05	46.8°	17.04	42.1°	03.05	31.8°
Start of egg laying	16.05	135.5°	10.05	108.2°	15.05	82.1°	18.05	103.2°	27.05	97.5°
Start of hatching	27.05	215.1°	20.05	220.2°	05.06	202.7°	29.05	167.2°	30.05	162.3°
Emergence of third-instar larvae	20.06	325.2°	25.06	278.8°	21.06	315.2°	20.06	308.5°	09.06	290.7°
Emergence of new adults	15.07	549.6°	25.07	537.5°	12.07	538.1°	22.07	543.7°	06.07	542.1°

It is observed that the beginning of migration and the appearance of adults in wheat crops vary between April 9 (2023) and April 27 (2022), with relatively close accumulated temperatures ($\sum tn - t0$) (between 17.5°C and 20.5°C). This temporal difference indicates a direct influence of the climatic conditions specific to each year on the onset of the biological cycle.

The copulation period presents important variations, both in terms of onset date and accumulated temperatures. The year 2021 is notable for a very early start (April 25), and the year 2024 for much lower accumulated temperatures compared to other years (31.8°C), which suggests a possible impact of climatic conditions on the synchronization of reproductive behavior.

Egg laying follows a relatively constant pattern, occurring between May 10 and May 27, with accumulated temperatures ranging from 82.1°C (2022) to 135.5°C (2020). In general, higher accumulated temperatures appear to be correlated with an earlier onset of this stage.

Egg hatching varies between May 20 (2021) and June 5 (2022), with accumulated temperatures ranging from 162.3°C to 220.2°C. The differences between years suggest an important influence of weather conditions on the duration of this stage.

The emergence of third-instar larvae occurs between June 9 (2024) and June 25 (2021), indicating a significant variation in the rate of development, although the accumulated temperatures remain relatively constant (between 278.8°C and 325.2°C).

The emergence of new adults occurs between July 6 (2024) and July 25 (2021), with accumulated temperatures between 537.5°C and 549.6°C, suggesting a relatively stable synchronization of this final stage of the biological cycle.

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The biological cycle of the species *Eurygaster integriceps* in the Țuțora – Iași area between 2020 and 2024 indicates significant variations between years, probably influenced by the climatic conditions specific to each season (table 2).

The onset of migration and emergence of adults in wheat crops shows considerable fluctuation, occurring between 7 April (2023) and 5 May (2022). The accumulated temperature at this stage varies from 15.1°C (2021) to 30.2°C (2022), suggesting a direct correlation between the average temperature and the timing of adult emergence in crops.

Copulation occurs with significant differences from one year to another, starting early in 2023 (11 April) and much later in 2022 (9 May). The accumulated temperatures required for this stage vary considerably, with the lowest being in 2024 (28.7°C), which could indicate slower development in that year.

Egg laying follows a relatively constant pattern, occurring between 9 May (2021) and 26 May (2020). Accumulated temperatures vary, being higher in 2020 (135.1°C) and lower in 2022 (85.4°C), suggesting that higher temperatures may accelerate this process.

Egg hatching varies significantly, with the earliest recorded being on 19 May (2021) and the latest on 10 June (2022). Accumulated temperatures at this stage are highest in 2022 (224.1°C), indicating a delay in the process, possibly due to colder or more unstable conditions at that time.

Third-instar larval emergence occurs between 13 June (2020) and 27 June (2022), with accumulated temperatures ranging from 275.5°C (2021) to 389.8°C (2022). The large differences in accumulated temperature may be influenced by climatic conditions and the speed of larval development each year.

New adult emergence occurs from July 7 (2020) to July 28 (2021), and the accumulated temperatures required are higher in 2022 (583.7°C) compared to 2020 (534.2°C). This suggests longer development in colder years and faster maturation in warmer seasons.

Table 2. ***The biological cycle of the Eurygaster integriceps species Put. in the ecological conditions of the Țuțora – Iași area in the period 2020 – 2024***

Specification	Year									
	2020		2021		2022		2023		2024	
	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$	Data	$\sum(t_n - t_0)$
Beginning of migration and emergence of adults in wheat crops	20.04	20.1°	23.04	15.1°	05.05	30.2°	07.04	19.2°	21.04	16.7°
Copulation	04.05	65.2°	01.05	51.5°	09.05	52.2°	11.04	39.7°	28.04	28.7°
Start of egg laying	26.05	135.1°	09.05	126.2°	13.05	85.4°	14.05	94.5°	20.05	89.2°
Start of hatching	29.05	198.5°	19.05	218.3°	10.06	224.10°	05.06	179.5°	03.06	175.8°
Emergence of third-instar larvae	13.06	331.7°	25.06	275.5°	27.06	389.8°	21.06	321.4°	14.06	325.7°
Emergence of new adults	07.07	534.2°	28.07	565.3°	21.07	583.7°	25.07	565.7°	18.07	562.4°

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The evolutionary cycle of the *Eurygaster integriceps* species, as a function of ∑(tn-t0) in two areas with different climates: Gorban, compared to Țuțora, in the period 2020 – 2024

The comparative analysis of the evolution of the *Eurygaster integriceps* species in the two localities, Gorban and Țuțora, during the period 2020 – 2024, highlights notable differences in the development of the insect, probably determined by microclimatic variations and the specific conditions of each area (table 3).

Regarding the beginning of the migration of adults in wheat crops, the differences are minimal, with accumulated temperatures of 19.2°C in Gorban and 20.26°C in Țuțora. This small variation suggests that local factors do not significantly influence the initial moment of the biological cycle (tab. 4.3).

Copulation, on the other hand, presents a more pronounced difference, being associated with a higher accumulated temperature in Gorban (60.62°C) compared to Țuțora (47.46°C). This could indicate a faster rate of the reproductive process in the first locality, possibly due to higher temperatures or more favorable conditions.

Egg laying is almost identical in the two localities (105.3°C vs. 106.08°C), which shows that this stage of development is less influenced by local environmental variations.

Table 3. ***The evolution of the species Eurygaster integriceps Put., in two localities under different conditions in the research area during 2020 – 2024***

SPECIFICATION	$\sum(t_n - t_0)$	
	GORBAN	ȚUȚORA
BEGINNING OF ADULT MIGRATION INTO WHEAT CROPS	19.2°	20.26°
COPULATION	60.62°	47.46°
BEGINNING OF EGGSLAYING	105.3°	106.08°
BEGINNING OF HATCHING	193.5°	199.24°
EMERGENCE OF THIRD STAGE LARVAE	303.68°	328.68°
EMERGENCE OF NEW ADULTS	540.4°	562.26°

In the case of egg hatching, the accumulated temperatures required are slightly higher in Țuțora (199.24°C) than in Gorban (193.5°C), suggesting a slight delay in this area.

A larger difference occurs at the emergence of third-instar larvae, where the accumulated temperature in Țuțora is considerably higher (328.68°C) compared to Gorban (303.68°C). This may indicate either slower larval growth in Țuțora, or less favorable conditions for their rapid development.

Finally, the emergence of new adults requires higher temperatures in Țuțora (562.26°C) compared to Gorban (540.4°C), which could suggest a delayed maturation of the population in this locality.

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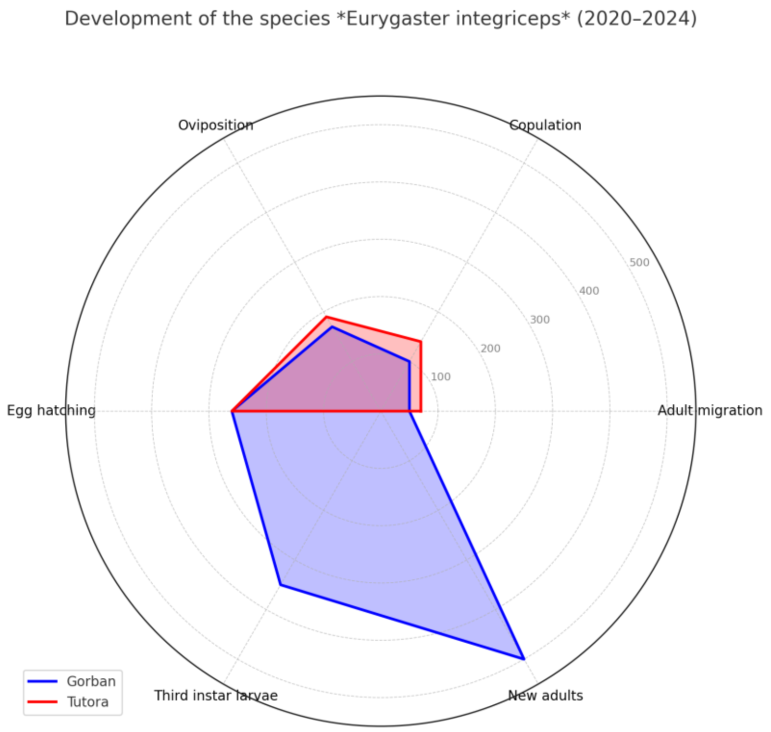

Figure 2. The evolution of Eurygaster integriceps species in two localities under different conditions

4. CONCLUSIONS

• Influence of climatic conditions on the timing of adult migration: The onset of adult migration of *Eurygaster integriceps* varies depending on annual climatic conditions, with a significant difference between warmer years (April) and colder years (April-May). This suggests an adaptability of the species to average temperatures and a direct impact of weather on the synchronization of the biological cycle.

The copulation period shows considerable variation between years, indicating a direct effect of temperatures on reproductive behavior. In colder years, this process can be delayed, and in warmer years it occurs earlier, as observed in 2021 compared to 2024.

During the observations, egg hatching and larval development are significantly influenced by accumulated temperatures, leading to the emergence of larvae and adults at different times throughout the years. In Țuțora, for example, third-instar larvae appear later than in Gorban, suggesting slower development in areas with lower temperatures.

The comparative analysis between Gorban and Țuțora shows faster development of *Eurygaster integriceps* in Gorban, probably due to more favorable climatic conditions. This may influence the rate of migration, copulation and emergence of adults, with a shorter biological cycle in Gorban.

• Correlation between average temperature and synchronicity of biological cycle phases: In both areas (Gorban and Țuțora), higher temperatures are correlated with faster development, especially in terms of egg hatching and adult emergence. The temperature differences between the two locations suggest a faster development rate in areas with higher temperatures, which may have implications for pest management and control strategies.

In conclusion, the development of the *Eurygaster integriceps* species is faster in Gorban than in Țuțora, which can be explained by more favorable temperatures and more favorable climatic

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conditions in this area. The observed differences are important for establishing effective measures to combat the pest, adapted to each region according to its development rate.

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