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OBSERVATIONS ON DIAPAUSE AND MIGRATION OF THE *EURYGASTER INTEGRICEPS* SPECIES IN THE CLIMATIC CONDITIONS OF THE IAȘI AREA DURING 2020-2024

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Abstract
The species Eurygaster integriceps (suun pest) has a biological cycle that is significantly influenced by climatic conditions. Diapause, which lasts between 8 and 9 months, is divided into two stages: aestivation (during the warm season) and hibernation (during the cold season). Aestivation ranged from 3 to 4.5 months during 2020-2024, and hibernation gradually decreased from 7 months in 2020 to 4 months in 2024, reflecting milder winters. These changes indicate an adaptation to changing climatic conditions and a greater potential for impact on crops.
Spring season migration begins in April, and mass migration occurs when temperatures exceed 10°C, lasting between 55 and 75 days, depending on the year.
The time of migration from field to forest is longer than the migration in the opposite direction. In 2024, migration was faster, suggesting possible climate change. The species prolificacy increased steadily between 2020 and 2024, from 25% to 50%, influenced by fat consumption and feeding conditions.
Feeding of plants in the grass family favors efficient reproduction, and embryonic development differs significantly, so in 2024 it was considerably extended (25 days).
The essential processes of the bedbug are supported by warm, dry and bright conditions, while cold and wet weather, accompanied by winds, limit them. These conditions are fundamental for migration, sexual maturation, feeding, reproduction, hatching and development. Their effective management is essential for the management of infestations.
In addition, nutrition has a significant restrictive role when the growth of the host plant progresses ahead of the pest cycle, inhibiting its normal development.

Keywords*: diapause, Eurygaster integriceps, migration.*

1. INTRODUCTION

Diapause and migration are two fundamental biological phenomena that influence the distribution and population dynamics of many insect species, including those in the *Scutelleridae* family. One such species is *Eurygaster integriceps* (Ahlawat, 2022), a major agricultural pest in regions of Europe and Asia, known for its significant impact on cereal crops, especially wheat and barley (Mitrea et al., 1995). Despite extensive research on the ecology and behavior of this species, essential aspects such as the mechanisms of diapause and migration patterns remain insufficiently documented.

Diapause, a period of suspended development, is a crucial adaptation that enables insects to survive adverse conditions, such as cold winters or prolonged droughts (Georgescu, 1996). In the case of *Eurygaster integriceps*, it plays a critical role in maintaining population stability, while migration -

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associated with seasonal changes and the search for new food sources or habitats—can significantly influence its dispersal (Demydov, 2023).
Previous studies on diapause in *Eurygaster integriceps* have shown that this species enters a state of physiological dormancy during the cold season, and environmental factors such as temperature and day length play a key role in initiating and terminating diapause (Ahlawat, 2022). Regarding migration, research has identified that these insects migrate in response to seasonal changes in weather conditions and the need to find new food sources (Mocanu et al., 2017). Migration may also contribute to the expansion of the species' distribution range and its evolution in response to climate change (Tălmaciu et al., 2018, 2019).
The aim of this paper is to analyze the characteristics and factors that influence diapause and migration in *Eurygaster integriceps*, through field observations and relevant previous studies. We will explore the physiological mechanisms regulating these processes, the impact of climatic conditions on the species behavior, and, not least, the implications of these phenomena for pest management and the protection of agricultural crops.

2. MATERIALS AND METHODS

To analyze the structure, dynamics, and evolution of cereal shield bug infestations, systematic observations were conducted in wheat crops across 10 localities in Iași County in 2024.
The studies were carried out both in the fields and in the forests where the bugs hibernate. In this regard, 10 forests—one from each locality—were selected, and surveys were conducted in the autumn and spring using a 0.5 x 0.5 m quadrat, covering a total area of 10 square meters per survey.
To identify and assess the numerical density of soil-dwelling pests, surveys involved digging control pits at various depths (0–10 cm, 10–20 cm, 20–30 cm) to determine the bugs' distribution within the soil layers and their interaction with the surrounding environment. Insects were collected from each control pit, and their numbers were recorded relative to the volume of soil extracted (Mocanu et al., 2017).
Additionally, direct capture methods were employed using pheromone traps to monitor their migration and estimate the density of adult populations. These traps were placed in various forest and field locations to analyze spring migration and observe population fluctuations throughout the growing season.
In the fields, to assess the impact of the bugs on wheat crops, direct observations were made of damage symptoms such as deformities or grain damage, as well as measurements of infestation rates on experimental plots. Statistical methods were applied to analyze the data and compare infestation intensity in relation to climatic conditions and other external variables (temperature, humidity, soil type).
To monitor the effectiveness of control measures, selected insecticide treatments were applied, and their effects on pest density and crop protection levels were observed. The effectiveness of different treatments was compared based on the number of insects captured in traps, signs of plant damage, and crop yield.
All collected data were centralized and analyzed using statistical models to determine correlations between ecological factors and the evolution of bug infestations in cereal crops, thereby providing a comprehensive framework for developing effective pest management strategies adapted to specific climatic conditions.

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3. RESULTS AND DISCUSSIONS

Ecology of the Species Eurygaster integriceps Put.

Diapause in the species Eurygaster integriceps Put. in our country, depending on climatic conditions, takes place in deciduous forests (oak), which provide favorable conditions for hibernation.

Diapause, which lasts around 8–9 months, according to some authors, can be divided into two distinct periods: estivation and hibernation (Table 1).

Table 1. Grain beetle diapause duration (estivation and hibernation) during 2020–2024

No.	DIAPAUSE	Diapause duration in months (2020–2024)				
		2020	2021	2022	2023	2024
1.	ESTIVATION	3	3.5	4	3	4.5
2.	HIBERNATION	7	6	5	5	4
TOTAL		10	9,5	9	8	8.5

By analyzing the diapause duration of the cereal bug (*Eurygaster integriceps*) (Fig. 1) during the period 2020–2024, significant variations can be observed in both estivation and hibernation, likely influenced by the specific climatic conditions of each year.

Estivation, the dormancy period during the warm season, ranged from 3 months (in 2020 and 2023) to 4.5 months (in 2024). A tendency toward a longer estivation period can be seen in more recent years, which may indicate drier summers or higher temperatures that trigger an earlier entry into, and prolonged maintenance of, this dormant state.

Hibernation, the dormancy period during the cold season, showed a gradual decrease from 7 months in 2020 to just 4 months in 2024. This significant reduction suggests milder winters, which allow an earlier exit from hibernation and, consequently, an acceleration of the species' biological cycle.

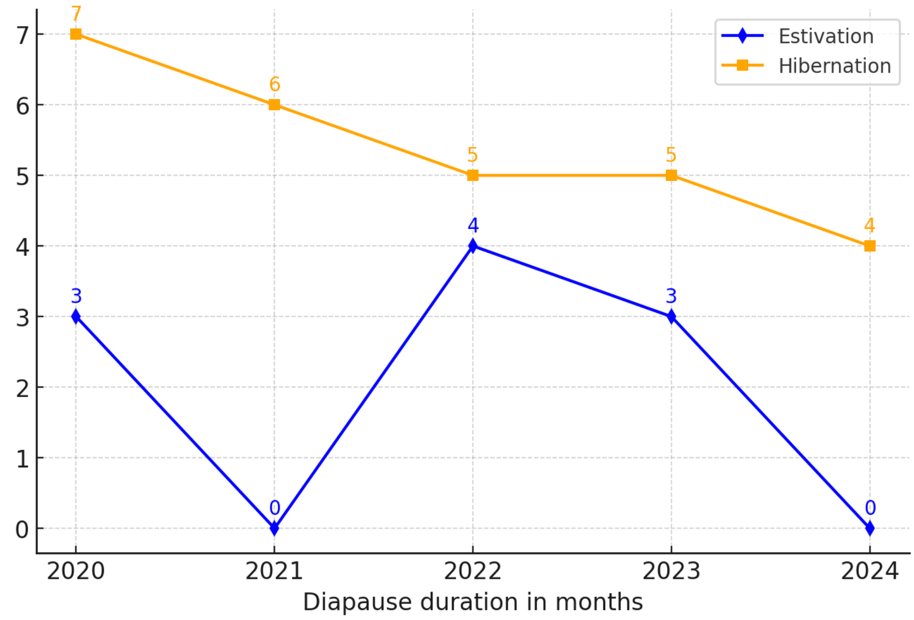

Figure 1. Representation of the Eurygaster species diapause during the research period

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Overall, the total diapause duration (estivation + hibernation) decreased progressively, from 10 months in 2020 to 8–8.5 months in 2023–2024. This may indicate an adaptation of the species to changing climatic conditions, with a longer active period and, implicitly, a higher potential impact on crops.

These observations are essential for implementing effective pest control strategies, adapted to the new developmental conditions of the pest.

The migration of Eurygaster integriceps Put. sometimes begins sporadically in the last ten days of March and may extend into the third ten-day period of May. However, the most important phase is the mass migration, when approximately three-quarters of the entire population migrates. This process can occur gradually over several weeks or be concentrated in a short interval of 3–4 days.

Overall, for regions in our country, spring migration of the bugs from their overwintering sites typically occurs in April, when the average daily temperature exceeds +10°C, with maximum values above +15°C. The extension of the migration phenomenon into early May occurs especially in years with late springs, when April remains relatively cold (Table 2).

The migration duration from forest to field ranged between 55 and 75 days, with the shortest period recorded in 2024 (55 days) and the longest in 2023 (75 days).

Table 2. Duration of grain borer migration from forests to fields and from fields to forests during 2020 – 2024

No.	MIGRATION	Migration duration in days				
		2020	2021	2022	2023	2024
1.	Forest - Field	70	60	65	75	55
2.	Field-Forest	80	85	95	80	75
TOTAL		**150**	**145**	**160**	**155**	**130**

Overall, the duration of migration shows moderate fluctuations, but there is no clear trend of increase or decrease (Fig.2).

Regarding the migration from field to forest, this stage tends to last longer compared to the reverse migration. The longest duration was recorded in 2022 (95 days), while the shortest was in 2020 and 2023 (80 days). Overall, the duration of the field-to-forest migration is more stable, ranging between 75 and 95 days. The total annual migration duration varies between 130 days (2024) and 160 days (2022).

A decrease in the total duration is observed in 2024, which may indicate climate change, more favorable environmental conditions or other ecological factors influencing insect behavior.

The values from 2020-2023 are relatively close (between 145 and 160 days), suggesting relative stability in these years.

Prolificity in the species Eurygaster integriceps Put.

The prolificacy of the species *Eurygaster integriceps* is a biological parameter influenced both by internal factors, such as physiological state and accumulated fat reserves, and by external factors during the imago phase.

These variations determine a great non-uniformity in prolificacy, with bedbug populations being able to present significant differences between regions and even within the same area, from one year to another (Tab.3).

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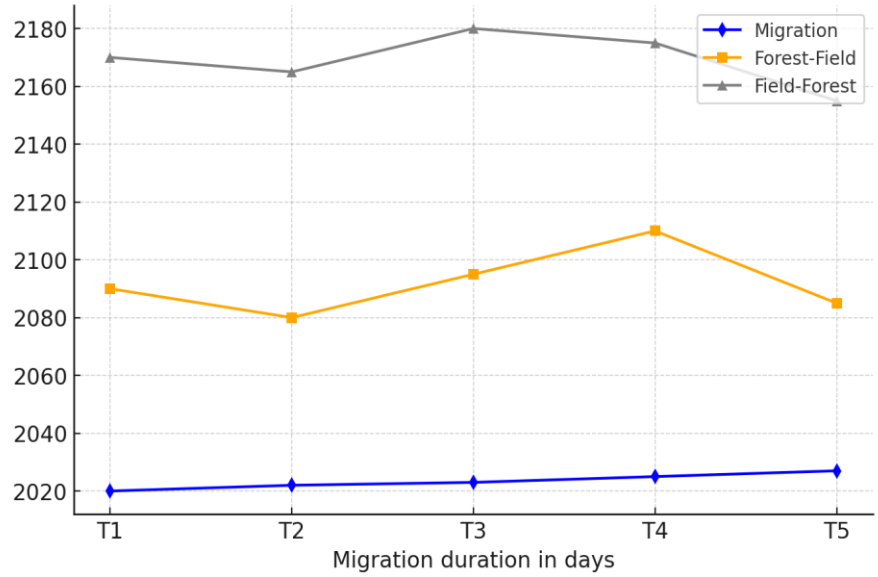

Figure 2. Representation of Eurygaster species migration during the research period

Table 3. Prolificity of Eurygaster integriceps according to fat during 2020 – 2024

No.	*Eurygaster integriceps*	**FAT CONSUMPTION**				
		2020	**2021**	**2022**	**2023**	**2024**
1.	PROLIFICACITY	25%	35%	40%	45%	50%

Analysis of the relationship between grain bug prolificacy and fat consumption over the period 2020-2024 reveals a steady increase in their reproductive capacity, from 25% in 2020 to 50% in 2024, indicating a doubling of prolificacy within five years. This trend suggests a direct influence of fat consumption on reproductive rate: as access to these resources increases, so does the prolificacy of the bugs.

Accumulated fat reserves play a key role in increasing prolificacy. During diapause, *Eurygaster integriceps* consume approximately 25% of their fat reserves, and with the emergence from diapause and the onset of egg laying, the use of these reserves reaches 50% of the total accumulated in the previous summer. The consumption of fat stored in the fat body has an inverse relationship with the total number of eggs laid.

Fat reserves were determined using the Rojo Sudan III (Sudan III) method, where Sudan III is a lipophilic dye that binds to neutral lipids in insect tissues, highlighting them in shades of red-orange.

In addition to lipid reserves, post-diapause feeding plays an essential role in maintaining normal prolificacy.

Egg laying occurs under optimal conditions when the food comes from grasses, and feeding efficiency decreases as the host plant moves away phylogenetically from this family.

Monitoring nutrition and factors that favor high fat consumption is essential to prevent massive infestations.

Embryonic development in the species *Eurygaster integriceps*, under field conditions, at an average temperature of 20°C lasts between 9 – 10 days, but usually the amplitude of this interval is much greater due to temperature oscillations. (Tab. 4)

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Table 4. The duration of embryonic development in field conditions for grain bugs in the period 2020 – 2024

No.	*Eurygaster integriceps*	EMBRYONIC DEVELOPMENT AT 20°C (no. of the days)				
		2020	2021	2022	2023	2024
1.	EMBRIOGENESIS	7	9	10	8	25

The analysis of the duration of embryonic development in grain bugs during the period 2020-2024 highlights significant variations depending on the year, thus the duration of embryogenesis varies considerably between 7 and 25 days (Fig. 3).
In the period 2020-2023, the values are relatively close (between 7 and 10 days), but in 2024 there is a sudden increase to 25 days. This unexpected increase in 2024 could be caused by climatic factors, changes in food resources or biological adaptations of the species.
In previous years, the duration of embryogenesis seems to remain relatively constant, suggesting more stable conditions during that period.
A longer duration of embryogenesis may influence the life cycle of grain bugs, affecting population dynamics and the degree of infestation of crops.
If this trend of prolonged embryonic development persists, additional measures may be needed to monitor and control these insects under field conditions.

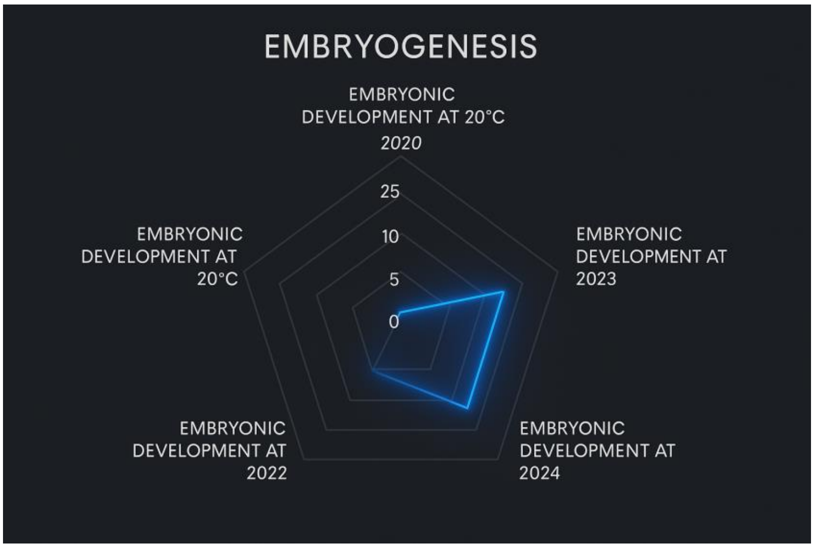

Figure 3. Representation of the embryonic development of Eurygaster species

Influence of promoting and inhibiting factors on vital processes in the species *Eurygaster integriceps* Put.
Eurygaster integriceps being thermoheliophilic insects, all vital processes subsequent to exiting diapause, i.e. spring migration, sexual maturation, feeding, copulation, spawning, hatching, larval and nymphal growth and development, proceed under optimal conditions when April, but especially May and June are characterized by dryness, warmth, brightness, calm, windless weather.
On the contrary, wet, cold, cloudy weather, with strong winds are inhibiting factors of normal development, having negative consequences on the numerical population (Tab. 4.8).

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The influence of promoting and inhibiting factors on the vital processes of the species Eurygaster integriceps Put. is complex and directly related to climatic and environmental conditions. Starting with the emergence from diapause in April, favorable factors such as heat and dryness stimulate the awakening of the insect from its dormant state, while low temperatures and wet weather can delay this process. These conditions are essential for the insects to begin their migratory activity, which occurs in May, when heat and light favor their movement, and calm, windless weather provides them with the ideal conditions for movement.

Regarding sexual maturation, which occurs in June, insects are more sensitive to high temperatures and light intensity, which accelerate the process. On the contrary, cold or wet weather slows down this vital process. During the feeding and reproduction period in July, the favorable climatic factors are, again, heat and calm weather, which allow for increased metabolic activity and high efficiency of the feeding and reproduction processes. However, cold and cloudy weather, along with strong winds, have negative effects, reducing the insect's activity.

Table 5. The influence of favorable and inhibitory factors on the vital processes in the species Eurygaster integriceps

Vital Processes	Period	Favorable Factors	Inhibitory Factors
Exit from diapause	April	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds
Spring migration	April - May	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds
Sexual maturation	May	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds
Feeding	May - June	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds
Reproduction (egg laying, copulation)	May - June	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds
Larval hatching	June	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds
Growth and development of larvae and nymphs	June - July	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds
Adult activity (new adults)	July	Dryness, Warmth, Brightness, Calm Weather	Wet weather, Cold weather, Cloudy weather, Strong winds

Regarding the hatching of larvae and their development, in the summer months, heat and light favor rapid development, while high humidity or low temperatures inhibit this process. Also, the activity of adults, which extends until August, is strongly influenced by the same climatic conditions, heat and calm weather being essential for the insects to remain active and carry out their feeding and reproductive processes.

In conclusion, the vital processes of the *Eurygaster integriceps* species are directly related to climatic and environmental factors, being favored by warm, dry and calm conditions and inhibited by cold, wet weather and strong winds. These observations can provide valuable information for pest management and for the development of effective control strategies, depending on seasonal climate changes.

The limiting role of food is evident when the phenology of the host plant outpaces the development cycle of the pest, so that plant development prevents the entire bedbug population from developing normally.

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4. CONCLUSIONS

The constant presence of bedbugs in their hibernation sites highlights the risk of a continuous attack on wheat crops, especially in areas with high densities of specimens, such as Moșna and Grozești. These areas should benefit from monitoring and effective control measures to protect the crops.

Periods of high temperatures favor a faster development of the species, while colder or unstable conditions lead to delays in the evolution of the insect. These differences must be taken into account for the management and control of the bedbug, which can vary significantly from year to year and from one location to another.

Diapause in *Eurygaster integriceps* occurs in deciduous forests, especially in oak, and lasts approximately 8-9 months, being divided into two distinct periods: aestivation and hibernation. The duration of aestivation varied between 3 months (2020 and 2023) and 4.5 months (2024), indicating a tendency for this stage to be longer in recent years, suggesting drier or warmer summer conditions. Hibernation lasted from 7 months in 2020 to 4 months in 2024, indicating milder winters that allow for a faster exit from hibernation and acceleration of the biological cycle.

Spring migration from forests to fields generally occurs in April, when the average daily temperature exceeds 10°C. The duration of migration varies between 55 and 75 days, being shorter in 2024 (55 days) and longer in 2023 (75 days), suggesting the influence of the year and climatic conditions on the migration process. The reverse migration (from field to forest) is more stable, varying between 75 and 95 days.

The constant presence of bedbugs in the hibernation sites highlights the risk of a continuous attack on wheat crops, especially in areas with high densities of specimens, such as Moșna and Grozești. These areas should benefit from monitoring and effective control measures to protect the crops. This ratio remained constant both in autumn 2020 and in spring 2021, indicating a better adaptation of the dominant species to local conditions.

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