

## PREVENTIVE MEASURES FOR RODENT (*RODENTIA*) CONTROL IN THREE DISTINCT URBAN LOCALITIES IN SKOPJE

Gazmend ISENI<sup>1</sup>, Ajten RUSHITI-DAUTI<sup>1</sup>, Nebehat ILJAZ<sup>2</sup>, Sheval MEMISHI<sup>1</sup>, Besa ISENI<sup>3</sup>, Besnik REXHEPI<sup>1</sup>

<sup>1</sup> Department of Biology, Faculty of Natural Sciences and Mathematics, University of Tetovo, North Macedonia

<sup>2</sup> "Center for Public Health-Skopje" DDD Service, Skopje, North Macedonia

<sup>3</sup> Primary School "Kultura" Mateç, Lipkovo, North Macedonia

\*Corresponding author's email: [gazmend.iseni@unite.edu.mk](mailto:gazmend.iseni@unite.edu.mk)

### Abstract

The main purpose of this study was to analyze rodent activity in three different buildings (companies) that are located in different environmental conditions, have different functions, and also differ in structural characteristics. The research was carried out by monitoring the consumption of poisoned bait placed in certain bait stations, both in the outdoor and indoor areas of these research points.

The monitoring of the activity of rodents was carried out in 4 periods during one year (January 2024, May 2024, September 2024, and January 2025). To determine rodent presence, we implemented a standardized scoring system that measures rodent activity from 0 (no activity) to 4 (high activity, defined as complete bait consumption). At the first study site (Dauti Komerc) in Saraj, data analysis showed the highest peak in January 2024, which is consistent with low environmental temperatures encouraging rodents to seek shelter indoors. The activity of rodents in the interior spaces of this research point resulted in generally lower values, but several high-risk areas were identified that require increased preventive measures. The highest levels of rodent activity in the outdoor spaces in the second research site (Feniks and El Farma - the industrial area in Vizbeg) were during January of 2024 and 2025. Meanwhile, the monitoring of the internal spaces of this point resulted in a minimum level of rodent activity, which was achieved by the effectiveness of deratization. The highest rodent activity was recorded in September and January, at the third research point (Kromberg-Schubert in the Ilinden story), while activity was at its lowest in May. Inside the buildings, evidence of the presence of rodents was limited to some isolated areas.

In summary, the analysis of rodent activity shows a distinct seasonal trend, with increased levels of activity recorded during the colder months, especially in January and September, when rodents seek shelter and food. The first research company had the highest overall rodent activity, both indoors and outdoors, most likely due to the food items being attractive to the pests. Despite the fact that the second company (Kromberg-Schubert) did not possess food products, its location in wide open spaces in nature contributed to the promotion of high rodent activity. Well-maintained and isolated facilities, such as those of Feniks and El Farma, demonstrate in particular the effectiveness of proactive deratization strategies. These results highlight the importance of environmental factors and site-specific management strategies in controlling rodent populations.

**Keywords:** Rodent Activity, Bait Stations, Deratization Strategies, Seasonal Patterns.

### Introduction

The order of rodents (Rodentia) represents one of the most diverse orders of the mammalian class and is characterized by a cosmopolitan distribution, exerting various impacts on forest ecosystems, urban and rural areas, agriculture and crop cultivation, as well as a significant and important impact on public health (Lan *et al.*, 2025; Capizzi *et al.*, 2014). The global diversity of all vertebrates numbers 6759 taxa recorded in the Mammalian Diversity Database ([www.mammaldiversity.org](http://www.mammaldiversity.org)), and of this total worldwide record, rodents lead with 40.6%, specifically with 2747 species (Burgin *et al.*, 2025). Mainly urban environments, where the human population is high, rats are rodents that have found ideal conditions to reproduce by taking advantage of the abundant food and shelter resources that urbanized areas offer, and all these favorable conditions are also related to the reproductive cycle of rodent species, which is characterized by rapid sexual maturity, short lifespan and a polyestrous cycle, with female individuals often capable of mating immediately after birth. Therefore, favorable climatic conditions, abundant food resources, and the reproduction of small rodents without a specific season often leads to population growth in urban environments and disruption of the ecological

balance (Gratz, 1999; Panti-May *et al.*, 2017; Jurišić *et al.*, 2022). Studying rats in urban environments is essential not only to understand their biology and ecology, but also to develop effective strategies for managing their negative impact. According to Tapia-Ramírez *et al.* (2022), species of the order Rodentia can be grouped into three categories in relation to their frequency in their environments. Even those species in urban environments, responding positively to urbanization, increase their abundance, and are known as "urban residents", permanently inscribed in the urban environment. The rapid increase in the abundance of some species poses economic and public health problems for humans. In addition, the second group includes species that make occasional visits: "urban visitors" and some species belonging to the third category react negatively, seeing their abundance as "urban avoiders".

Among the above-mentioned categories, special emphasis is usually given to urban visitors, including synanthropic species, mainly by the World Health Organization (WHO, 1974), due to their direct impact on public health and harmful urban consequences. In this context, WHO has played a central role in the development of global guidelines for rodent control, publishing a series of documents that provide recommendations on the use of rodenticides, monitoring rodent populations, and evaluating control measures. These guidelines emphasize and highlight the importance of integrating mechanical and chemical approaches, giving priority to the safest and most sustainable methods of rodent control and management.

In accordance with these recommendations, effective management and control of commensal rodents can be achieved by combining environmental hygiene, proper food storage, elimination of shelter, and protection of buildings from rodents with various control methods such as blocking, fumigation, and rodenticides. Although the application of chemical methods is increasingly preferred and the widespread use of anticoagulant rodenticides is also recommended due to their effectiveness, long-term management success must be combined with the improvement of environmental conditions and the implementation of multiple control methods in combination (Brooks *et al.*, 1987). Rodenticides are widely used to control rodents in agriculture and forestry; however, their application and use in amateur settings are strictly regulated throughout Europe due to risks to non-target species, environmental impacts, and the emergence of resistance (Jacob & Tkadlec, 2010).

Numerous initiatives focusing on the use of safer chemicals, the promotion of biological control methods and improved waste management as a strategy to reduce rodent populations have also been undertaken by the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP). These organisations also stress the need for training local specialists and strengthening capacities to implement international standards at the national level (FAO, 2011). In recent years, faster and more accurate responses to population outbreaks have been achieved as advances in information technology have led to the development of data management systems that help track and analyse rodent infestations.

Therefore, this study aims to assess the effectiveness of preventive measures and the selection of chemical control agents for rodent management in three different companies operating in industrial areas of Skopje, North Macedonia.

## Materials and methods

Three companies with different activities and different spatial and structural conditions were selected for the realization of this study, which represent important places for an interesting comparison:

1. Dauti Komerc-Saraj (N: 42.00553, E: 21.31462), a company that deals with the storage and distribution of food products.
2. Feniks and El Farma-Vizbeg (N: 42.03275, E: 21.40005), a pharmaceutical company for the storage and transportation of medicines.

3. Kromberg & Schubert-Ilinden (N:41.99595, E: 21.541), an automotive industry company, producing parts for vehicles (Fig. 1).



Fig. 1. Satellite images of the locations of the companies included in the study (arrows indicate their locations). A-Dauti Komerc (Saraj); B-Feniks and El Farma (Vizbeg); Kromberg & Schubert (Ilinden) (source: <https://maps.google.com>).

The rodenticides used for this study are well known and tested so far: Brodisa Blue PE in pellet form containing the active anticoagulant substance - brodifacoum (0.005%), Brodisan Blue PF in paraffin block form containing the active anticoagulant substance - bromadiolone (0.005%) and Brodisan Blue MM, a ready-to-use soft bait, containing the active anticoagulant substance (0.0025%) (European Chemicals Agency [ECHA], n.d). Anticoagulant rodenticides act by disrupting blood clotting and causing fatal internal hemorrhage. Compared with acute rodenticides, their advantage is that they are better tolerated by rodents and generally pose lower risks to non-target species when used properly (Bentley,1972; Brooks *et al.*, 1987). The target rodents of this study were: house mouse (*Mus musculus* Linnaeus, 1758), Norway rat (*Rattus norvegicus* (Berkenhout, 1769)), and black rat (*Rattus rattus* (Linnaeus, 1758)). Monitoring was carried out in four different time periods within one year: January 2024, May 2024, September 2024, and January 2025. In each period, data from boxes placed with poison baits were observed and recorded, both inside and outside the facilities (Fig. 2, 3).

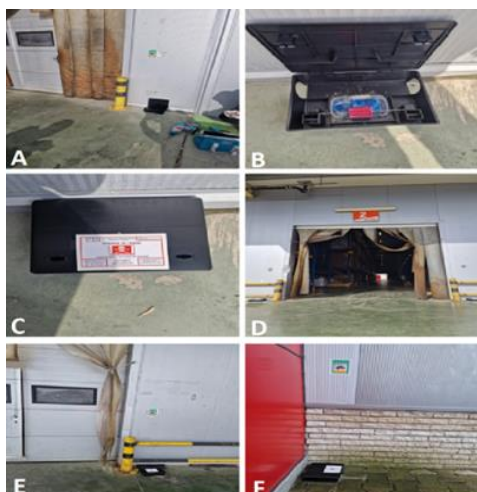


Fig. 2 Dauti Komerc location in Saraj, Skopje and in the companies Feniks and El Farma in Vizbeg, Skopje. The photographs show the way the boxes are mounted outside the buildings (A, B, C) and their correct position (D, E, F).



Fig. 3. Third location of the Kromberg-Shubert Company in the municipality of Ilinden. The photographs show bait boxes placed inside and outside the facility, half-bitten baits, which served to assess the level of activity and the finding of dead mice outside the facility (A, C, H), as well as assessing the level of manifestation (B, D, E, G)

The activity assessment was carried out according to a standardized monitoring system based on EPPO field guidelines for rodent control (OEPP, 1995), which determines the level of rodent manifestation from 0 (no activity) to 4 (high activity, when the bait is completely consumed). The calculation of the average values for rodent activity was carried out based on the number of boxes and baits consumed.

Results are presented with the help of graphs, in particular for each company. A comparative analysis was also conducted to assess the effectiveness of deratization, the impact of climatic conditions, and the construction structure of each facility, as well as the composition and form of the rodenticides used in each case.

## Results and discussion

### *Dauti Komerc- Company, Saraj*

Dauti Komerc is a company that has constant contact with food products, which makes it very susceptible to rodent infestation. 43 bait boxes were placed outside the facility, while 25 were placed inside the facility.

The data analysis indicates that the period of highest activity was January 2024, when temperatures were lower, and rodents sought shelter in such conditions (Fig. 4, a). Within the research facility, activity has been lower, but specific high-risk areas have nevertheless been identified that require ongoing treatment (Fig. 4, b).

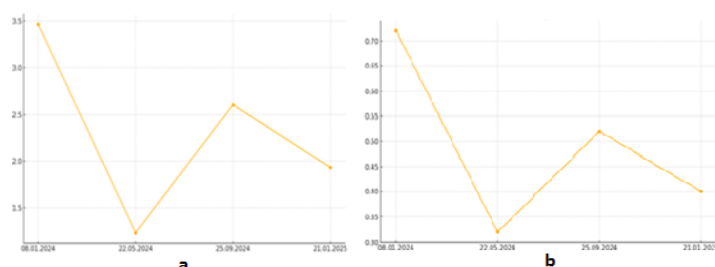


Fig.4 Average rodent activity outside (a) and inside (b) the Dauti Komerc Company premises during the time periods January, May, September 2024 and January 2025.

### *Feniks and El Farma-Vizbeg*

This pharmaceutical company has high safety and hygiene measures, but the outdoor areas still pose a potential risk for infestation. 22 boxes are placed outside the facility and 18 boxes inside the facility. The highest activity outside the facility was recorded in January, September 2024 and January 2025, while in May 2024, activity was lowest (Fig. 5, a). Inside the facility, activity was very low in almost all periods, indicating successful indoor pest control management (Fig. 5, b)

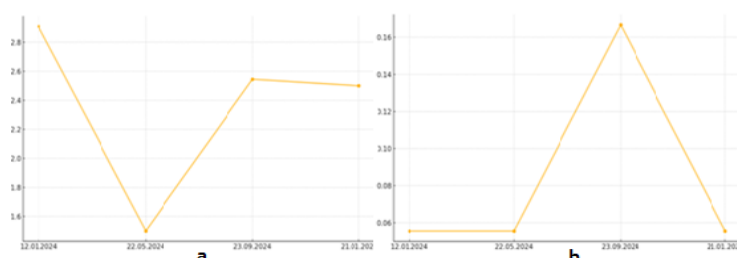


Fig. 5. Average rodent activity outside (a) and inside (b) the Feniks and El Farma company during the time periods January, May, September 2024, and January 2025.

### *Kromberg and Schubert Company - Ilinden*

Kromberg and Schubert Company operates in the technical and industrial sector, where rodent damage can cause serious consequences to equipment or products. 55 boxes have been placed outside the facility, and 30 boxes inside the facility. The highest activity was recorded in January, September 2024, and January 2025, while in May 2024 the activity was lowest (Fig. 6, a). Within the premises of this company, the presence of rodents has only been detected in a few places, mainly in the most isolated places (Fig.6, b).

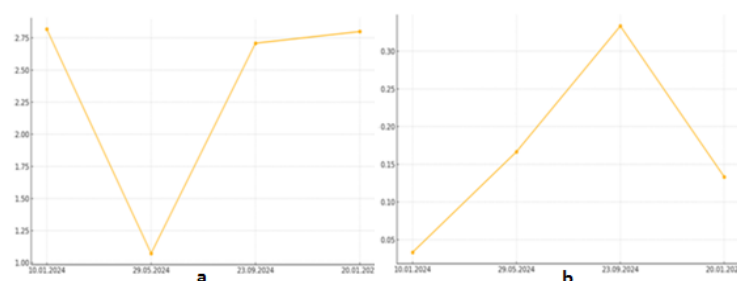


Fig. 6. Average rodent activity outside (a) and inside (b) the Kromberg and Shubert-Ilinden company premises during the time periods January, May, September 2024, and January 2025.

The capture of rodents with mechanical traps and the application of rodenticides were analyzed as control methods; however, certain limitations were identified in the implementation of these methods. Eliminating rodents with traps requires more time and a large number of traps, so rodenticides have shown efficacy in enclosed spaces, compared to their weaker effectiveness in natural environments. The recommendations of the European Chemicals Agency (ECHA), which are also acceptable to the European Committee (2016), emphasize that the dose of these anticoagulants should not exceed 30 ppm or 0.003%, but despite this dose limitation, which has ecological importance in terms of reducing anticoagulant residues, this causes an extension of the consumption time of rodents, specifically a slower mortality that automatically makes these animals in natural outdoor conditions hunted by other predators of the trophic chain, increasing the chances of secondary and tertiary poisoning (Frankova et al., 2019; Blažić et al., 2024).

Regarding the research in different months, the lowest rate of rodent species capture was observed in May in all three localities, both in indoor and outdoor areas. The justification for this result has to do with the abundant presence of food reserves available to rodents in nature (for example, insects) (Kikkawa, 1964). Previous studies (Romanach et al., 2005; Quirici et al., 2010) have also proven that the abundance and mobility of rodents are influenced by key factors such as food availability and environmental climatic conditions. Also, the increase in rodent numbers in September and January is related to the company of this research providing sustainable food sources.

## Conclusions

This research shows that the rodent control process must be continuous and specific for different facilities, as rodent activity is affected by seasonal changes, food availability, building conditions, and the presence of the anthropogenic factor itself. Rodenticides, mainly anticoagulants, are used at different levels of effectiveness depending on their formulation and environmental conditions, emphasizing the importance of proper selection and regular monitoring to avoid as many cases of secondary and tertiary poisoning as possible. The protection of public health, safety in the workplace, and the increase in the quality of manufactured products can only be achieved with effective rodent management by alternating continuous controls, training of employees in different companies, and related institutional and scientific efforts.

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