

Popular Democratic Republic of Algeria  
Ministry of High Education and Scientific Research  
Abbes Laghrour University- Khenchela-  
Natural and life sciences Faculty  
Molecular and Cellular Biology Department



Serial N°: .....

**DISSERTATION PRESENTED**  
**FOR GRADUATION ACADEMIC**  
**MASTER'S DEGREE**

Domain : **Nature and Life Sciences**

FIELD: **Biological Sciences**

Speciality: **Biology and Control of Insect Populations**

*Presented by:*

*Zohra Bouzidi*

**Theme**

Study the insecticidal activity of *Schinus molle* and  
*Lantana camara* against *Blattella germanica*

*Dissertation publicly defended on 17/06/2025 before a jury composed of:*

**Mr Hichem MAAMAR**

MCB, University of Abbes Laghrour – Khenchela, President

**Ms Malika SAIDI**

MCB, University of Abbes Laghrour – Khenchela, Promoter

**Ms Fatima GAGUI**

MAA, University of Abbes Laghrour – Khenchela, Examiner

Academic year 2024 – 2025

# Thanks

*Above all, I thank Allah Almighty for giving me the strength and patience to complete this work.*

*I especially thank the dearest creatures in the universe, my parents, who raised me and supported me throughout my life.*

*The real person who deserves all the thanks is my mother, my sunshine, who stayed up and worked hard to see me in the highest ranks with a look of pride.*

*Moreover, my father, who did not spare me his efforts and constant support.*

*Special thanks to myself for enduring all the difficulties and hardships that constantly stood in my way and the obstacles that I faced, and I still continue to embrace myself every time I return from a defeated, devastating battle and stand again from the ashes, challenging everything that hurts me.*

*I thank my son and my spoiled little brother, **Mouataz Billah**, who accompanied me throughout the completion of this research, in addition to my brothers **Nassim** and **Yamine**.*

*I would like to thank everyone who supported me psychologically, financially or morally, even with just a word. It is worth mentioning my close friend who did not spare me during a difficult period with all the support that anyone needs.*

*I thank the professor supervising my research, **Ms. Saidi**, who never neglected me and continued to guide me to the end of the path.*

*I thank Professor **Bensizrara Djamel** for his efforts with us in the laboratories and equipment that he worked hard to provide for us.*

# *Dedications*

*I dedicate this work, the fruit of my labor, to the one who deserves every beautiful thing, to the person closest to my heart in existence, to my dear mother, to whom, if my success indicates anything; it indicates her effort and staying up late with me for my comfort. You deserve all my successes, so that look of pride will ease the echo of my fatigue.*

*I dedicate this work to my father, who never failed to support and protect me, and to deserve my successes.*

*I dedicate this research to the first people to enter my heart after my parents: my son, my little brother Moataz Billah, and my brothers Nassim and Yamine.*

*I dedicate my joy of this success to everyone who left a beautiful mark on me and has a good memory in my heart, and my closest friends: Mihoubi Rima and Zelfani Seddik, and everyone who truly loves me.*

*I dedicate my work to my tired and stressed self, who did not give up despite everything that happened to her.*

## **Abstract**

Many studies have investigated the effectiveness of essential oils as potential alternatives to synthetic insecticides, with the aim of addressing insect resistance to conventional chemicals. *Blattella germanica*, a major pest and disease vector, has shown strong resistance to chemical pesticides. In Algeria, *Schinus molle* L. and *Lantana camara* L. are widely used medicinal plants. This study aimed to assess the toxicological effects of their essential oils on adult male and female *Blattella germanica*.

The experimental approach involved exposing cockroaches to *Schinus molle* L. essential oil vapors and *Lantana camara* L. hydrosol at different concentrations (5%, 15%, and 30%). The study included an experimental group of 30 males and 30 females for each plant.

The results demonstrated promising insecticidal activity against *Blattella germanica*. The experiments showed that *Schinus molle* L. essential oil exhibited notable efficacy on both male and female cockroaches during the first three days of exposure. In contrast, *Lantana camara* L. hydrosol showed a weaker effect, though it remained relatively effective on both sexes. These findings suggest that *Schinus molle* L. essential oil possesses strong insecticidal properties, while *Lantana camara* L. hydrosol has more limited potential. Together, they may represent promising natural alternatives to synthetic pesticides in controlling German cockroaches.

## **Keywords**

*Blattella germanica*; hydrosol; Essential oil; *Lantana camara* L.; *Schinus molle* L.

## Résumé

De nombreuses études ont examiné l'efficacité des huiles essentielles comme alternatives potentielles aux insecticides synthétiques, dans le but de lutter contre la résistance croissante des insectes aux produits chimiques conventionnels. *Blattella germanica*, un ravageur majeur et vecteur de maladies, a montré une forte résistance aux pesticides chimiques. En Algérie, *Schinus molle* L. et *Lantana camara* L. sont des plantes médicinales largement utilisées. Cette étude visait à évaluer les effets toxicologiques de leurs extraits sur les mâles et femelles adultes de *Blattella germanica*.

L'approche expérimentale consistait à exposer les cafards aux vapeurs de l'huile essentielle de *Schinus molle* L. et à l'eau distillée de *Lantana camara* L. à différentes concentrations (5 %, 15 % et 30 %). Le protocole comprenait un groupe expérimental de 30 mâles et 30 femelles pour chaque plante.

Les résultats ont montré une activité insecticide prometteuse contre *Blattella germanica*. Les expériences ont révélé que l'huile essentielle de *Schinus molle* L. présentait une efficacité notable sur les mâles et les femelles durant les trois premiers jours d'exposition. En revanche, l'eau distillée de *Lantana camara* L. a montré un effet plus faible, tout en restant relativement efficace sur les deux sexes. Ces résultats suggèrent que l'huile essentielle de *Schinus molle* L. possède de fortes propriétés insecticides, tandis que l'eau distillée de *Lantana camara* L. présente un potentiel plus limité. Ensemble, elles pourraient constituer des alternatives naturelles prometteuses aux pesticides synthétiques dans la lutte contre les blattes germaniques.

## Mots-clés

*Blattella germanica*; Eau distillée; Huile essentielle; *Lantana camara* L.; *Schinus molle* L.

## الملخص

تناولت العديد من الدراسات فعالية الزيوت الأساسية كخيارات بديلة للمبيدات الحشرية الكيميائية بهدف التصدي لمشكلة مقاومة الحشرات للمواد الكيميائية التقليدية. تُعد *Blattella germanica* (الصرصور الألماني) من الآفات الرئيسية و الناقلة للأمراض، وقد أظهرت مقاومة قوية للمبيدات الحشرية الكيميائية. في الجزائر، تُستخدم *Schinus molle* L. و *Lantana camara* L. على نطاق واسع كنباتات طبية. ولذلك تهدف هذه الدراسة إلى تقييم التأثيرات السمية لهاتين النباتتين على الذكور والإناث البالغين من *Blattella germanica*

اعتمدت الدراسة على تعريض الصراصير لأبخرة زي *Schinus molle* L. الأساسي و الماء المقطر لـ *Lantana camara* L. بتركيزات مختلفة (5%، 15%، و30%). وتضمنت الدراسة مجموعة تجريبية مكونة من 30 ذكرًا و30 أنثى لكل نبتة.

أظهرت النتائج نشاطًا حشريًا واعدًا ضد *Blattella germanica*. وقد بينت التجارب أن زيت *Schinus molle* L. الأساسي يمتلك فعالية ملحوظة على الذكور والإناث خلال الأيام الثلاثة الأولى من التعرض. في المقابل، أظهر ماء *Lantana camara* L. المقطر تأثيرًا أقل، لكنه بقي فعالًا نسبيًا على كلا الجنسين. وتشير هذه النتائج إلى أن زيت *Schinus molle* L. يتميز بخصائص قوية مضادة للحشرات، بينما يمتلك ماء *Lantana camara* L. المقطر قدرة محدودة، ما يجعلهما معًا بدائل طبيعية واعدة للمبيدات الاصطناعية في مكافحة الصراصير الألمانية.

## الكلمات المفتاحية

*Blattella germanica*؛ ماء مقطر؛ زيت أساسي؛ *Lantana camara* L.؛ *Schinus molle* L.

# TABLE OF CONTENTS

**Abstract**

**Dedication**

**Acknowledgments**

**List of figures**

**List of tables**

<b>Introduction</b> .....	<b>1</b>
	<b>3</b>
<b>Chapter 1. Presentation of <i>Blattella germanica</i></b>	
1. History.....	4
2. Origine and geographic distribution .....	4
3. German cockroach species in Algeria.....	5
4. Taxonomy of <i>Blattella germanica</i> .....	5
5. Description of <i>Blattella germanica</i> .....	5
6. Biological cycle of <i>Blattella germanica</i> .....	5
7. Habitat of <i>Blattella germanica</i> .....	6
8. Reproduction of <i>Blattella germanica</i> .....	7
9. Communication of <i>Blattella germanica</i> .....	7
10. Diet of <i>Blattella germanica</i> .....	7
11. Ecological role of <i>Blattella germanica</i> .....	8
12. Impact on human health.....	8
13. Control methods for <i>Blattella germanica</i> .....	8
<b>Chapter 2. Presentation of <i>Schinus molle</i> L.</b>	<b>9</b>
1. Classification of <i>Schinus molle</i> L.....	10
2. Origin and history of <i>Schinus molle</i> L.....	10
3. Zone and production of <i>Schinus molle</i> L.....	11
4. Botanical description of <i>Schinus molle</i> L.....	11
5. Phytochemical characteristics of <i>Schinus molle</i> L.....	12
6. Medicinal properties and biological activities of <i>Schinus molle</i> L.....	13
7. Essential oil of <i>Schinus molle</i> L.....	13

8. Antimicrobial activity.....	13
9. Insecticidal and repellent properties.....	14
10. Utilization of <i>Schinus molle</i> L.....	14
11. Toxicity of <i>Schinus molle</i> L.....	14
12. Mechanism of toxicity of <i>Schinus molle</i> L.....	15
13. Biological control and bio-insecticidal activity.....	15
<b>Chapter 3. Presentation of <i>Lantana camara</i> L.</b>	<b>16</b>
1. Origin and history of <i>Lantana camara</i> L.....	17
2. Zone and production of <i>Lantana camara</i> L.....	17
3. The species of <i>Lantana camara</i> L. in Algeria.....	17
4. Botanical description of plant <i>lantana camara</i> L.....	18
5. Phytochemical composition.....	19
6. Antimicrobial activity.....	19
7. Antioxidant activity.....	19
8. Physicochemical properties.....	20
9. Essential oil of plant <i>Lantana camara</i> L.....	20
10. Utilization of plant <i>Lantana camara</i> L.....	20
11. Toxicity of plant <i>Lantana camara</i> L.....	20
12. Biological control and bio-insecticidal activity.....	21
13. Insecticidal activities.....	21
14. Biological activities.....	21
<b>Chapter 4. Materials and Methods</b>	<b>22</b>
1. Animal material.....	22
2. Plant material.....	22
3. Collecting the arial part of <i>Schinus molle</i> L.....	22
4. Collecting the arial part of <i>Lantana camara</i> L. ....	23
5. Extraction of essential oil.....	23
6. Bioassay.....	24
7. Statistical analysis .....	24
<b>Chapter 5. Results</b>	<b>25</b>
1. Yield of <i>Schinus molle</i> L. essential oil .....	26
2. <i>Lantana camara</i> L. hydrosol.....	26
3. Effect of <i>Schinus molle</i> L. essential oils on <i>B. germanica</i> .....	26
3.1. Male mortality rate.....	26

3.2. Female mortality rate.....	26
4. Effect of <i>Lantana camara</i> L. hydrosol on <i>B. germanica</i> .....	27
4.1. Male mortality rate.....	27
4.2. Female mortality rate.....	28
<b>Discussion</b> .....	<b>30</b>
<b>Conclusion and perspective</b> .....	<b>32</b>
<b>References</b> .....	<b>33</b>

## *List of figures*

<b>Figure 1.</b> The spread of the German cockroach around the world .....	<b>4</b>
<b>Figure 2.</b> Life stages of <i>Blattella Germanica</i> .....	<b>6</b>
<b>Figure 3.</b> Ovarian morphological features and proteome of <i>Blattella germanica</i> .....	<b>7</b>
<b>Figure 4.</b> Current ecological niche modeling map for <i>Schinus molle</i> L. ....	<b>10</b>
<b>Figure 5.</b> The tree of <i>Schinus molle</i> L. ....	<b>11</b>
<b>Figure 6.</b> The different parts of the <i>Schinus molle</i> L. tree. ....	<b>12</b>
<b>Figure 7.</b> The phytochemical characteristics of <i>Schinus molle</i> L.....	<b>13</b>
<b>Figure 8.</b> <i>Lantana camara</i> L. native and introduced or naturalized regions.....	<b>17</b>
<b>Figure 9.</b> Flower of <i>Lantana camara</i> L.....	<b>18</b>
<b>Figure 10.</b> Fruits (black berries) of <i>Lantana camara</i> L. ....	<b>19</b>
<b>Figure 11.</b> Rearing of <i>Blattella germanica</i> .....	<b>22</b>
<b>Figure 12.</b> Aerial parts of <i>schinus molle</i> L. plant.....	<b>22</b>
<b>Figure 13.</b> Aerial parts of <i>Lantana camara</i> L. plant.....	<b>23</b>
<b>Figure 14.</b> Extraction equipment, Hydro steam distillation apparatus from the inside and the outside	<b>23</b>
<b>Figure 15.</b> Extraction equipment, separatory funnel.....	<b>24</b>
<b>Figure 16.</b> Mortality rate of adult male <i>B. germanica</i> exposed to <i>Schinus molle</i> L. essential oil .....	<b>26</b>
<b>Figure 17.</b> Mortality rate of adult female <i>B. germanica</i> exposed to <i>Schinus molle</i> L. essential oil ...	<b>27</b>
<b>Figure 18.</b> Mortality rate of adult Male <i>B. germanica</i> exposed to <i>Lantana camara</i> L. hydrosol ...	<b>28</b>
<b>Figure 19.</b> Mortality rate of adult female <i>B. germanica</i> exposed to <i>Lantana camara</i> L. hydrosol ...	<b>29</b>

# *General introduction*

## Introduction

Insects are diverse and fascinating creatures, whose adaptability, reproductive capacity, and small size contribute to rapid population growth. Some species can lay thousands of eggs daily (Walter *et al.*, 2016). Nevertheless, this proliferation of harmful insects poses significant global threats, impacting ecosystems, agriculture, and public health. The German cockroach is a significant global pest, known for its potential dangers to human health. This invasive species is prevalent in various countries and poses serious risks due to its ability to spread diseases and trigger allergies. German cockroaches are commonly found in warm, humid environments near food and water sources, thus making homes and businesses susceptible to infestations (Tang *et al.*, 2019).

These pests are vectors for diseases such as salmonellosis, dysentery, and gastroenteritis, because they carry harmful bacteria like *Salmonella* and *E. coli* on their bodies, which can lead to food poisoning and other illnesses. Additionally, cockroach fecal matter, shed skin, and saliva can cause allergic reactions, particularly affecting individuals with asthma (Menasria *et al.*, 2014).

The medical significance of German cockroaches lies in their potential to carry various pathogens, including bacteria, protozoa, helminths, fungi, and viruses, although direct transmission of infections is not always established (El-Sharabasy *et al.*, 2013).

The term pesticide encompasses various substances like insecticides, herbicides, fungicides, and rodenticides designed to eliminate specific pests. Pesticides can be categorized based on their origin as chemical pesticides or biopesticides (Tang *et al.*, 2019). Biopesticides are highly specific, targeting only the intended pests and closely related species, while chemical pesticides have a broad spectrum, affecting many non-target organisms. Biopesticides are considered environmentally friendly due to their lower toxicity, ease of decomposition, and the small quantities needed. On the other hand, chemical pesticides are often toxic, non-biodegradable, and cause environmental pollution. Moreover, biopesticides are less likely to induce genetic resistance in pests, which is a common issue with chemical pesticides (El-Sharabasy *et al.*, 2014).

Plants are essential to biological diversity and play a crucial role in human well-being. Since antiquity, great civilizations have used medicinal plants for their therapeutic, cosmetic, chemical, dietary, agri-food, industrial, and pharmaceutical properties. Today, interest in herbal medicine is growing, which is supported by scientific studies using innovative analytical methods and experimentation. This research allows the medical field to better understand and validate the benefits of traditional plant-based treatments (Walter *et al.*, 2016). In fact, these plants constitute invaluable resources for producing pesticides and pharmaceuticals, while many of them are known for their great metabolic potential as so-called secondary substances. These compounds

are extracted from various parts of the plant (roots, stems, leaves, etc.), regardless of the parts and forms in which they are found (Godlewska *et al.*, 2021).

This has intensified interest in identifying new classes of insecticides, especially those derived from plants, due to their minimal secondary effects (Pathak *et al.*, 2022). In the face of this problem, many studies have been conducted to develop effective alternative molecules against widespread harmful insects. Medicinal and aromatic plants constitute an important source of bioactive molecules that can be exploited as natural biological insecticides. Many studies have shed light on the various biological activities of aromatic and medicinal plants, specifically their antifungal, antibacterial, antioxidant, and insecticidal capabilities (Abubakar *et al.*, 2020).

Essential oils are often used in traditional folk medicine. In nature, environmental organizations play an important role in protecting plants because they contain a large variety of secondary metabolites capable of inhibiting reproduction or eliminating the distribution of insects. Currently, the phenomenon of insect resistance is widespread among many species of insects. Therefore, the importance of directing research towards discovering new pathways is a source of inspiration for new plant medicines (Tang *et al.*, 2019).

In this regard, *Schinus molle* L., commonly known as the Peruvian pepper tree, is an evergreen tree native to South America. It is prized for its attractive appearance, feathery leaves, and small, pinkish-red berries, which resemble peppercorns. *Schinus molle* L. has long been used in traditional medicine for its antibacterial, antifungal, and anti-inflammatory properties. The tree's essential oils and extracts have also been studied for their potential as natural insecticides, making it a valuable resource in integrated pest management. Due to its adaptability, *Schinus molle* L. thrives in a variety of climates and is often used in landscaping and erosion control, though it can be invasive in some regions (Hosni *et al.*, 2011; López *et al.*, 2014).

Similarly, *Lantana camara* L. is a hardy, flowering shrub native to tropical and subtropical regions. Known for its colorful clusters of flowers that change shades as they mature, it is often used in ornamental gardening. Despite its beauty, *Lantana camara* L. is considered invasive in many parts of the world, spreading aggressively and outcompeting native plants. It is toxic to livestock and humans if ingested, yet it has some medicinal uses in traditional medicine, particularly for treating wounds and infections. Additionally, *Lantana camara's* essential oils are studied for their potential insecticidal properties, making it a candidate for natural pest control solutions (Lonare *et al.*, 2012; Rajashekar *et al.*, 2014).

Numerous studies worldwide have focused on the valorization of natural substances and therefore bioactive molecules with biological activities in order to establish scientific bases for their use (Walter *et al.*, 2016). Within this study, the main goal of our work is to evaluate the insecticidal activity of *Schinus molle* L. and *Lantana camara* L. against *Blattella germanica*,

More specifically, we investigate their efficacy against male and female *Blattella germanica*, a pervasive household pest with a notorious reputation for its resilience and adaptability.

This dissertation is structured into three main chapters, beginning with an overview of *Blattella germanica*, followed by focused sections on *Schinus molle* L. and *Lantana camara* L. The methodology used to achieve the study's goals is then described, followed by the results and discussion. The dissertation ends with a summary of the main findings and suggestions for future research.

# *Bibliographic Part*

# CHAPTER 01

*Blattella germanica*

## 1. History

The German cockroach, characterized by its tiny size and dark-brown color, is an extensively prevalent and problematic insect within human dwellings, often referred to as the "croton bug." It is the most frequent and widely distributed cockroach species in urban settings, believed to originate from Southeast Asian regions before being introduced to Europe during or prior to the 18th century. Subsequent global dissemination occurred due to advancements in transportation technology, particularly via trade colonies, and the advent of indoor heating systems in colder climates (Jacobs, 2023). Upon arrival at novel locations, this species quickly expanded locally, supplanting native urban cockroach populations. German cockroaches exclusively thrive alongside humans; they inhabit residences, eateries, vessels (ships), railways, airplanes, medical facilities, and various contemporary interior spaces. This species reproduces profusely, generating three to six generations annually, posing risks for food contamination owing to their potential transmission of pathogens. Successful management strategies include sanitation measures, removal of food sources, shelter reduction, and ongoing surveillance (Tang *et al.*, 2019).

## 2. Origin and geographic distribution

The German cockroach, *Blattella germanica*, likely originated in Southeast Asia and has spread globally through human activities like trade and travel. It thrives in warmer climates and diverse habitats, except for extremely cold regions and altitudes above 2,000 meters. Their success is due to their adaptability to human environments, making them an obligate commensal species commonly found in urban areas and industrialized societies (Jacobs, 2023).



**Figure 1.** The spread of the German cockroach around the world (Jkan, 2019)

### **3. German cockroach species in Algeria**

According to the results of the study by Hedjouli *et al.* (2021) in Algeria, researchers have identified eight species of cockroaches belonging to the subfamily Ectobiinae. These species are:

- *Loboptera decipiens*
- *Loboptera ovobata*
- *Ectobius kervillei*
- *Ectobius sp.*
- *Dziriblatia stenoptera*
- *Dziriblatia nigriventris*
- *Dziriblatia sp.*
- *Phyllodromica zebra*

### **4. Taxonomy of *Blattella germanica***

According to the study of Beccaloni (2019) the German cockroach belongs to the following taxonomic hierarchy:

- Kingdom: Animalia
- Phylum: Arthropoda
- Class: Insecta
- Order: Blattodea
- Family: Ectobiidae
- Genus: *Blattella*
- Species: *Blattella germanica*

### **5. Description of *Blattella germanica***

The German cockroach, is a diminutive cockroach species ranging from 13 to 16 mm in length. This species is frequently encountered in human-inhabited areas like residences, eateries, vessels, trains, and medical facilities (Wang, 2020). It boasts a bronze hue with dual stripes adorning its thorax. The young of *Blattella germanica* exhibit a dark-brown to black coloration with dark parallel bands traversing the length of the pronotum. Notably, the female possesses a broader physique compared to the male, and both genders sport fully developed wings. Renowned for its remarkable agility, this species is swift in movement. The German cockroach is recognized for its swift proliferation and reliance on human proximity for survival. As an omnivorous creature, it consumes a variety of foods rich in starch, sugar, fat, and protein (Jacobs, 2023).

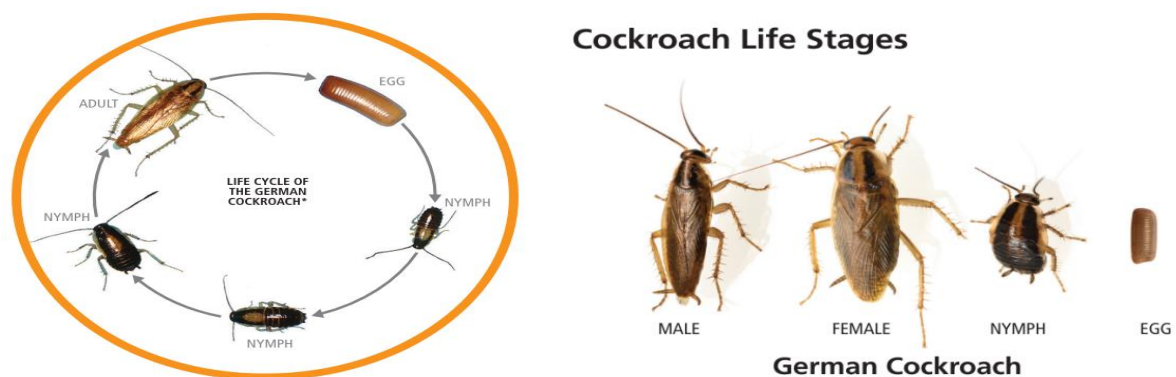
### **6. Biological cycle of *Blattella germanica***

The life cycle of the German cockroach, progresses through three primary phases: egg, nymph, and adult. Typically, this cycle spans around 100 days, but variables like temperature, diet, and injuries can impact its duration (Wang, 2020). Notably, the female German cockroach is highly fecund, with the ability to lay nearly 400 eggs in her lifetime. Remarkably, a solitary cockroach can potentially give rise to as many as 10,000 offspring throughout its existence (Valles, 2008). Nymphs are similar in appearance to adults, but smaller. As the nymph matures, it sheds its exoskeleton to grow. Freshly molted cockroaches are white, assuming their typical coloration within a few hours as their cuticle hardens (Tang *et al.* 2019).

Each nymphal stage is larger than the previous one and the adult emerges after the last nymphal stage (Beccaloni, 2019).

Nymphs hatch from egg cases known as oothecae and go through multiple molts before maturing into winged adult roaches, typically measuring around 15 mm in length. The German cockroach is notably recognized for its capacity to acquire resistance to insecticides (Wang, 2020).

The life cycle from egg to adult is dependent upon environmental conditions and the specific cockroach species. Each cockroach species has a unique number of immature stages (Valles, 2008).



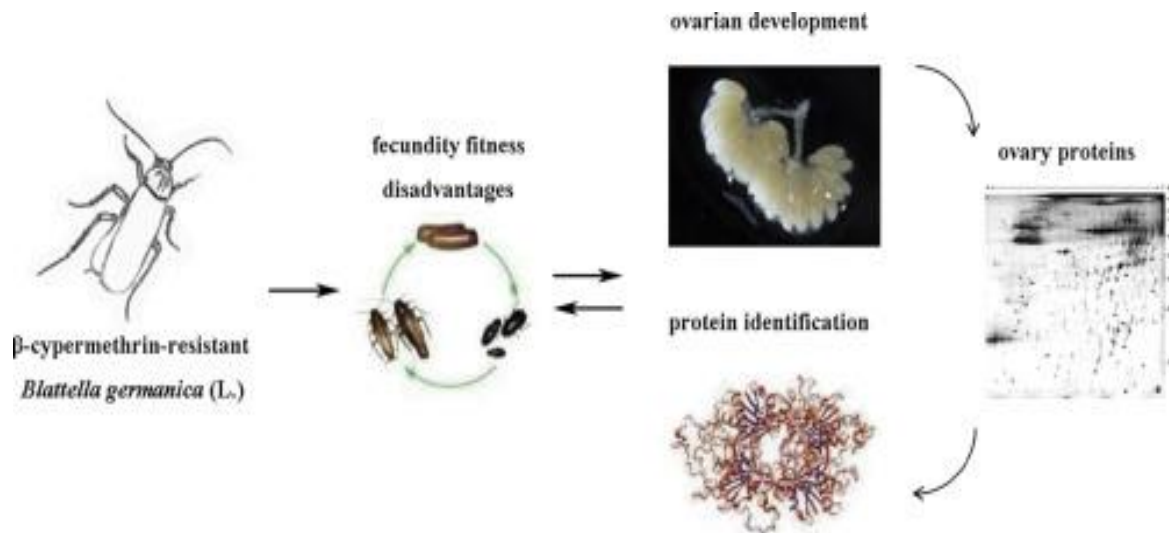
**Figure 2.** Life stages of *Blattella Germanica* (MGK, 2019)

### **7. Habitat of *Blattella germanica***

The German cockroach is a small cockroach species present in numerous countries globally. This species thrives in regions with a Mediterranean climate, typically between 30- and 40-degrees latitude. While they inhabit various environments like rainforests, scrub forests, taigas, chaparrals, forests, caves, and urban, suburban, and rural areas, German cockroaches heavily rely on human presence for survival (Beccaloni, 2019). They are frequently sighted in places such as homes, restaurants, hotels, and hospitals. Preferring warm and humid conditions, these cockroaches are exclusively terrestrial. Notably, cold temperatures significantly restrict their habitat range (Jacobs, 2023; Valles, 2008).

## 8. Reproduction of *Blattella germanica*

The German cockroach is known for its rapid reproduction. Female German cockroaches produce oothecae, which are protective cases for their eggs. Each ootheca contains around 30-40 eggs and the female carries it until the eggs are ready to hatch (Brenner, 2019). German cockroaches breed continuously, with a short breeding interval, and the development from egg to adult can take about 100 days. They are prolific breeders, with a single female and her offspring capable of producing over 30,000 individuals in a year (Wang, 2020).



**Figure 3.** Ovarian morphological features and proteome of *Blattella germanica* (Cai *et al.*, 2020).

## 9. Communication of *Blattella germanica*

German cockroaches use their head ganglia to visually perceive their environment. They can also use their subesophageal ganglia to detect pheromones and other chemical signals to communicate with each other. Mating, intake of high-quality food, social interactions, and the presence of vitellogenic ovaries facilitate juvenile hormone synthesis, which is important for reproduction (Schal, 1997).

## 10. Diet of *Blattella germanica*

The German cockroach has a varied diet, but it shows a preference for starchy and sugary foods as well as protein-rich sources. Research has shown that 72-hour starved cockroaches were given choices among eight food items, including carbohydrate-rich foods like bread, biscuit, banana, and potato, and protein-rich sources (El-Sharabasy *et al.*, 2014).

Additionally, studies have demonstrated that the German cockroach is able to convert protein into body lipid, indicating its adaptability to different food sources (Sieksmeyer, 2022).

This aligns with the fact that German cockroaches are commonly found in human habitats such as homes, restaurants, and hospitals, where they can access a variety of food sources (El-Sharabasy *et al.*, 2014).

### **11. Ecological role of *Blattella germanica***

The German cockroach, is a widespread urban pest found globally. These creatures play a role in nutrient recycling and serve as hosts to parasitic organisms such as bacteria, protozoans, and viruses (Pan, 2020). While they may be beneficial in certain ecological contexts, their presence does not provide any clear benefits to humans economically. In fact, they feed on a variety of items, including leftover food, animal feed, and even books, which could potentially pose hygiene risks. Overall, the German cockroach presents no positive impacts on human society (Menasria *et al.*, 2014).

### **12. Impact on human health**

The German cockroach, is an important factor affecting human health due to its ability to produce allergens that cause respiratory issues like asthma and rhinitis. Furthermore, this species serves as a carrier for several human enteric pathogens, including Salmonella, Enterococcus, and Escherichia coli, while also hosting numerous other types of bacteria, including those resistant to antibiotics. As a result, the presence of *Blattella germanica* in human environments can directly lead to food contamination and allergic reactions, presenting a major threat to public health. (Menasria *et al.*, 2014).

### **13. Control methods for *Blattella germanica***

Various techniques exist to manage The German cockroach. Some of these approaches involve employing chemicals such as poisonous baits and pesticides, while others utilize biology-based strategies like utilizing *Bacillus thuringiensis*. Additionally, genetic control measures have been investigated, which includes implementing dominant lethal mutations and conditionally lethal elements, also research has explored the manipulation of its gut microbiota (Pan *et al.*, 2020).

The exploration of gut microbial dynamics and symbiotic interactions in *Blattella germanica* can involve either the utilization of the antibiotic rifampicin or entomopathogenic fungi to target its gut microbiota. Furthermore, there is a proposal to use symbiotic microorganisms for the biological control of *Blattella germanica*, indicating a promising avenue. (Cai *et al.*, 2020) Research indicates that manipulating the gut microbiota of *Blattella germanica*, possibly by targeting particular bacteria, could be an effective strategy for its management (Chang, 2010).

With the increasing prevalence of insecticide resistance in cockroaches, biocontrol strategies have emerged as a more effective approach to managing these pests. We therefore concentrate our efforts on various methods such as using entomopathogenic bacteria, fungi, viruses, natural predators, parasitoids, and plant extracts. Additionally, recent advancements like genetic

modification and microinjection techniques offer novel insights into controlling German cockroaches through the use of Wolbachia, paratransgenesis, and RNA interference (RNAi). (Pan *et al.*, 2020).

# CHAPTER 02

## *Schinus molle*

### 1. Classification of *Schinus molle*

The *Schinus molle* L., commonly known as the Peruvian peppertree, is classified as follows (Council, 2006).

Kingdom: Plantae

Class: Magnoliopsida

Order: Sapindales

Family: Anacardiaceae

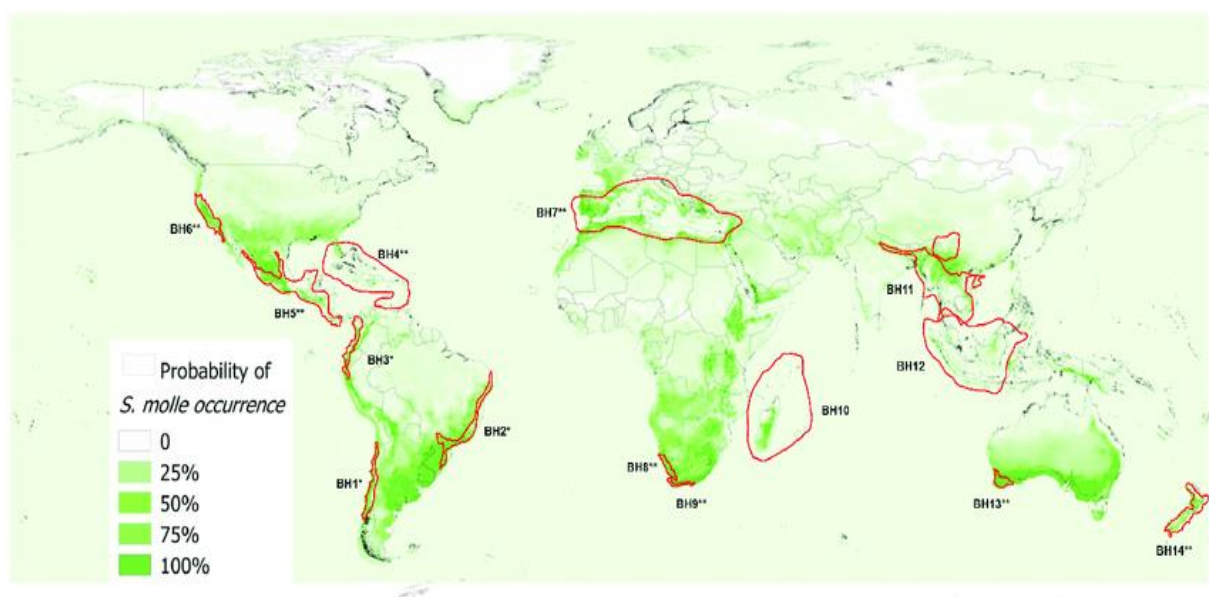
Genus: *Schinus*

Species: *Schinus molle* L.

This classification places it within the Anacardiaceae family, which is known for other notable plants like mangoes and cashews. The *Schinus molle* L. is particularly recognized for its aromatic leaves and pink peppercorn-like drupes.

### 2. Origin and history of *Schinus molle* L.

*Schinus molle* L., or Peruvian pepper, is native to northern South America. Brought to Central and South America by the Spaniards, it now grows throughout the New World, including Australia, New Zealand, South Africa, northern Argentina, Chile, and the Mediterranean (Ramírez Albores *et al.*, 2021). *Schinus molle* L., a feral crop native to the Andes, thrives in arid regions of Peru and has spread globally, especially to hot, tropical areas. Its early introduction to places like Chile and California makes tracing its secondary spread challenging (Razzak *et al.*, 2023). Some nations, most notably the United States (California, Hawaii), South Africa, and Australia, view it as invasive. It is grown as an ornamental for its graceful leaf along the Mediterranean coast and in other southern regions of France (Walter *et al.*, 2016).



**Figure 4.** Current ecological niche modeling map for *Schinus molle* L. (Lemos *et al.*, 2019)

### 3. Zone and production of *Schinus molle* L.

#### a) Around the world

The *Schinus molle* L., commonly called the False Pepper tree, is indigenous to Argentina, Bolivia, and Peru. It has been brought to many other countries, including the United States of America, Australia, Brazil, India, and Mexico (Orwa *et al.*, 2009).

In terms of production, this plant is cultivated for a variety of functions, including apiculture, fuel production, lumber, and aesthetic appeal. Although *Schinus molle* L. berries are not often eaten, they are pulverized and added to drinks in Mexico, and the seeds are occasionally used to fake pepper (Kasimala, 2012). Furthermore, *Schinus molle* L. wood can be utilized to make charcoal and firewood. This plant is also a good source of feed for bees (Hassaine, 2017).

#### b) In Algeria

In Algeria *Schinus molle* L. is a nationally used urban greening tree, where the plant *Schinus molle* L. is climatically tolerant, albeit it is most common along the Mediterranean shore (Rouibi *et al.*, 2010).



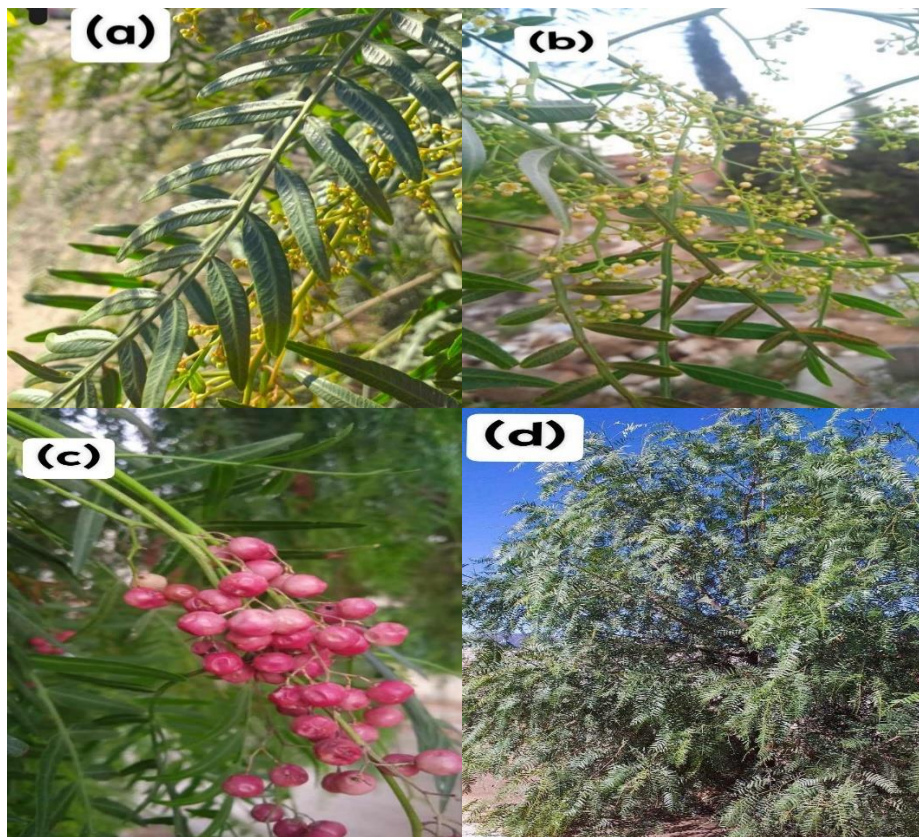
**Figure 5.** The tree of *Schinus molle* L. (Original photo - Khenchela, 2024)

### 4. Botanical description of *Schinus molle* L.

*Schinus molle* L. is an evergreen tree with weeping foliage, 3-15 m in height; trunk short; crown with equal spread; bark dark brown, deeply fissured, flaking; very sticky latex forms if the bark is damaged (Orwa *et al.*, 2009). *Schinus molle* L. has evergreen, pepper-scented leaves with 20-40 narrow, lanceolate leaflets. The leaflets are 2-5 cm long and 4-8 mm wide, with entire or dentate margins, and continuously regenerate (Kasimala, 2012). *Schinus molle* L. has small, yellowish-white flowers in hanging panicles up to 30 cm long. Female flowers produce pink berries, while male flowers yield few (Hassaine, 2017). The fruits are small, round berries that

develop from green to red then black, most of the time, fruits that are red, globular, and almost dry, having the size and flavor of a peppercorn, are drupes (Walter *et al.*, 2016).

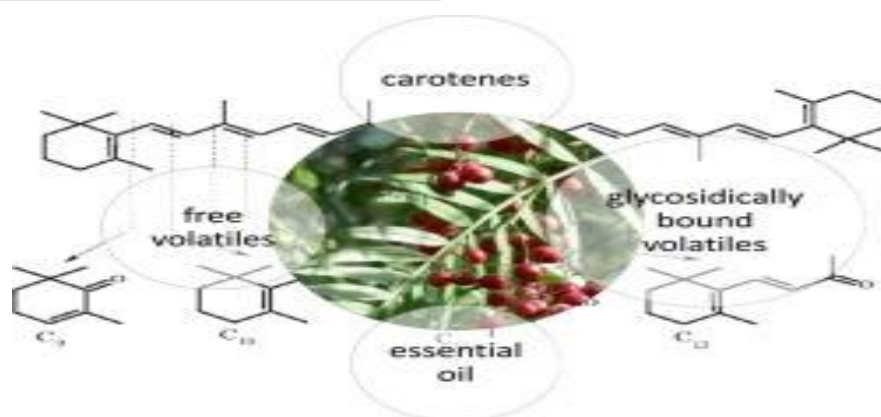
The seeds: The seeds are ripe when the fruits have turned red, 2 to 4 mm in diameter, round, brown-black, furrowed when dry. There are 30,000 to 40,000 seeds per kg; the fruits are harvested directly from the tree (Jøker *et al.*, 2002).



**Figure 6.** The different parts of the *Schinus molle* L. tree. A: leaves, B: flowers, C: fruit, D: The tree (Original photo- Khenchela, 2024).

### 5. Phytochemical characteristics of *Schinus molle* L.

*Schinus molle* L. is a plant species from the Anacardiaceae family. It is renowned for a variety of therapeutic qualities, including antioxidant, antibacterial, and cytotoxic actions. The herb has been used in traditional medicine to cure a variety of ailments (Eryigit *et al.*, 2017). GC-MS analysis of *Schinus molle* L. extracts identified monoterpene hydrocarbons like  $\alpha$ -phellandrene,  $\beta$ -phellandrene,  $\beta$ -myrcene, limonene, and  $\alpha$ -pinene, which contribute to the plant's antioxidant and antibacterial properties. Toxicity tests in rats showed no significant side effects (Shehata *et al.*, 2024).



**Figure 7.** The phytochemical characteristics of *Schinus molle* L.

### **6. Medicinal properties and biological activities of *Schinus molle* L.**

*Schinus molle* L. has been used for centuries in medicine for its analgesic, antifungal, antitumor, antispasmodic, diuretic, and antiseptic properties, and to treat hypertension, wounds, infections, and asthma. Studies have confirmed its sedative, anti-inflammatory, antibacterial (effective against *Staphylococcus aureus* and *Streptococcus pyogenes*), repellent, and insecticidal effects (Lemos *et al.*, 2019). This plant's essential oil has also been shown to exhibit biological activity such as antibacterial, antifungal, and cytotoxic properties. Furthermore, volatile oil is employed as an adjuvant in a variety of food product applications due to its antibacterial and antioxidant qualities, as well as an antiparasitic in livestock and beekeeping (Machado *et al.*, 2019).

### **7. Essential oil of *Schinus molle* L.**

The essential oil of *Schinus molle* L. has been widely examined for its numerous biological qualities, including potential antibacterial, insecticidal, and repellent capabilities, making it a potential source of bioactive chemicals for a variety of uses (Do Prado *et al.*, 2019). The essential oil from the leaves of *Schinus molle* L. has been shown to exhibit cytotoxic effects through a mechanism related to apoptosis (programmed cell death) in various cell types, including breast carcinoma, leukemic cells, and fibroblasts (Duarte *et al.*, 2018). The essential oil was cytotoxic in several cell lines, with breast carcinoma and leukemic cell lines being the most sensitive. The LD50 (lethal dose for 50% of cells) for cytotoxicity at 48 hours (Diaz *et al.*, 2008). Cytotoxicity could be related to the presence of certain compounds in the essential oil, such as  $\alpha$ -pinene, which is the major compound. However, other compounds may also contribute to this effect (Duarte *et al.*, 2018).

### **8. Antimicrobial activity**

The essential oil has been proven to have substantial antifungal action against *Paracoccidioides brasiliensis*, a fungus that causes the deadly respiratory ailment *paracoccidioidomycosis* (Diaz *et al.*, 2008). It also displayed mild antifungal activity against *Cryptococcus neoformans* and *Trichophyton quinckeanum*, but was inert against varieties of *Candida* (Do Prado *et al.*, 2019).

---

The essential oil has strong antibacterial action against *Staphylococcus aureus* and *Escherichia coli* bacteria (Tajeddine *et al.*, 2021).

### **9. Insecticidal and repellent properties**

The essential oil effectively combats the potato/tomato psyllid *Bactericera cockerelli* and the maize weevil *Sitophilus zeamais* (Tajeddine *et al.*, 2021). It has a significant repellent action against the maize weevil at doses greater than 100 ppm (Landro-Valenzuela *et al.*, 2022).

### **10. Utilization of *Schinus molle* L.**

*Schinus molle* L., or the California pepper tree, produces pink peppercorns that are dried and used as a spice. They add a peppery flavor and visual appeal to dishes. However, they should be used cautiously, as excessive consumption may lead to gastric issues (Tlili *et al.*, 2018). *Schinus molle* L. serves as a food source. The pink or red berries of the tree are marketed as "pink peppercorns" and are frequently combined with commercial black pepper. The fruit and leaves may be toxic to various animals, including fowl, pigs, and calves (Do Rosário *et al.*, 2014). Ornamental: Due to its elegant weeping form and attractive clusters of pink berries, *Schinus molle* L. is widely cultivated for ornamental purposes in gardens, especially in regions with a mild climate (Tlili *et al.*, 2018). *Schinus molle* L., or the California pepper tree, produces pink peppercorns that are dried and used as a spice. They add a peppery flavor and visual appeal to dishes. However, they should be used cautiously, as excessive consumption may lead to gastric issues (Do Rosário *et al.*, 2014).

*Schinus molle* L. used in the Andes for fuel and lumber, reinforces stone walls with its strong roots. Its wood, once used for saddles, and leaves, used for natural fabric dyes and Incan mummification, highlight its historical significance (Landro-Valenzuela *et al.*, 2022). In the Andes, *Schinus molle* L. fruits are used to brew chicha, a potent crimson beer, and vinegar. The tree's essential oil also has insecticidal properties, effective against pests like the potato psyllid and maize weevil, offering a natural pesticide alternative (López *et al.*, 2014). Overall, *Schinus molle* L. is a versatile tree that has been used by locals for food, medicine, and a variety of other purposes (Goldstein *et al.*, 2004). It is crucial to highlight that, while *Schinus molle* L. has these traditional uses, it should be treated with caution because it has the potential to induce allergic responses and other health problems if not utilized correctly (Mekuria *et al.*, 2021).

### **11. Toxicity of *Schinus molle* L.**

*Schinus molle* L., has toxic properties: its berries can cause vomiting and diarrhea, its flowers may lead to respiratory irritation, and it can irritate skin and eyes. However, it also has beneficial antimicrobial and antioxidant properties (Do Rosário *et al.*, 2014). Cytotoxicity: There is evidence of cytotoxic activities in *Schinus molle* L. extracts, which means they can be harmful to cells. This property is being studied for potential biomedical applications. It's important to

---

handle *Schinus molle* L. with care and to be aware of its potential adverse effects, especially if you have pets or children who might ingest the plant parts (Shehata *et al.*, 2024). *Schinus molle* L. has been studied for its toxicity and repellent effects against various organisms, including agricultural pests. Its extracts show varying levels of toxicity depending on concentration and the specific organism tested (Ferrero *et al.*, 2007).

### **12. Mechanism of toxicity of *Schinus molle* L.**

*Schinus molle* L. contains bioactive compounds that can be toxic if misused, despite its traditional medicinal use. Key compounds include bis(2-ethylhexyl) phthalate (59.11%) in seeds, linked to health risks, and squalene (16.87%), azulene (14.88%), and lupeol (12.4%) in leaves (Shehata *et al.*, 2024).

*Schinus molle* L. compounds have beneficial antimicrobial and antioxidant properties but also exhibit cytotoxicity. Extracts have shown strong antioxidant and antimicrobial effects but disrupt cell division and cause chromosomal abnormalities in *Allium cepa* root tips. In Peru, studies found *S. molle* extracts toxic to biological control agents of agricultural pests, with varying lethal and effective concentrations (Iannacone *et al.*, 2010). The toxicity of *Schinus molle* L. is linked to its bioactive compounds that can interfere with cellular processes and structures, leading to antimicrobial and antioxidant effects but also potential cytotoxicity and genotoxicity. It's important to use such extracts with caution and under proper guidance, especially in biomedical applications (Duarte *et al.*, 2018).

### **13. Biological control and bio-insecticidal activity**

*Schinus molle* L. shows potential as a bio-insecticide, with volatile oils from its leaves and stems proving highly toxic to bed bugs. Major components like  $\beta$ -pinene,  $\alpha$ -pinene, limonene, and muurolol contribute to its effectiveness, making it a promising natural insecticide with a spicy aromatic odor (Vicenco *et al.*, 2020). The essential oil (EO) from *S. molle* L. leaves exhibited insecticidal effects against several pests, including *Sitophilus zeamais* (maize weevil), *Triatoma infestans* (a kissing bug), *Stegomyia aegypti* (yellow fever mosquito), and *Tribolium castaneum* (red flour beetle) (Landro-Valenzuela *et al.*, 2022). *S. molle* L. EO caused 90% mortality in *T. castaneum* after 144 hours of exposure. It also showed larvicidal activity against *S. aegypti*, with 82% mortality of larvae after 72 hours at a concentration of 775.68  $\mu\text{g/mL}$  (Vicenco *et al.*, 2020). Microencapsulation of *Schinus molle* L. essential oil boosted its insecticidal potential and controlled release, effectively targeting greenhouse whiteflies. The leaf extracts were also insecticidal against *Gonipterus platensis* larvae, and the essential oil was toxic to potato/tomato psyllid nymphs. *S. molle* L. EO showed strong repellent activity against maize weevils (*S. zeamais*), with a selection index of 0.37 at 800 ppm (Landro-Valenzuela *et al.*, 2022). *Schinus*

---

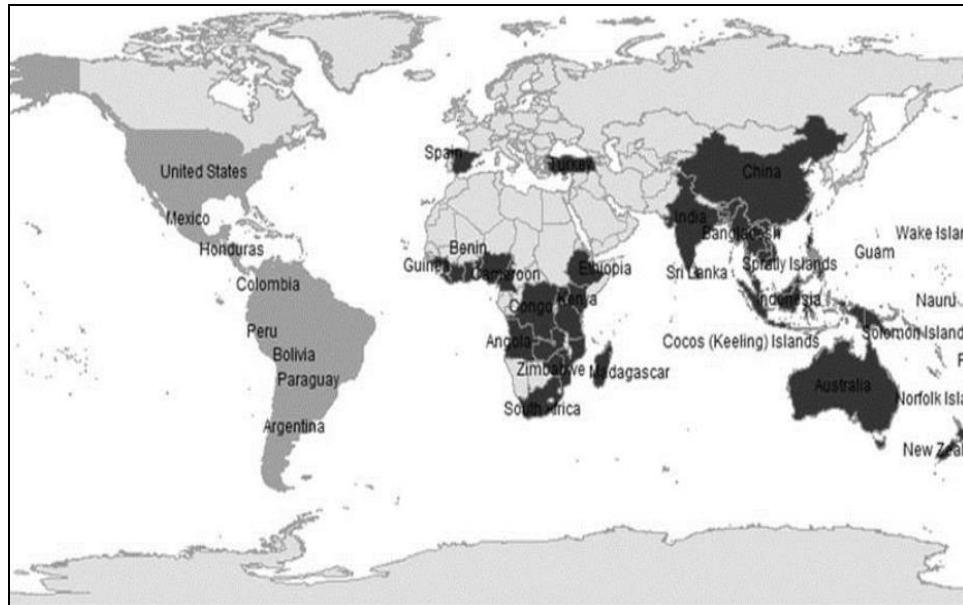
*molle* L. possesses significant bio-insecticidal properties and can be a promising alternative to synthetic insecticides for the control of various agricultural pests (Vicenzo *et al.*, 2020).

# CHAPTER 03

*Lantana camara*

### 1. Origin and history of *Lantana camara* L.

*Lantana camara* L., was likely imported into Europe around 1640 from Brazil (Howard, 1969), where both prickly and non-prickly taxa are regarded as natural, common, and ubiquitous (Schauer, 1851). *Lantana* became a popular hothouse plant in Europe in the late nineteenth century, with nurserymen adding 397 new varietal names to their catalogues between 1850 and 1900 (Howard, 1969).



**Figure 8.** *Lantana camara* L. native (light grey) and introduced or naturalized (dark grey) regions (Priyanka and Joshi, 2013)

### 2. Zone and production of *Lantana camara* L.

*Lantana camara* L., widely grown as an ornamental shrub, is an established weed across the tropics and subtropics, from the southern USA and Mediterranean to South Africa and northern New Zealand (Thaman, 1974). *Lantana* is widely distributed in Australia, from Ulladulla in New South Wales to Cape Melville in Queensland, with scattered infestations in the Northern Territory, Western Australia, South Australia, and on Lord Howe and Norfolk Islands. (Swarbrick, 1985), *Lantana* thrives in areas with over 1250 mm of rainfall, particularly in northern Queensland. It's less common with lower rainfall and may spread along river systems in northern Australia (Day, 2003).

### 3. The species of *Lantana camara* L. in Algeria

*Lantana camara* L. is a single species with diverse flower colors and forms, known for its adaptability across various ecosystems. In Algeria and other regions, it is considered invasive due to its rapid spread and ability to outcompete native plants (Zoubiri & Baaliouamer, 2012). *Lantana*, known for its invasive nature and biological activities, is considered a weed in many

regions, including Algeria. It commonly grows around houses and forms dense thickets, choking native vegetation (Day, 2003).

#### 4. Botanical description of plant *lantana camara* L.

*Lantana camara* L. is a perennial, erect, sprawling, or scandent shrub that typically grows to around 2 meters (6.5 feet) tall. It forms dense thickets in various environments. Under favorable conditions, it can even scramble up into trees and reach heights of up to 6 meters (20 feet). The shrub's taxonomic position is defined as belonging to the class of magnoliopsida, order lamiales, family verbenaceae and genus *Lantana* (GISIN, 2011). *Lantana camara* L. has square, prickly stems, a strong root system, rough aromatic leaves, and multi-colored flowers that change after pollination. Its poisonous berries attract birds and insects, and its seeds germinate quickly (Lonare *et al.*, 2012).

##### 4.1. Flowering

*Lantana camara* L. produces small, tubular flowers in clusters, with colors ranging from red, yellow, and white to pink and orange. The flowers have a "tutti frutti" scent with a peppery hint. After pollination, their color shifts, often from yellow to shades of orange, pink, or red. *Lantana* can flower year-round with sufficient moisture and light (Gujral & Vasudevan, 1983; Graaff, 1986), with flowering peaking during the wet summer months. In cooler or drier regions, flowering occurs only in the warmer or wetter months, due to frost or drought damage (Winder, 1980; Swarbrick, *et al.*, 1998).



**Figure 9.** Flower of *Lantana camara* L. (Original photo- Khenchela, 2024)

##### 4.2. Seeds and fruits

*Lantana* seeds need high light conditions for germination and early growth (Gentle & Duggin, 1997), the germination rate of *lantana* is low under both laboratory and field conditions, with estimates of 4–20% (Graaff, 1987). Low germination rates in *lantana* may result from seed dormancy, low viability, or meiotic instability. Removing the fleshy pulp increases germination from 10% to 46%, similar to seeds from bird feces. Seeds can germinate year-round with enough

soil moisture, especially after summer storms in northern Australia (Parsons & Cuthbertson 2001).



**Figure 10.** Fruits (black berries) of *Lantana camara* L. (Original photo- Khenchela 2024)

### **5. Phytochemical composition**

According to Ghisalberti (2000) *Lantana camara* L. has been traditionally used for medicinal purposes and is rich in diverse phytochemicals. Analysis reveals the presence of secondary metabolites such as flavonoids, alkaloids, tannins, saponins, and triterpenoids, along with phenolics, anthocyanins, and proanthocyanidins in its leaves, contributing to its antibacterial properties. Additionally, GC-MS analysis identified 66 bioactive compounds with anti-inflammatory, antiandrogenic, anti-tumor, and antimicrobial activities.

### **6. Antimicrobial activity**

*Lantana camara* L. exhibits significant antimicrobial activity, attributed to its diverse chemical compounds such as flavonoids, alkaloids, terpenoids, and essential oils. Studies have shown that extracts from its leaves, flowers, and roots are effective against a range of pathogens, including bacteria, fungi, and viruses (Sharma & Sharma, 2000). The plant's antimicrobial properties are particularly noted against bacteria like *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Bacillus subtilis*, as well as fungi like *Candida albicans* and *Aspergillus Niger*. The essential oils in *Lantana camara* L. have been found to disrupt microbial cell membranes, inhibiting their growth and spread. This makes *Lantana camara* L. a potential natural alternative for antimicrobial treatments (Siddiqui *et al.*, 1995).

### **7. Antioxidant activity**

The plant extracts of *Lantana camara* L. exhibit significant antioxidant activity due to their diverse phytochemical content. These extracts demonstrate high antioxidant and free radical scavenging abilities, contributing to their effectiveness. They are rich in total phenols, flavonoids, and alkaloids, which enhance their antioxidant potential. Additionally, the extracts

---

show notable hydrogen peroxide radical scavenging activity, further supporting their role in combating oxidative stress (Sharma & Sharma, 1989).

### **8. Physicochemical properties**

*Lantana camara* L. extracts (petroleum ether, ethanolic, and aqueous) contain alkaloids, cardiac glycosides, and saponins. The leaf ethanolic extract has a particle size of 541.7 nm to 4265.8 nm, a zeta potential of -14 mV, and a pH of 6. FTIR spectra reveal terpenoids, saponins, steroids, and alkaloids (Kalita, 2011). The extract contains triterpenoids, saponins, steroids, and alkaloids, and shows significant antioxidant activity with strong reducing power and hydrogen peroxide radical scavenging (Anon, 1962; Ghisalberti, 2000). The extract demonstrated significant antimicrobial activity against bacteria (e.g., *Staphylococcus aureus*, *Pseudomonas aeruginosa*) and fungi (e.g., *Aspergillus fumigatus*). It also showed notable insecticidal activity against *Crocidolomia pavonana* larvae, with LC50 values of 1.88% at 24 hours, 1.21% at 48 hours, and 0.99% at 72 hours (Sharma & Sharma, 1989).

### **9. Essential oil of plant *Lantana camara* L.**

The essential oil contained in *lantana* have been investigated for use as a perfumery ingredient. Yields vary significantly among plants from different regions (Sharma & Sharma, 1989) and commercialisation may be difficult because the raw material cannot be dried or stored without losing much of its oil (Morton, 1994). *Lantana* oil is sometimes used for the treatment of skin itches, as an antiseptic for wounds (Anon, 1962), and externally for leprosy and scabies (Ghisalberti, 2000). Plant extracts are used in folk medicine for the treatment of cancers, chicken pox, measles, asthma, ulcers, swellings, eczema, tumors, high blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism, malaria and atoxy of abdominal viscera (Anon, 1962; Ghisalberti, 2000).

### **10. Utilization of plant *Lantana camara* L.**

*Lantana* was originally introduced to most countries as a garden ornamental, and it is still popularly grown. In some countries, it is planted as a hedge to contain or keep out livestock (Bradley, 1988; Ghisalberti, 2000). The use of *lantana* extracts as potential biocides has been suggested. For example, aqueous leachate at 1–3% can kill water hyacinth, a troublesome weed in many tropical countries (Saxena, 2000). Its application as a weedicide would depend on the size of the waterbodies being treated and the cost of extraction of the leachate. The active constituents have not yet been characterized (Sharma & Sharma, 1989).

### **11. Toxicity of plant *Lantana camara* L.**

In Queensland, *Lantana* is responsible for the deaths of 1000-1500 cattle every year and is recognized as one of the most dangerous toxic plants in agricultural regions (Harley, 1973). According to Wells and Stirton (1988).

---

**12. Biological control and bio-insecticidal activity**

The biological control and bio-insecticidal activity of *Lantana camara* L. have been extensively studied for their potential as a natural and environmentally friendly method for managing storage pests (IJSRP, 2013).

**13. Insecticidal activity**

Fumigant toxicity: The essential oil of *L. camara* L. has been found to exhibit significant fumigant toxicity against *Tribolium castaneum*, *Lasioderma serricorne*, and *Callosobruchus chinensis*, with LC50 values of 16.70 mg/L air, 4.141 mg/L air, and 6.245 mg/L air, respectively, at 24 hours (Aisha *et al.*, 2024).

**14. Biological activities**

Antioxidant activity: The extract has been found to exhibit significant antioxidant activity, which is attributed to the presence of various phytochemicals.

Antimicrobial activity: The extract has been found to exhibit significant antimicrobial activity against various bacterial and fungal strains, including *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Bacillus subtilis*, *Aspergillus fumigatus*, and *Aspergillus flavus* (Ndezo *et al.*, 2022).

*Lantana camara's* essential oil shows strong bio-insecticidal properties, including fumigant toxicity, contact toxicity, and repellency against storage pests. Its phytochemicals like terpenoids and alkaloids contribute to these effects, making *L. camara* a promising natural biopesticide (Parsons & Cuthbertson, 2001).

# *Practical Part*

# **CHAPTER 04**

## ***Materials and Methods***

---

## Materials and Methods

### 1. Animal material

Cockroaches were collected from various locations near the city of Khenchela, including clinics, hospitals, university residences, and residential buildings. The collection was carried out manually. The cockroaches were then reared in transparent, ventilated plastic containers (20 cm long by 9 cm high) without exposure to insecticides for six months. Each container was equipped with paper egg cartons for shelter. The cockroaches were fed dog kibble and provided water via cotton soaked in a plastic test tube filled with water. The rearing took place under ambient temperature conditions with a 12-hour photoperiod at the University Abbes Laghrour of Khenchela- Algeria.



**Figure 11.** Rearing of *Blattella germanica* (Original photo, 2024)

### 2. Plant material

#### 3. Collecting the arial part of *Schinus molle*

On January 12, 2024, the arial part of *Schinus molle* L. plant was collected while it was green and fresh from the region of Kais, in Khenchela – Algeria (Fig 14). The plant was arranged in a dry and shaded area and dried for a period of up to 15 days.



**Figure 12.** Aerial parts of *schinus molle* L. plant (Original photo, 2024)

#### 4. Collecting the arial part of *Lantana camara* L. plant

On January 18, 2024, fresh *Lantana camara* L. specimens were collected from the Al-Hamma region in Khenchela, Algeria. The plant material was then air-dried in a shaded, well-ventilated area for up to 15 days.



**Figure 13.** Flower of *Lantana camara* L. (Original photo- Khenchela, 2024)

#### 5. Extraction of essential oil

Essential oil was obtained by steam distilling 3000 g of dried plant material for 3 hours using a Hydro Steam Distillation Apparatus (Fig 16). After extraction, the distilled water and oil were separated with a separating funnel. The oils were then stored in sealed glass vials at 4-5°C until bioassay testing (Fig 17). The extraction yield was calculated based on the dry weight of each sample.



**Figure 14.** Extraction equipment, Hydro steam distillation apparatus from the inside and the outside (Original photo, 2024)



**Figure 15.** Extraction equipment, separatory funnel (Original photo, 2024)

## 6. Bioassay

Different concentrations were prepared to evaluate adult insect mortality following an initial dose-finding experiment. The bioassay involved three increasing concentrations of essential oil—25%, 50%, and 100%—dissolved in dimethylsulfoxide (DMSO) for both plant types. A volume of 0.1 ml of each concentration was applied to a small cotton ball, which was then placed in Petri dishes. Control insects were maintained under the same conditions without exposure to essential oils. Each concentration was tested in triplicate, with 10 insects in each replicate. The number of live insects was recorded daily for each essential oil until the end of the exposure period.

## 7. Statistical analysis

### 7.1. Calculating plant yield post-extraction

To determine the essential oil yield, the process begins by weighing the raw plant material used for extraction (in grams). The extraction is then performed, and the resulting essential oil is collected and weighed. The yield is expressed as the weight of the extracted oil relative to the initial plant material.

Finally, the yield is determined by applying the following formula to calculate the percentage:

$$\text{Yield (\%)} = [\text{Weight of extracted essential oil} / \text{Weight of raw plant material used}] \times 100$$

### 7.2. Calculation of corrected mortality

Statistical analyses were performed using XLSTAT software. To account for natural mortality, the observed mortality percentages were adjusted using Abbott's formula (1925). The formula used to calculate the corrected mortality is as follows:

$$\text{Corrected Mortality (\%)} = [\text{Number of survivors in the control group} - \text{Number of survivors in the treated group} / \text{Number of survivors in the control group}] * 100$$

---

The normalized data are subjected to one-way analysis of variance (ANOVA), followed by dose ranking using the Tukey test.

# CHAPTER 05

## *Results*

## Results

### 1. Yield of *Schinus molle* L. essential oil

The essential oil was extracted from the aerial parts of *Schinus molle* L. using a Hydro Steam Distillation Apparatus. The process produced a clear, transparent oil with a strong, fresh aroma. A total of 20 ml of essential oil was collected, achieving a 0.4% yield.

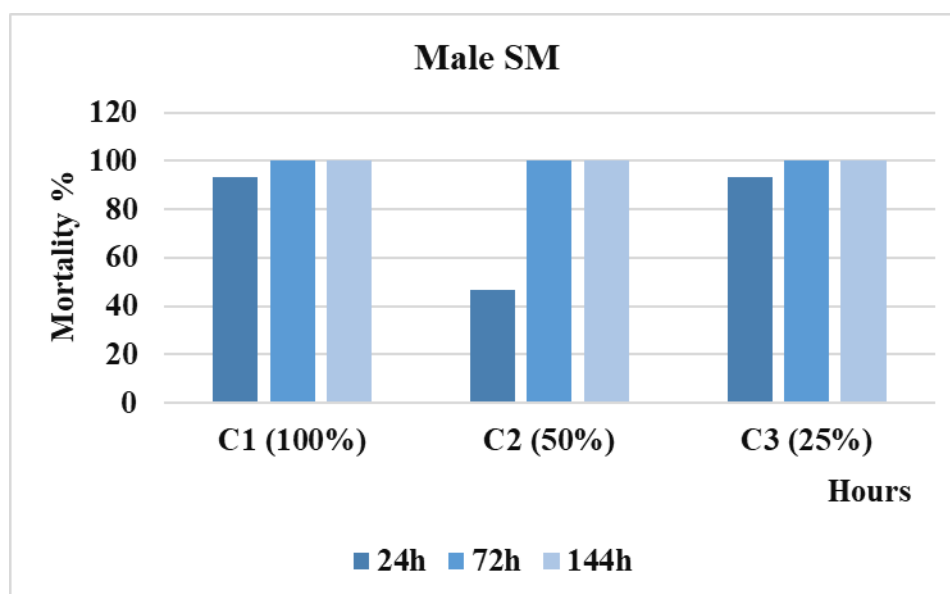
### 2. *Lantana camara* L. hydrosol

The hydrosol was extracted from the aerial parts of *Lantana camara* L. using a Hydro Steam Distillation Apparatus. The process produced a hydrosol with a pleasant, fresh scent. A total of 2000 ml was collected.

### 3. Effect of *Schinus molle* L. essential oil on *Blattella germanica*

#### 3.1. Male mortality rate

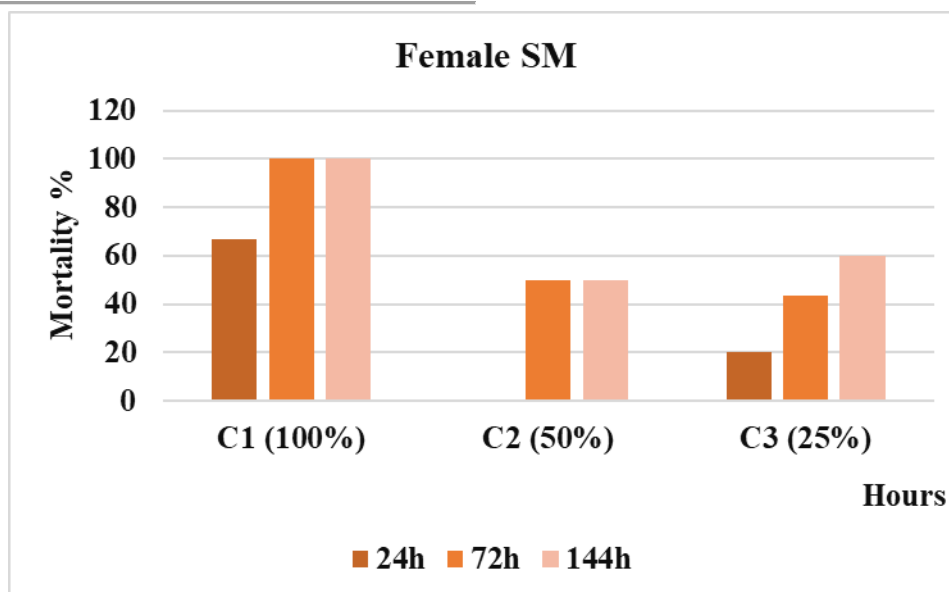
The mortality rates of male cockroaches exposed to C1, C2, and C3 concentrations of *Schinus molle* L. essential oil demonstrated a notable increase. The data illustrated that after three days of treatment, all three concentrations resulted in a 100% mortality rate (see Fig. 16).



**Figure 16.** Mortality rate of adult male *Blattella germanica* exposed to *Schinus molle* L. essential oil (SM: *Schinus molle*)

#### 3.2. Female mortality rate

The findings show that at concentrations C2 and C3, only partial mortality was achieved after six days of treatment, approximately 50% for C2 and 60% for C3 (Fig. 17). In contrast, concentration C1 caused complete mortality within three days. This was observed throughout the exposure of female cockroaches to various concentrations of *Schinus molle* L. essential oil.

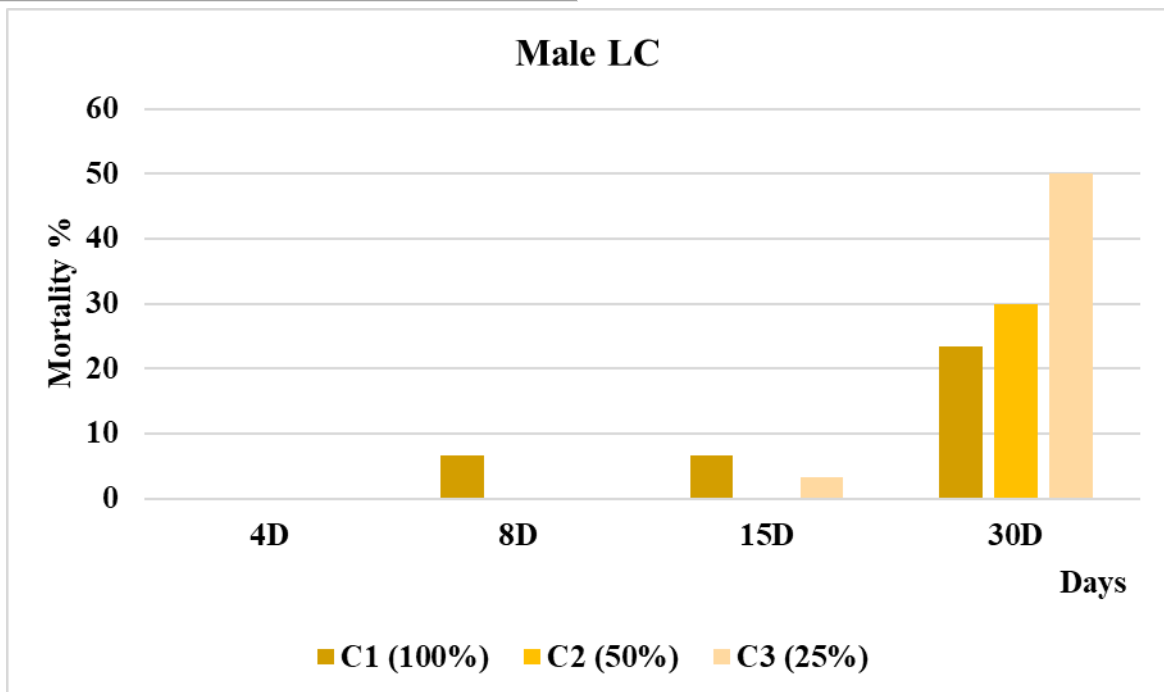


**Figure 17.** Mortality rate of adult female *Blattella germanica* exposed to *Schinus molle* L. essential oil. (SM: *Schinus molle*)

#### 4. Effect of *Lantana camara* L. hydrosol on *Blattella germanica*

##### 4.1. Male mortality rate

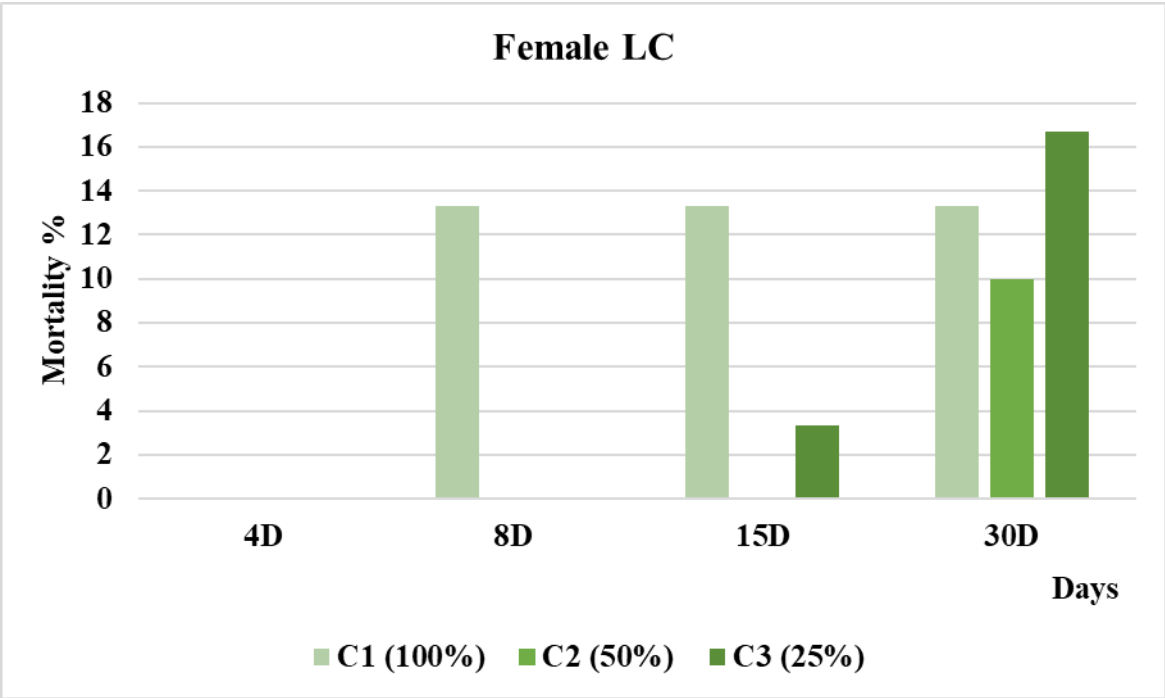
During the exposure period of male cockroaches to various concentrations (C1, C2, and C3) of *Lantana camara* L. hydrosol, no major increase in mortality rate was observed. According to the data (Fig. 18), mortality rates increased to 3% within 15 days for C3 concentration, reaching 50% by the 30 days of the treatment period. Similarly, mortality rates achieved 5% within 15 days for the concentration of C1, reaching 25% by the end of the treatment period. Conversely, when *Blattella germanica* exposed to a C2 concentration, the mortality rate reached 30% after 30 days, while there were no deaths occurred during the first 15 days.



**Figure 18.** Mortality rate of adult Male *Blattella germanica* exposed to *Lantana camara* L. hydrosol. (LC: *Lantana camara*)

#### 4.2. Female mortality rate

The exposure of female cockroaches to various concentrations of *Lantana camara* L. hydrosol reveals that at a concentration of C3, it started in the first 15 days with a mortality of 4%; an incomplete mortality was recorded after 30 days of treatment of about 16%. Similarly, a concentration of C2 only about 10 % mortality was observed at the end of the trial and no deaths were recorded in the first 15 days. Conversely, at a concentration of C1, a mortality rate of 14% was observed after 8 days of treatment and remained constant until the end of the experiment (Fig. 19).



**Figure 19.** Mortality rate of adult female *Blattella germanica* exposed to *Lantana camara* L. hydrosol. (LC: *Lantana camara*)

# Discussion

---

**Discussion**

*Blattella germanica* is a major urban pest and a recognized vector of numerous pathogens, including bacteria, fungi, and viruses (Mourier, 2014). Widespread resistance to chemical insecticides has increased the need for alternative control methods. Among the most promising are plant-based essential oils, which present a more sustainable and environmentally responsible solution compared to synthetic pesticides (Souto *et al.*, 2021). This study investigates the insecticidal efficacy of *Schinus molle* L. essential oil and *Lantana camara* L. hydrosol against adult *B. germanica*.

The study results indicate that exposure to *Schinus molle* L. essential oil resulted in 100% mortality of male cockroaches at all concentrations (C1, C2, and C3) within three days. As cited by Chopa *et al.* (2006) this suggests that the essential oil's efficacy is likely due to the combined effects of its bioactive compounds, which interfere with the physiological processes of *Blattella germanica*. For female cockroaches, mortality rates varied with concentration. At lower concentrations (C2 and C3), female cockroach mortality reached approximately 50% and 60%, respectively, after six days of exposure. In contrast, full mortality was achieved at concentration C1 within just three days. This variation in effectiveness highlights the concentration-dependent nature of *Schinus molle* L. essential oil (Chopa *et al.*, 2006). The effectiveness of this oil in eliminating insects is due to many active compounds known for their insecticidal properties. Such as:  $\alpha$ -Pinene,  $\beta$ -Caryophyllene, limonene. According to Bendaoud *et al.* (2010) these compounds can affect the central nervous system of insects leading to paralysis and death. *Schinus molle* L. exhibits a broad spectrum of bioinsecticidal, repellent, and insecticidal effects on various insect species, as mentioned by Scalvenzi *et al.* (2024) the resin essential oil of *Schinus molle* L. is a potent bioinsecticide against *T. castaneum*, a major pest of stored grains worldwide, with repellency percentages reaching up to 96.7% after 120 minutes of exposure. They also exhibit fumigant toxicity with median lethal doses (LD50) between 120.6 and 160.8  $\mu\text{L/L}$  (Baccari *et al.*, 2024). Similarly, *Schinus molle* L. oil have shown fumigant toxicity against bedbugs, although the effect is relatively weak compared to other insecticides (Landeró-Valenzuela *et al.*, 2022). Moreover, the insecticidal activity of *Schinus molle* L. essential oil is linked to neurotoxic effects, by inhibition of acetylcholinesterase (AChE), disrupting nerve signal transmission (Scalvenzi *et al.*, 2024). These mechanisms cause paralysis and death in susceptible insects (Baccari *et al.*, 2024).

On the other hand, male cockroaches exposed to *Lantana camara* L. hydrosol showed a mortality rate of 3% for C3 in 15 days, reaching 50% by 30 days. For C1, the mortality rate increased to 5% in 15 days and 25% by the end. In contrast, C2 caused no mortality in the first

---

15 days but reached 30% by day 30. This may be due to the fact that *Lantana camara* L. contains compounds known to disrupt insect physiology, their concentrations in hydrosol may be insufficient for high efficacy. Lantadene A and B triterpenoids, are notable examples. Despite their identical formula, structural differences between these compounds influence their biological activities (Ngassoum *et al.*, 1999). Consequently, extracts from *Lantana camara* L. leaves have demonstrated strong insecticidal activity against major stored grain pests such as the rice weevil (*Sitophilus oryzae*), rust red flour beetle (*Tribolium castaneum*), and adzuki bean weevil (*Callosobruchus chinensis*). At sufficient concentrations, *Lantana camara* L. leaf extracts caused 90–100% mortality in these species within 7 days, with *C. chinensis* being the most susceptible (Rajashekar *et al.*, 2012). Similarly, methanol and ethanol extracts of *Lantana camara* L. leaves and flowers show significant larvicidal activity against mosquito species such as *Aedes aegypti* and *Culex quinquefasciatus*. Maximum mortality was observed at higher concentrations, indicating a dose-dependent effect (Sathish and Maneemegalai, 2008.).

The findings of our study indicated that hydrosol from *Lantana camara* L. resulted in considerably lower mortality rates against *Blattella germanica* when compared to *Schinus molle* L. The lower efficacy of *Lantana camara* L. hydrosol compared to essential oil is likely attributed to a reduced concentration of active compounds. The compounds present may not be as potent or abundant enough to produce significant insecticidal effects within the study period.

# Conclusion

---

## Conclusion

The findings of this study clearly demonstrate the successful achievement of its main objectives. We assessed the insecticidal toxicity of *Schinus molle* L. essential oil and *Lantana camara* L. hydrosol against adult *Blattella germanica*, evaluating their effects on both males and females. The results highlight the strong potential of these plant-based products as effective and sustainable tools for pest management. Both plants exhibited significant lethal toxicity against *B. germanica* under the tested conditions. These findings support the use of botanically-derived formulations as viable insecticidal agents for managing adult cockroach infestations. Looking ahead, this work lays the foundation for developing eco-friendly natural insecticides from these toxic plants, offering a promising and sustainable alternative for pest control.

To further expand the scope of this research, additional experiments should be conducted, with a particular focus on:

- Evaluating the insecticidal effects on different life stages (eggs, nymphs, etc.).
- Study the effect of mixing essential oils extracted from poisonous plants on both adult male and female.
- Evaluation the toxicity of hydrosol mixture for toxics plants.
- Investigating potential resistance development by exposing successive generations of insects to the essential oils.
- Evaluating performance of the essential oils across different environmental conditions (temperatures, humidity, surfaces).
- Trials on semi-field or field scales to assess practical efficacy outside of laboratory conditions.

# **BIBLIOGRAPHIC REFERENCES**

---

## Bibliographic references

- Abbott, W.S. (1925). A Method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, 18(2), 265-267. doi:10.1093/jee/18.2.265a
- Abubakar, Y., Tijjani, H., Egbuna, C., Adetunji, C. O., Kala, S., Kryeziu, T. L., Jonathan C. I., & Patrick-Iwuanyanwu, K. C. (2020). Pesticides, history, and classification. In *Natural remedies for pest, disease and weed control* (pp. 29-42). Academic Press.
- Aisha, K., Visakh, N. U., Pathrose, B., Mori, N., Baeshen, R. S., & Shower, R. (2024). Extraction, chemical composition and insecticidal activities of *Lantana camara* Linn. Leaf essential oils against *Tribolium castaneum*, *Lasioderma serricorne* and *Callosobruchus chinensis*. *Molecules*, 29(2), 344.
- Anon. 1962. *Lantana Linn.* (Verbenaceae). In: *The Wealth of India: A Dictionary of Raw Materials and Industrial products*, vol VI (ed. Sastri, B.N.), Council of Scientific and Industrial Research, New Delhi, India: 31–34
- Baccari, W., Saidi, I., Jebnoui, A., Teka, S., Osman, S., Mansoor Alrasheeday, A., Mohamed, N., El Oudi, M., & Ben Jannet, H. (2024). *Schinus molle* Resin Essential Oil as Potent Bioinsecticide Against *Tribolium castaneum*: Chemical Profile, In Vitro Acetylcholinesterase Inhibition, DFT Calculation and Molecular Docking Analysis. *Biomolecules*, 14(11), 1464.
- Beccaloni, G. (2019). Cockroach Species File. Blattodea Species File Curator, The Natural History Museum, London, GBIF. 8(13), doi.org/10.15468/a7uxkl
- Bendaoud, H., Romdhane, M., Souchard, J. P., Cazaux, S., & Bouajila, J. (2010). Chemical composition and anticancer and antioxidant activities of *Schinus molle* L. and *Schinus terebinthifolius* Raddi berries essential oils. *Journal of food Science*, 75(6), C466-C472.
- Bradley, P.N. (1988). Survey of woody biomass on farms in Western Kenya. *Ambio* 17: 40–48
- Brenner, R. J., & Kramer, R. D. (2019). Cockroaches (blattaria). In *Medical and veterinary entomology* (pp. 61-77). Academic Press.
- Cai, T., Huang, Y. H., & Zhang, F. (2020). Ovarian morphological features and proteome reveal fecundity fitness disadvantages in  $\beta$ -cypermethrin-resistant strains of *Blattella germanica* (L.) (Blattodea: Blattellidae). *Pesticide Biochemistry and Physiology*, 170, 104682.
- Chavan, S.R. & S.T. Nikam. (1982). Investigation of *Lantana camara* Linn. (Verbenaceae) leaves for larvicidal activity. *Bulletin of Haffkine Institute* 10: 21–22.

- 
- Chopa, C. S., Alzogaray, R., & Ferrero, A. (2006). Repellency assays with *Schinus molle* var. *areira* (L.)(Anacardiaceae) essential oils against *Blattella germanica* L.(Blattodea: Blattellidae). *BioAssay*, 1.
- Council, F. E. P. P. (2006). Interagency Brazilian peppertree (*Schinus terebinthifolius*) Management plan for florida 2<sup>nd</sup> edition.
- Day MD, Wiley CJ, Playford J, Zalucki MP. (2003). Lantana: Current Management, Status and Future Prospects. Australian Centre for International Agricultural Research, 5: 1- 20.
- Diaz, C., Quesada, S., Brenes, O., Aguilar, G., & Ciccio, J. F. (2008). Chemical composition of *Schinus molle* essential oil and its cytotoxic activity on tumour cell lines. *Natural product research*, 22(17), 1521-1534.
- Do Prado, A. C., Garces, H. G., Bagagli, E., Rall, V. L. M., Furlanetto, A., Fernandes Junior, A., & Furtado, F. B. (2019). *Schinus molle* essential oil as a potential source of bioactive compounds: antifungal and antibacterial properties. *Journal of applied microbiology*, 126(2), 516-522.
- Do Rosário Martins, M., Arantes, S., Candeias, F., Tinoco, M. T., & Cruz-Morais, J. (2014). Antioxidant, antimicrobial and toxicological properties of *Schinus molle* L. essential oils. *Journal of ethnopharmacology*, 151(1), 485-492.
- Duarte, J. A., Zambrano, L. A. D. B., Quintana, L. D., Rocha, M. B., Schmitt, E. G., Boligon, A. A., Anraku de Campos, M. M., Souza de Oliveira, L. F., & Machado, M. M. (2018). Immunotoxicological evaluation of *Schinus molle* L. (Anacardiaceae) essential oil in lymphocytes and macrophages. *Evidence-Based Complementary and Alternative Medicine*, 2018(1), 6541583.
- El-Sharabasy, H. M., Mahmoud, M. F., El Bahrawy, A. F., El Badry, Y. S., & El Kady, G. A. (2013). Food preference of the German cockroach, *Blattella germanica* (L.) (Dictyoptera: Blattellidae).
- Eryigit, T., Yildirim, B., Ekici, K., & Çirka, M. (2017). Chemical composition, antimicrobial and antioxidant properties of *Schinus molle* L. essential oil from Turkey. *Journal of Essential oil Bearing Plants*, 20(2), 570-577.
- Ferrero, A. A., Chopa, C. S., González, J. W., & Alzogaray, R. A. (2007). Repellence and toxicity of *Schinus molle* extracts on *Blattella germanica*. *Fitoterapia*, 78(4), 311-314.
- Gentle, C.B. & J.A. Duggin. (1997). Allelopathy as a competitive strategy in persistent thickets of *Lantana camara* L. In three Australian forest communities. *Plant Ecology* 132: 85–95.
- Ghisalberti, E. L. (2000). *Lantana camara* L. (verbenaceae). *Fitoterapia*, 71(5), 467-486.

- Godlewska, K., Ronga, D., & Michalak, I. (2021). Plant extracts-importance in sustainable agriculture. *Italian Journal of Agronomy*, 16(2).
- Goldstein, D. J., & Coleman, R. C. (2004). *Schinus molle* L. (Anacardiaceae) Chicha production in the central Andes. *Economic Botany*, 58(4), 523-529.
- Graaff, J.L. (1986). *Lantana camara*, the plant and some methods for its control. *South African Forestry Journal* 136: 26-30.
- Gujral, G.S. & P. Vasudevan. (1983). *Lantana camara* L., a problem weed. *Journal of Scientific and Industrial Research* 42: 281–286.
- Hassaine, S. (2017). Activité biologique de quelques plantes sur les ravageurs des denrées stockées. Mémoire de Master, Université de Tlemcen, 66p.
- Hosni, K., Jemli, M., Dziri, S., M'rabet, Y., Ennigrou, A., Sghaier, A., Casabianca, H., Vulliet, E., Ben Brahim, N., & Sebei, H. (2011). Changes in phytochemical, antimicrobial and free radical scavenging activities of the Peruvian pepper tree (*Schinus molle* L.) as influenced by fruit maturation. *Industrial Crops and Products*, 34(3), 1622-1628.
- Howard, R.A. (1969). A checklist of cultivar names used in the genus *lantana*. *Arnoldia* 29: 73–109.
- Iannacone, J., & Alvarino, L. (2010). Toxicity of *Schinus molle* L. (Anacardiaceae) on four biological control agents of agriculture pest in Peru. *Acta zoológica mexicana*, 26(3), 603-615.
- IJSRP: International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013 42\_ISSN 2250-3153 p: 43,44
- Jacobs, S. 2023. German Cockroaches (On-line). Entomology Notes, Pennsylvania State University. Accessed february 21, 2024 at [http://www.ento.psu.edu/extension/factsheets/german\\_cockroach.htm](http://www.ento.psu.edu/extension/factsheets/german_cockroach.htm)
- Jkan. (2019). World zoo-mini zoo map, Own work.
- Jøker, D., Cruz, N. T., Morales, M. U., & Rojas, E. (2002). *Schinus molle* L. Danida Forest Seed Centre, Krogerupvej 21, DK-3050 Humlebaek, Denmark.
- Kalita, S., Kumar, G., Karthik, L., & Rao, K. V. B. (2011). Phytochemical composition and in vitro hemolytic activity of *Lantana camara* L. (Verbenaceae) leaves. *Pharmacologyonline*, 1, 59-67.
- Kasimala, M.B., & Kasimala, B.B. (2012). A review on Brazilian pepper plant: *Schinus molle*. *Journal of Atoms and Molecules*, 2(2), 6.
- Khoshoo, T.N. & C. Mahal. (1967). Versatile reproduction in *Lantana camara*. *Current Science* 8: 200–203

- 
- Landero-Valenzuela, N., Alonso-Hernández, N., Lara-Viveros, F., Gómez-Domínguez, N. S., Juárez-Pelcastre, J., Aguado-Rodríguez, J., Luna-Cruz, A., Lagunez-Rivera, L., Aguilar-Pérez, L. A., Hinojosa-Garro, D., & Granados-Echegoyen, C. (2022). Efficiency of *Schinus molle* essential oil against *Bactericera cockerelli* (Hemiptera: Triozidae) and *Sitophilus zeamais* (Coleoptera: Dryophthoridae). *Agriculture*, *12*(4), 554.
- Lemos, R. P., Matielo, C. B., Marques Jr, A. S., Santos, M. G. D., Rosa, V. G. D., Sarzi, D. S., ROSA, J. V. S., & Stefenon, V. M. (2019). Ecological niche modeling of *Schinus molle* reveals the risk of invasive species expansion into biodiversity hotspots. *Anais da Academia Brasileira de Ciências*, *91*(04), e20181047.
- Lonare, M. K., Sharma, M., Hajare, S. W., & Borekar, V. I. (2012). *Lantana camara*: overview on toxic to potent medicinal properties. *International Journal of Pharmaceutical Sciences and Research*, *3*(9), 3031.
- López, A., Castro, S., Andina, M. J., Ures, X., Munguía, B., Llabot, J. M., Elder, H., Dellacassa, E., Palma, S., & Domínguez, L. (2014). Insecticidal activity of microencapsulated *Schinus molle* essential oil. *Industrial Crops and Products*, *53*, 209-216.
- Machado, C. D., Raman, V., Rehman, J. U., Maia, B. H., Meneghetti, E. K., Almeida, V. P., Silva, R. Z., Farago, P. V., Khan, I. A., & Budel, J. M. (2019). *Schinus molle*: anatomy of leaves and stems, chemical composition and insecticidal activities of volatile oil against bed bug (*Cimex lectularius*). *Revista Brasileira de Farmacognosia*, *29*(1), 1-10.
- Mekuria, A. B., Geta, M., Birru, E. M., & Gelayee, D. A. (2021). Antimalarial activity of seed extracts of *Schinus molle* against *Plasmodium berghei* in mice. *Journal of Evidence-Based Integrative Medicine*, *26*, 2515690X20984287.
- Menasria, T., Moussa, F., El-Hamza, S., Tine, S., Megri, R., & Chenchouni, H. (2014). Bacterial load of German cockroach (*Blattella germanica*) found in hospital environment. *Pathogens and global health*, *108*(3), 141-147.
- MGK. (2019) Cockroach Control Protocol. 8810 Tenth Avenue North Minneapolis, MN 55427
- Morton, J.F. (1994). Lantana, or red sage (*Lantana camara* L. (Verbenaceae)), notorious weed and popular garden flower; some cases of poisoning in Florida. *Economic Botany* *48*: 259–270.
- Mourier, A. (2014). Lutte intégrée contre deux insectes synanthropes: *Blattella germanica* et *Cimex lectularius*. Apports de l'écologie scientifique pour le conseil à l'officine.
- Ndezo Bisso, B., Njikang Epie Nkwelle, R., Tchuenguem Tchuenteu, R., & Dzoyem, J. P. (2022). Phytochemical screening, antioxidant, and antimicrobial activities of seven

- 
- underinvestigated medicinal plants against microbial pathogens. *Advances in Pharmacological and Pharmaceutical Sciences*, 2022(1), 1998808.
- Ngassoum, M. B., Yonkeu, S., Jirovetz, L., Buchbauer, G., Schmaus, G., & Hammerschmidt, F. J. (1999). Chemical composition of essential oils of *Lantana camara* leaves and flowers from Cameroon and Madagascar. *Flavour and fragrance journal*, 14(4), 245-250.
- Orwa, C. (2009). Agroforestry Database: a tree reference and selection guide, version 4.0. <http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp>.
- Pan, X., Wang, X., & Zhang, F. (2020). New insights into cockroach control: using functional diversity of *Blattella germanica* symbionts. *Insects*, 11(10), 696.
- Parsons, W.T. & E.G. Cuthbertson. (2001). Common lantana. In: Noxious Weeds of Australia, CSIRO Publishing, Melbourne: 627–632.
- Pathak, V. M., Verma, V. K., Rawat, B. S., Kaur, B., Babu, N., Sharma, A., Dewali, S., Yadav, M., Kumari, R., Singh, S., Mohapatra, A., Pandey, V., Rana, N., & Cunill, J. M. (2022). Current status of pesticide effects on environment, human health and its eco-friendly management as bioremediation: A comprehensive review. *Frontiers in microbiology*, 13, 962619.
- Perricone, M., Arace, E., Corbo, M. R., Sinigaglia, M., & Bevilacqua, A. (2015). Bioactivity of essential oils: a review on their interaction with food components. *Frontiers in microbiology*, 6, 76.
- Priyanka, N., & Joshi, P. K. (2013). A review of *Lantana camara* studies in India. *International Journal of Scientific and Research Publications*, 3(10), 1-11.
- Rajashekar, Y., Ravindra, K. V., & Bakthavatsalam, N. (2014). Leaves of *Lantana camara* Linn. (Verbenaceae) as a potential insecticide for the management of three species of stored grain insect pests. *Journal of food science and technology*, 51(11), 3494-3499.
- Ramírez Albores, J. E., Richardson, D. M., Stefenon, V. M., Bizama, G., Pérez Suárez, M., & Badano, E. I. (2021). A global assessment of the potential distribution of naturalized and planted populations of the ornamental alien tree *Schinus molle*. *NeoBiota* 68: 105-126. <https://doi.org/10.3897/neobiota.68.68572>.
- Razzak, A., Khiari, R., Moussaoui, Y., & Belgacem, N. (2023). *Schinus Molle*: Currently Status and Opportunity. In Annual Plant: Sources of Fibres, Nanocellulose and Cellulosic Derivatives: Processing, Properties and Applications (pp. 535-551). Singapore : Springer Nature Singapore.
- Rouibi, A., Saidi, F., & Boutoumi, H. (2009). Identification par CG/MS et détermination des effets antimicrobiens des huiles essentielles du faux poivrier (*Schinus molle* L.). In

- 
- International Symposium on Medicinal and Aromatic Plants-SIPAM2009 853 (pp. 219-228).
- Sathish, K. M., & Maneemegalai, S. (2008). Evaluation of larvicidal effect of *Lantana camara* Linn. against mosquito species *Aedes aegypti* and *Culex quinquefasciatus*. *Adv. Biol. Res*, 2(3-4), 39-43.
- Saxena, M.K. (2000). Aqueous leachate of *Lantana camara* kills water hyacinth. *Journal of Chemical Ecology* 26: 2435–2447
- Scalvenzi, L., Durofil, A., Cáceres Claros, C., Pérez Martínez, A., Guardado Yordi, E., Manfredini, S., Baldini E, Vertuani S & Radice, M. (2024). Unleashing Nature’s Pesticide: A Systematic Review of *Schinus molle* Essential Oil’s Biopesticidal Potential. *Sustainability*, 16(23), 10444.
- Schal, C., Holbrook, G. L., Bachmann, J. A., & Sevala, V. L. (1997). Reproductive biology of the German cockroach, *Blattella germanica*: juvenile hormone as a pleiotropic master regulator. *Archives of Insect Biochemistry and Physiology: Published in Collaboration with the Entomological Society of America*, 35(4), 405-426.
- Schauer, J.C. (1851). Verbenaceae. In ‘Flora Brasiliensis Volume 9, ed. C.F.P. Martius. (R. Oldenberg, Leipzig)
- Sharma, O. P., Singh, A., & Sharma, S. (2000). Levels of lantadenes, bioactive pentacyclic triterpenoids, in young and mature leaves of *Lantana camara* var. *aculeata*. *Fitoterapia*, 71(5), 487-491.
- Sharma, O.P. & P.D. Sharma. (1989). Natural products of the *Lantana plant* — the present and prospects. *Journal of Scientific and Industrial Research* 48: 471–478
- Shehata M. E., Gamal M. El-Sherbiny, Mohamed H. Sharaf, Mohamed H. Kalaba, Abdelghany S. Shaban. (2024). Phytochemical analysis, antimicrobial, antioxidant, and cytotoxicity activities of *Schinus molle* (L.) extracts, *Biomass Conversion and Biorefinery*, <https://doi.org/10.1007/s13399-024-05301-1>
- Siddiqui, B. S., Raza, S. M., Begum, S., Siddiqui, S., & Firdous, S. (1995). Pentacyclic triterpenoids from *Lantana camara*. *Phytochemistry*, 38(3), 681-685.
- Sieksmeyer, T., He, S., Esparza-Mora, M. A., Jiang, S., Petrašiūnaitė, V., Kuroпка, B., Banasiak, R., Julseth, M. J., Weise, CH., Johnston, P. R., Rodríguez-Rojas, A., & McMahon, D. P. (2022). Eating in a losing cause: limited benefit of modified macronutrient consumption following infection in the oriental cockroach *Blatta orientalis*. *BMC ecology and evolution*, 22(1), 67.

- 
- Souto, A. L., Sylvestre, M., Tölke, E. D., Tavares, J. F., Barbosa-Filho, J. M., & Cebrián-Torrejón, G. (2021). Plant-derived pesticides as an alternative to pest management and sustainable agricultural production: Prospects, applications and challenges. *Molecules*, 26(16), 4835.
- Swarbrick, J.T. (1985). History of the lantanas in Australia and origins of the weedy biotypes. *Plant Protection Quarterly* 1, 115-21.
- Swarbrick, J.T., B.W. Willson & M.A. Hannan-Jones. (1998). *Lantana camara* L. In: The Biology of Australian Weeds (eds. Panetta, F.D., R.H. Groves & R.C.H. Shepherd), R.G. & F.J. Richardson, Melbourne: 119–140.
- Tajeddine, N. N. (2021). Anti-microbial study of *Schinus molle* L. fruit essential oil western Algerian region. *RHAZES: Green and Applied Chemistry*, 11, 108-117.
- Tang, Q., Bourguignon, T., Willenmse, L., De Coninck, E., & Evans, T. (2019). Global spread of the German cockroach, *Blattella germanica*. *Biological invasions*, 21, 693-707.
- Thaman, R.R. (1974). *Lantana camara*: its introduction, dispersal and impact on islands of the tropical Pacific Ocean. *Micronesica* 10, 17-39.
- Tlili, N., Yahia, Y., Feriani, A., Labidi, A., Ghazouani, L., Nasri, N., Saadaoui, E., & Khaldi, A. (2018). *Schinus terebinthifolius* vs *Schinus molle*: A comparative study of the effect of species and location on the phytochemical content of fruits. *Industrial Crops and Products*, 122, 559-565.
- Valles, S. (2008). German Cockroach. University of Florida Institute of Food and Agricultural Sciences – Featured Creatures.
- Vicenço, C. B., Sylvestre, W. P., Silva, V. T. D., Menegol, I. V., Hahn, R. C., Lima, T. S., Agostini, F., & Pauletti, G. F. (2020). Bioactivity of *Schinus molle* L. and *Schinus terebinthifolia* Raddi. Essential oils on *Anticarsia gemmatalis* (Hübner 1818). *Brazilian Archives of Biology and Technology*, 63, e20200111.
- Walter E., Jaeger P., Ortscheit A., (2016). Jardin botanique de saverne. Bulletin. Strasbourg. P 18-20.
- Wang C, (2020), German cockroach, New Jersey Agricultural Experiment Station Cooperative Extension Fact Sheet FS1322.
- Wells, M. J., & Stirton, C. H. (1988). *Lantana camara*: A poisonous declared weed. *Farming in South Africa. Weeds A*, 27, 1-4.
- Winder, J.A. (1980). Factors affecting the growth of lantana in Brazil. Phd thesis, Department of Agriculture and Horticulture, University of Reading, UK.

---

Zoubiri, S., & Baaliouamer, A. (2012). GC and GC/MS analyses of the Algerian *Lantana camara* leaf essential oil: Effect against *Sitophilus granarius* adults. *Journal of Saudi Chemical Society*, 16(3), 291-297.