

**A SURVEY OF INSECTS ASSOCIATED WITH *CALOTROPIS PROCERA* (AITON) W.T.
AITON (FAMILY: APOCYNACEAE; ORDER: GENTIANALES; COMMON NAME:
SODOM APPLE) WITHIN UDUS CAMPUS**

BY

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**A PROJECT SUBMITTED TO THE DEPARTMENT OF BIOLOGY, FACULTY OF
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CERTIFICATION

This is to certify that this research project titled “A survey of insects associated with *Calotropis procera* (Aiton) W.T. Aiton (family: Apocynaceae; order: Gentianales; common name: Sodom apple) within Udu Campus” was carried out by Ikechukwu Goodness, with Adm. No: 2010302121, of the Department of Biology, Faculty of Chemical and Life Science, Usmanu Danfodiyo University, Sokoto. This work has been read and approved as meeting part of the requirements for the award of the Bachelor of Science (B.Sc. Hons.) Degree in Biology.

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DEDICATION

This project is dedicated to my beloved parents, Mr. Ikechukwu Okorie and Mrs. Faith Ikechukwu, for their constant support and prayers.

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ABSTRACT

Diversity and ecological roles of insects associated with *Calotropis procera* (Aiton) W.T. Aiton, commonly known as Sodom Apple within the Usmanu Danfodiyo University, Sokoto (UDUS) campus were studied. Three locations within the UDUS campus; Veterinary Department (VET Building), Gidan Yunfa Area, and Behind Stadium Area were selected for the study. Field observations and sampling were conducted using sweep nets, pitfall traps, and direct hand collection to identify insect species visiting or inhabiting *C. procera*. Findings revealed a total of eleven insect species representing different ecological groups, including pollinators, herbivores, predators, and shelter-seekers. The honey bee (*Apis mellifera*) recorded the highest frequency of occurrence across all sites, followed by *Rhabdotis obrina*, *Forficula auricularia*, and *Tettigonia viridissima*, while *Camponotus* species were the least frequent. The observed insects performed various activities such as feeding, pollination, sheltering, and predation at different times of the day. The dominance of pollinators such as *A. mellifera* indicates that *C. procera* plays a vital role in sustaining pollinator populations and maintaining ecological balance within the semi-arid environment. The results indicate that the area supports a rich mix of pollinators, herbivores, and predators. The high presence of *Dysdercus angulatus* (red cotton bug) reflects the plant's susceptibility to sap-sucking insects. The abundance of *Forficula auricularia* (earwig) suggests that *C. procera* provides ideal sheltering and breeding sites. The study concludes that *Calotropis procera* supports a rich and functionally diverse insect community, emphasizing its ecological importance in biodiversity conservation. It recommends the conservation of native plants like *C. procera*, increased awareness of their environmental value, and further research on seasonal insect dynamics to enhance ecosystem management strategies in northern Nigeria.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Calotropis procera, commonly known as Sodom apple or giant milkweed, is a widely distributed plant species found in arid and semi-arid regions, including the Sokoto metropolis. It thrives in disturbed habitats, roadsides, and abandoned lands, and has been noted for its medicinal, ecological, and ethnobotanical importance (Kahsay *et al.*, 2020). The plant produces a milky latex and is known for its resilience in poor soil conditions, making it a dominant flora in many dry zones (Kahsay *et al.*, 2020).

The plant also plays host to a variety of insect species, some of which are essential for pollination, while others may act as herbivores, parasites, or vectors of plant diseases (Aliyu *et al.*, 2022). Understanding the diversity and ecological roles of these insects is important for conservation biology, ecological balance, and sustainable environmental management. Insects associated with *Calotropis procera* can include beetles, butterflies, wasps, ants, and true bugs, many of which have co-evolved specific interactions with the plant. *Calotropis procera* (Aiton) W.T. Aiton, commonly known as **Sodom Apple**, is a perennial shrub or small tree belonging to the family **Apocynaceae** and order **Gentianales**. It is native to tropical Africa and Asia but is

now widely distributed in arid and semi-arid regions, including northern Nigeria. The plant typically grows between two to four meters in height, with thick, woody stems and large, opposite leaves that are grayish-green, leathery, and covered with fine hairs to reduce water loss. Its flowers are star-shaped and vary in color from white to lavender or purple, appearing in clusters at the ends of branches. The fruit is a large, green, spindle-shaped pod that bursts open when mature, releasing numerous brown seeds attached to silky white hairs that aid in wind dispersal. The plant produces a milky latex when cut, which is characteristic of members of the Apocynaceae family.

Calotropis procera is a plant of great ecological and medicinal significance. Ecologically, it serves as a pioneer species that helps to stabilize soils and restore degraded environments in dry and semi-arid regions. Its presence supports biodiversity by providing food and shelter for many insects, particularly pollinators such as bees, butterflies, and beetles. The plant's deep root system improves soil structure and prevents erosion, making it important for land restoration in desert-prone areas.

Medicinally, *C. procera* has been used for centuries in traditional healing systems across Africa and Asia. Its leaves, roots, flowers, and latex are used to treat several ailments, including skin infections, fever, cough, asthma, and rheumatism. The latex contains bioactive compounds such

as cardiac glycosides, alkaloids, and flavonoids, which exhibit antimicrobial, anti-inflammatory, and analgesic properties. Despite its toxicity in large quantities, careful use in traditional medicine has made it a valuable natural remedy.

The plant also has industrial and economic importance. Its silky fibers are used in making ropes, paper, and stuffing materials, while its latex is explored in the production of biopesticides and natural rubber-like substances. In addition, *C. procera* is sometimes grown as an ornamental shrub because of its attractive flowers, and it is culturally valued in some local traditions. Recent studies also recognize its potential in environmental management, particularly in phytoremediation, as it can absorb and tolerate heavy metals in polluted soils

1.2 Statement of the Problem

Despite the widespread presence of *Calotropis procera* within Sokoto metropolis and its ecological importance, there is limited scientific documentation regarding the diversity and ecological roles of the insects associated with this plant. Most existing studies on insect-plant interactions have focused on agricultural crops or economically important plants, leaving a research gap in the understanding of insects associated with wild and medicinal plants like *Calotropis procera*.

Insects play crucial roles in ecosystem functioning, including pollination, seed dispersal, herbivory, and nutrient cycling. However, without proper identification and documentation of these insects and their interactions with local flora, such ecological benefits may go unnoticed or underutilized. the impacts of urbanization, pollution, and climate variability in Sokoto metropolis may be influencing insect populations, possibly leading to biodiversity loss without detection.

The lack of baseline data on insect diversity associated with *Calotropis procera* limits efforts in biodiversity conservation, entomological research, and environmental management in the region. This study, therefore, seeks to fill this gap by conducting a comprehensive survey of insects found in association with *Calotropis procera* within Sokoto metropolis.

1.3 Aim and Objectives of the Study

The main aim of this research is to conduct a survey of insects associated with *Calotropis procera* within Sokoto metropolis.

The specific objectives of this study are to:

1. To collect and classify insect species associated with *Calotropis procera* in the study area.
2. To determine the frequency and abundance of the insect species observed.
3. To provide the barline data on the insects associated with *Calotropis procera*.

1.4 Research Questions

1. What insect species are associated with *Calotropis procera* within Sokoto metropolis?
2. What are the frequency and abundance levels of the insect species observed on *Calotropis procera*?
3. What ecological roles do these insects play in relation to *Calotropis procera*?

1.5 Justification

Given the increasing interest in insect-plant relationships, especially in the context of biodiversity and climate change, this study aims to investigate and document the various insects associated with *Calotropis procera* in Sokoto metropolis. Such studies are vital in regions like Sokoto, where urban expansion and climatic variability may be impacting local ecosystems (Abubakar & Yusuf, 2023). A survey of insect diversity around this plant species could contribute to baseline data for entomological research, integrated pest management, and environmental conservation programs in northern Nigeria.

This study contributes to the growing body of knowledge on insect-plant interactions, particularly in arid and semi-arid regions like Sokoto metropolis. *Calotropis procera* is a common wild plant in this region, yet there is a lack of detailed research on the insect species that associate with it. By identifying and documenting these insects, the study will provide baseline data that can be used for future ecological, entomological, and conservation research.

Understanding the diversity and roles of insects associated with *Calotropis procera* is important for ecological balance. Some of these insects may serve as pollinators, herbivores, or natural pest controllers, while others could act as vectors of plant diseases. Identifying their roles will help in

appreciating their contribution to ecosystem functioning and may guide the development of environmentally friendly pest management strategies.

This research can be valuable to students, researchers, environmentalists, and policymakers. It offers insights into how native vegetation like *Calotropis procera* supports insect biodiversity, which is especially important in the face of increasing urbanization and climate change. The findings could also stimulate further interest in the conservation of under-studied plant and insect species in northern Nigeria.

1.6 Scope and Limitations

This study is specifically focused on surveying the insect species associated with *Calotropis procera* within selected areas of Sokoto metropolis. It will involve identifying, classifying, and analyzing the frequency and ecological roles of insects found on or around this plant species. The research will be limited to field surveys conducted during the dry and/or early rainy season, depending on accessibility and insect activity. Only insects directly observed or collected from *Calotropis procera* will be considered in this study.

While the research aims to provide valuable baseline data, it is not without limitations. First, the study is restricted geographically to Sokoto metropolis, and findings may not fully represent the

insect-plant interactions in other ecological zones. Secondly, due to time and resource constraints, insect identification may rely on available taxonomic keys and expert consultation, which may not cover all species at a detailed level. Seasonal variation in insect population, limited access to some locations, and the potential for human disturbance may also affect the comprehensiveness of data collection.

Despite these limitations, the study is expected to make a significant contribution to local ecological knowledge and open doors for further research into the biodiversity and ecological importance of native plant species in arid regions.

1.7 Definition of Terms

1. **Insects:** Insects are a class of arthropods characterized by a three-part body (head, thorax, and abdomen), three pairs of legs, compound eyes, and one pair of antennae. They are the most diverse group of organisms on Earth and play critical roles in ecosystems.
2. ***Calotropis procera*:** A plant species commonly known as Sodom apple or giant milkweed. It is a perennial shrub that grows in arid and semi-arid regions and is often found in disturbed habitats such as roadsides and abandoned fields. It is known for its medicinal properties and resilience in poor soil conditions.

3. **Ecological Role:** The function or position of a species within an ecosystem, including its interactions with other organisms and its contribution to the flow of energy and matter. Insects associated with *Calotropis procera* may serve as pollinators, herbivores, predators, or decomposers.
4. **Insect-Plant Interaction:** The relationship between insects and plants, which can include pollination, herbivory, mutualism, and parasitism. This interaction is crucial for plant reproduction, insect survival, and overall ecosystem health.
5. **Biodiversity:** The variety of life forms in a given area, including the diversity of species, ecosystems, and genetic diversity. High biodiversity is essential for the stability and resilience of ecosystems.
6. **Frequency:** The number of times a particular insect species is observed or collected from *Calotropis procera* during the study period.
7. **Abundance:** The relative number of individuals of a particular insect species present in the study area, reflecting its population density.
8. **Pollination:** The transfer of pollen from one flower to another, often by insects, enabling fertilization and the production of seeds. Insects such as bees and butterflies often play key roles in pollination.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of *Calotropis procera*

Calotropis procera, commonly known as Sodom apple, giant milkweed, or rubber bush, is a flowering plant species belonging to the family Apocynaceae. It is a perennial shrub that is widely distributed in arid and semi-arid regions of Africa, the Middle East, and parts of Asia. The plant is known for its ability to grow in harsh environments with poor soil fertility, high temperatures, and limited rainfall (Kahsay *et al.*, 2020). It is often seen colonizing disturbed areas such as roadsides, abandoned farmlands, construction sites, and degraded ecosystems.

The plant typically grows up to 1.5–4 meters in height and is characterized by thick, grayish-green leaves that are covered with a waxy coating. Its stems exude a toxic milky latex when injured, which has been found to contain a variety of bioactive compounds such as cardiac glycosides, flavonoids, alkaloids, and terpenoids (Akinmoladun *et al.*, 2021). The flowers of *C. procera* are attractive and fragrant, ranging in color from white to lavender, and they play a crucial role in attracting pollinators like bees, butterflies, and other insects.

From an ethnobotanical perspective, *Calotropis procera* has been used traditionally in African and Asian medicine to treat a range of ailments including skin infections, digestive disorders, respiratory diseases, and joint pain (Mubashir *et al.*, 2019). It is also used in the preparation of local insecticides and repellents. Despite its toxicity, different parts of the plant are used with caution in folk medicine, indicating its cultural significance and pharmacological potential.

Ecologically, *C. procera* is considered both a valuable resource and an invasive species. Its ability to outcompete native vegetation in disturbed environments has raised concerns among ecologists and land managers. In Nigeria, it is increasingly spreading across northern regions such as Sokoto, Katsina, Kano, and Borno, often replacing native flora and altering soil properties (Abubakar & Yusuf, 2023). However, its capacity to stabilize soils, provide shade, and serve as a source of nectar and shelter for insect populations makes it an integral part of many dryland ecosystems (Usman *et al.*, 2020).

Research into the ecological roles of *Calotropis procera* is still ongoing, particularly concerning its interaction with insect fauna and its adaptability to climate stress. For example, studies have shown that the plant supports a wide range of insect species including pollinators like honeybees and butterflies, as well as herbivores and seed feeders (Aliyu *et al.*, 2022). Understanding these relationships is essential in assessing its impact on biodiversity and ecosystem dynamics.

In recent years, the resilience of *C. procera* has also attracted attention in the context of climate change mitigation and rehabilitation of degraded lands. Its physiological features such as deep root systems, high water-use efficiency, and tolerance to salinity and drought make it a potential candidate for afforestation and land reclamation programs in arid zones (Obiakor & Tanko, 2021). In addition, the plant's phytochemical richness continues to drive interest in its potential as a source of industrial and pharmaceutical compounds.

2.2 Ecological Importance of *Calotropis procera*

Calotropis procera is a highly adaptable plant species that plays significant ecological roles, particularly in arid and semi-arid environments where vegetation is generally sparse and biodiversity is vulnerable. Its ability to thrive under extreme environmental stress, including high temperatures, poor soils, and low rainfall, positions it as a pioneer species in disturbed habitats. It contributes to ecological restoration by stabilizing soils, reducing erosion, and aiding in the rehabilitation of degraded lands (Kahsay *et al.*, 2020; Obiakor & Tanko, 2021).

One of the critical ecological roles of *Calotropis procera* is its support for local insect biodiversity. The plant produces an abundance of nectar, especially during the flowering season, attracting a wide range of insects such as bees, butterflies, wasps, and beetles. These insects, in turn, perform essential ecological services including pollination, which facilitates genetic

diversity and the propagation of plant species. Recent studies have shown that *C. procera* is especially important for pollinators during dry periods when few other nectar sources are available (Aliyu *et al.*, 2022). Its flowers are particularly attractive to species such as *Apis mellifera* and *Danaus chrysippus*, which are not only important pollinators but also indicators of healthy ecosystems.

The presence of *C. procera* in degraded or abandoned lands also contributes to soil improvement over time. Its deep root system enhances soil structure and aeration, while the leaf litter and organic matter it deposits contribute to nutrient cycling. In semi-arid regions like Sokoto, where land degradation and desertification pose significant threats to agriculture and human livelihoods, plants like *C. procera* serve as natural buffers, gradually enhancing land quality and supporting the return of other vegetation (Yusuf *et al.*, 2022).

The plant offers shelter and microhabitats for various arthropods, reptiles, and small mammals. Its broad leaves and dense canopy provide protection from direct sunlight and predators. Some insect species, such as aphids, true bugs, and caterpillars, feed directly on the plant's sap or tissues, while others utilize it for oviposition (egg-laying) and reproduction. Although *C. procera* produces toxic latex to deter herbivory, some specialized insect species have developed adaptations that allow them to feed on it without harm, thereby maintaining a balanced food web (Ahmed *et al.*, 2023).

The ability of *C. procera* to grow in saline and nutrient-deficient soils makes it a suitable candidate for afforestation and phytoremediation programs. Studies have shown that it can absorb heavy metals and other contaminants from the soil, contributing to environmental detoxification in polluted areas (Akinmoladun *et al.*, 2021). This makes it ecologically relevant for use in reclaiming mining sites, industrial lands, and other environmentally stressed zones, hence it plays a role in climate resilience strategies.

Despite being labeled as invasive in some ecosystems, especially where it spreads aggressively and displaces native flora, *Calotropis procera* remains an ecologically significant species in its native range. The ecological balance depends on how its spread is managed and the role it plays within the local biodiversity context. In Sokoto metropolis, its coexistence with insects and other wildlife provides essential ecosystem services that are often overlooked due to its invasive tendencies in other regions (Usman & Lawal, 2023).

2.3 Insect-Plant Interactions

Insect-plant interactions are fundamental ecological relationships that shape biodiversity, ecosystem structure, and evolutionary processes. These interactions can be mutualistic, antagonistic, or neutral, depending on the nature and outcome of the relationship between the insect and the plant. Mutualistic interactions, such as pollination and seed dispersal, benefit both

the insect and the plant. On the other hand, herbivory, parasitism, and seed predation are typically antagonistic, where the insect benefits at the plant's expense (Adeyemi *et al.*, 2021).

One of the most widely studied forms of insect-plant interaction is pollination. Insects such as bees, butterflies, wasps, and flies visit flowers to collect nectar or pollen. During these visits, they inadvertently transfer pollen from the male anthers to the female stigma, facilitating fertilization and the production of seeds. According to Aliyu *et al.* (2022), over 75% of flowering plants globally depend on insect pollinators, with specific insects co-evolving alongside certain plant species to form highly specialized relationships. *Calotropis procera*, for example, has a complex floral structure that attracts both generalist and specialist pollinators.

Herbivory is another important type of interaction, where insects feed on different parts of the plant such as leaves, stems, flowers, or seeds. These interactions can have significant implications for plant health, reproduction, and community dynamics. Some herbivorous insects, such as caterpillars, beetles, and aphids, can cause extensive damage, while others feed selectively and help regulate plant growth (Musa *et al.*, 2023). Interestingly, *Calotropis procera* produces a toxic latex that deters most herbivores, but certain adapted insects, like the Danaid butterfly (*Danaus chrysippus*), have evolved resistance to the plant's toxic compounds and even use them for their own defense mechanisms.

Insects also interact with plants by serving as vectors for pathogens. For instance, aphids and leafhoppers may transmit viruses or bacteria while feeding, often resulting in plant diseases. Such interactions can reduce agricultural productivity and alter natural plant populations. In a study by Ahmed *et al.* (2023), certain insect species were found to act as vectors for fungal spores on wild medicinal plants, including *C. procera*, which may influence plant community dynamics and succession.

Some insects utilize plants as shelter or oviposition sites. The structure of a plant, including its leaves, flowers, or bark, may provide ideal conditions for insects to lay eggs or escape predation. *Calotropis procera*'s dense foliage and robust stem structure are often exploited by insects seeking temporary habitats or reproductive sites. This interaction supports insect population sustainability and enhances local biodiversity, especially in arid and semi-arid environments where alternative resources are limited (Yusuf & Lawal, 2023).

Insect-plant interactions contribute significantly to nutrient cycling and energy flow within ecosystems. When insects consume plant material or die and decompose on or near plant surfaces, they release essential nutrients back into the soil. This facilitates plant growth and supports the broader ecosystem. As highlighted by Obiakor and Tanko (2021), such interactions are particularly vital in low-nutrient environments, where biological recycling plays a key role in maintaining soil fertility.

2.4 Theoretical Framework

A theoretical framework provides the conceptual grounding for scientific inquiry by linking the research problem with established theories. In ecological studies involving insect-plant relationships, several theories have been developed to explain how species interact, adapt, and influence each other within their environment. This study draws upon key ecological theories such as Mutualism Theory, Ecological Niche Theory, and the Theory of Coevolution, which together offer a lens for understanding the complex interactions between *Calotropis procera* and associated insect fauna.

The Mutualism Theory posits that many ecological relationships between species are beneficial to both parties. In plant-insect interactions, this is most often observed in pollination, where insects obtain food (nectar or pollen) while plants achieve reproduction through pollen transfer. According to Adeyemi *et al.* (2022), mutualism is especially prominent in arid regions where plant species have evolved floral structures that selectively attract certain insect pollinators, leading to efficient pollination despite low biodiversity. In the case of *Calotropis procera*, its vibrant and nectar-rich flowers serve as attractants to bees, butterflies, and other insects, thereby supporting mutualistic relationships.

Another relevant model is the Ecological Niche Theory, which describes how species occupy particular roles and habitats within an ecosystem. Each organism's niche includes its physical habitat, resource usage, and interactions with other species. Insects associated with *Calotropis procera* may exploit the plant for food, shelter, or reproduction, and in doing so, they fulfill specific ecological roles such as herbivory, pollination, or predation. Yusuf and Lawal (2023) emphasize that niche differentiation reduces competition among insect species and contributes to species coexistence in ecosystems dominated by resilient plants like *C. procera*. This theory helps explain the distribution patterns and abundance of various insect species observed on the plant across different parts of Sokoto metropolis.

The Theory of Coevolution also provides a foundational basis for this study. Coevolution describes the reciprocal evolutionary changes between interacting species over time. Insects and flowering plants are among the most well-studied coevolved groups. Certain insects have developed behavioral, morphological, or physiological traits that allow them to interact efficiently with specific plant species, while plants evolve features that promote or limit access to floral rewards. *Calotropis procera*, for instance, has a complex floral morphology with a hooded corona and sticky pollinia that require precise handling, which only certain insect species can navigate (Aliyu *et al.*, 2022). This implies a selective advantage for insects with specialized adaptations, reflecting coevolutionary dynamics.

The Biodiversity and Ecosystem Function Theory (BEF) supports the premise that biodiversity enhances the productivity, stability, and resilience of ecosystems. In the context of insect-plant interactions, the diversity of insect species visiting or inhabiting *C. procera* may contribute to broader ecological functions such as nutrient cycling, pest regulation, and pollination networks. According to Ahmed *et al.* (2023), ecosystems with diverse insect-plant associations are more likely to resist disturbance and recover from environmental shocks, which is particularly relevant in urban and semi-arid environments like Sokoto.

Each of these theories underscores a different aspect of the relationship between *Calotropis procera* and its associated insect fauna be it mutual benefit, resource partitioning, evolutionary adaptation, or ecosystem functioning. Together, they create a comprehensive framework for analyzing the observed interactions.

For the purpose of this research, the Ecological Niche Theory is adopted as the guiding theoretical framework. This theory provides the most suitable basis for understanding the specific roles and behaviors of insect species associated with *Calotropis procera* within the varied microhabitats of Sokoto metropolis. By analyzing how these insects utilize the plant for food, shelter, or reproduction, the study aims to categorize their ecological functions and explain their distribution patterns within the urban landscape.

2.5 Insects Commonly Associated with *Calotropis procera*

Calotropis procera serves as a host to a wide variety of insect species due to its persistent foliage, attractive flowers, and adaptability to dry, open environments. These insects interact with the plant in various ways some as pollinators, others as herbivores, sap feeders, or even shelter seekers. The plant's rich nectar and distinctive floral architecture attract both generalist and specialist insects, many of which have evolved unique adaptations to overcome its physical and chemical defenses (Aliyu *et al.*, 2022).

Among the most frequently reported insect visitors of *C. procera* are honeybees (*Apis mellifera*), carpenter bees (*Xylocopa* spp.), and butterflies, particularly the plain tiger butterfly (*Danaus chrysippus*). These species are primary pollinators that forage for nectar while inadvertently transferring pollen from flower to flower. The interaction with *D. chrysippus* is especially significant, as this butterfly is not only a common pollinator but has also been observed feeding on the plant during its larval stage. It has developed tolerance to the plant's toxic cardiac glycosides, storing these compounds in its body tissues as a defense mechanism against predators (Ahmed *et al.*, 2023).

Other insects such as ants (Formicidae), wasps (Vespidae), and flies (Diptera) are also commonly associated with *C. procera*. Some of these insects act as opportunistic foragers,

feeding on extra-floral nectaries or preying on other insects present on the plant. Wasps, in particular, have been observed nesting around the plant, benefiting from the microhabitats created by its broad leaves and thick stem surfaces (Usman & Lawal, 2023). These interactions contribute to the broader trophic dynamics around the plant, linking it to higher levels of the food web.

True bugs (Hemiptera) such as aphids, mealybugs, and leafhoppers are often found feeding on the plant's sap. These sap feeders can sometimes become pests, weakening the plant and potentially transmitting pathogens. Nevertheless, their presence is important for understanding the plant's ecological relationships, as they may attract predatory insects like lady beetles and lacewings, which help maintain insect population balance (Yusuf & Lawal, 2023).

Herbivorous beetles from the families Chrysomelidae and Curculionidae have also been recorded on *Calotropis procera*. These beetles feed on the leaves and flowers, sometimes creating visible damage. Their role, however, is dual; while some act as pests, others contribute to organic matter decomposition when they feed on senescent or dead plant tissues, thereby aiding nutrient cycling in the ecosystem (Musa *et al.*, 2023).

Some parasitic and parasitoid insect species, including certain tachinid flies and ichneumonid wasps, utilize *C. procera* as a hunting ground. They may lay eggs on or near herbivorous insects

that feed on the plant, thereby controlling pest populations indirectly. These predator-prey dynamics highlight the complex ecological interactions supported by *C. procera*, which go beyond basic herbivory and pollination.

2.6 Empirical Review of Related Literature

Empirical studies on insect-plant relationships have expanded significantly in recent years, driven by increased interest in biodiversity conservation, pollinator decline, and ecosystem resilience. Research specifically focused on *Calotropis procera* has revealed a broad spectrum of insect associations that vary across regions and ecological contexts. In northern Nigeria, for instance, Aliyu *et al.* (2022) conducted a study on insect visitors to *C. procera* in arid zones and found that bees, butterflies, and true bugs constituted the most frequent and active insect groups. Their findings emphasized the plant's significance as a nectar source, particularly during the dry season when other floral resources are scarce.

In a similar study, Ahmed *et al.* (2023) examined the interaction between *Danaus chrysippus* and *C. procera* and observed that the butterfly not only served as a pollinator but also used the plant as a larval host. The study provided empirical evidence for chemical adaptation, showing how the larvae sequester cardiac glycosides from the plant's toxic latex for defense. This relationship

exemplifies a coevolutionary interaction and highlights the complexity of ecological functions that *C. procera* supports.

Yusuf and Lawal (2023) conducted fieldwork in Sokoto metropolis focusing on the diversity and ecological roles of insects found on *Calotropis procera*. Their results showed that apart from pollinators, a wide range of herbivores, predators, and decomposers interact with the plant. Notably, beetles, ants, and hemipterans were abundant, indicating that the plant supports not only plant reproduction but also energy flow across multiple trophic levels. The researchers emphasized that urbanization had begun to affect insect diversity, making *C. procera* patches critical refuges for insect populations.

Musa *et al.* (2023) conducted an ecological survey in the semi-arid regions of Kano and Zamfara, assessing the insect fauna associated with wild medicinal plants, including *Calotropis procera*. Their data revealed high insect species richness during the early rainy season. The authors also documented parasitic interactions, such as tachinid flies laying eggs on herbivorous caterpillars feeding on the plant. These findings support the argument that *C. procera* functions as an ecological hub, sustaining insect interactions even under harsh environmental conditions.

In another empirical investigation, Usman and Bello (2022) assessed the pollination efficiency of various insect species visiting *C. procera* in rural communities of Kebbi State. They measured

fruit set and seed viability across multiple sites and found that plots with higher bee visitation rates showed significantly improved reproductive success. This study not only confirmed the plant's dependence on insect pollination but also highlighted the ecological services rendered by native pollinators, many of which are often overlooked in conservation programs.

A study by Obasohan *et al.* (2021) on insect-plant interactions in degraded environments of northern Nigeria found that *C. procera* had the highest insect attraction rate among wild plants surveyed. The study suggested that the plant's persistence in poor soils, coupled with its consistent nectar production, made it a key player in sustaining insect diversity in marginal habitats.

2.7 Summary and Gaps in the Literature

The reviewed literature provides substantial evidence that *Calotropis procera* plays a critical ecological role in supporting insect biodiversity across arid and semi-arid ecosystems. It has been widely studied in terms of its medicinal properties, resilience to environmental stress, and potential for land restoration. Numerous empirical studies have documented its interactions with a variety of insect species, highlighting its function as a nectar source, a larval host, and a microhabitat provider. Reports from different regions, particularly in northern Nigeria, have confirmed the presence of pollinators such as bees and butterflies, herbivores including beetles

and true bugs, and parasitoids that contribute to regulating herbivore populations. These interactions collectively point to *C. procera* as a key species in maintaining ecological balance.

Several gaps remain in the current body of knowledge. First, most existing studies tend to focus on insect-plant relationships in broader ecological contexts without narrowing down to specific urban or semi-urban environments like Sokoto metropolis. This limits the understanding of how *C. procera* supports insect diversity within rapidly urbanizing settings, where natural vegetation is declining. While some researchers have listed insect groups associated with the plant, few have conducted comprehensive field surveys that document both diversity and abundance of insect species in a structured and location-specific manner.

Secondly, although there is general recognition of the pollination role of certain insects, many studies have not assessed the ecological functions of lesser-known insect visitors. There is a lack of detailed classification regarding the roles played by different insect taxa whether as pollinators, herbivores, predators, or decomposers within the *C. procera* microhabitat. This creates a gap in understanding the extent of the plant's contribution to sustaining multiple insect guilds, especially in low-biodiversity zones.

Temporal and seasonal variations in insect activity around *C. procera* are largely underreported. Insect assemblages may vary across seasons and ecological conditions, influencing the dynamics

of insect-plant interaction. Current literature does not adequately explore such variations in relation to *C. procera*, particularly in regions like Sokoto where dry and wet seasons create distinct ecological phases.

While some studies mention the presence of insects like *Danaus chrysippus* and *Apis mellifera*, there is insufficient empirical work detailing their frequency of visitation, ecological significance, and patterns of interaction specific to *C. procera*. The absence of such data makes it difficult to fully appreciate the depth of biodiversity supported by the plant.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

Three areas with high populations of *Calotropis procera* were purposively selected within Usmanu Danfodiyo University, Sokoto (UDUS), after a preliminary survey was conducted. These areas include:

3.1.2 Veterinary Department (VET Building) Area

The Veterinary Department area is located within the main campus of Usmanu Danfodiyo University, Sokoto. It lies approximately on latitude 13° 03' N and longitude 5° 14' E. The direction of the study was around the open field behind the VET complex, where *Calotropis procera* naturally occurs in large numbers. The area is characterized by open grassland, sandy soil, and sparse vegetation with a mixture of shrubs and herbs. Moderate human and animal activities occur in this site, making it a suitable environment for observing insect interactions with *C. procera*.

3.1.3 Gidan Yunfa Area

Gidan Yunfa is also located within the main campus of Usmanu Danfodiyo University, Sokoto, along the road leading to the university's staff quarters. The site lies approximately on latitude 13° 04' N and longitude 5° 15' E. It consists of open fields and slightly disturbed areas where *Calotropis procera* grows abundantly on sandy soil. The vegetation includes scattered shrubs and grasses typical of the semi-arid environment. The area provides a good habitat for different insect species that utilize *C. procera* for food, shelter, and breeding.

3.1.4 Behind Stadium Area

The Behind Stadium Area, commonly referred to as Belunj, is located around the Usmanu Danfodiyo University stadium, also within the main campus. It lies approximately on latitude 13° 04' N and longitude 5° 15' E. The site is characterized by open grassy vegetation and sandy loam soil. *Calotropis procera* is widely distributed in this area, growing along footpaths and open spaces. The site is relatively undisturbed, making it ideal for studying insect diversity and abundance associated with *C. procera*

3.2 Research Design

This study adopts a descriptive survey design. The purpose of using this design was to observe, document, and describe the different insect species that are associated with *Calotropis procera* within selected areas of Sokoto metropolis. This design enabled the researcher to gather data through field observation and sampling without manipulating the natural environment. The study will aim to identify and classify insect types, describe their roles (such as pollinators, herbivores, or predators), and record the frequency of their occurrence.

3.3 Population of the Study

The population of this study consists of all insect species associated with *Calotropis procera* within the selected study sites in Sokoto metropolis. This includes both visible and non-visible insect species that visit, live on, or feed on any part of the plant (flowers, leaves, stems, or roots). The population was open and natural, not controlled in any form, and reflects the actual insect diversity interacting with the plant.

3.4 Sample Size and Sampling Technique

The study involves purposive sampling to select areas where *Calotropis procera* is naturally abundant. From these areas, 10 mature and healthy *Calotropis procera* plants were selected per

location. Insects found on or around these plants were collected, observed, and recorded during field visits. The sampling will be done during both morning and evening hours, as insect activity varies with time of day. Sampling took place over a 4-week period, with each location visited at least twice weekly. The sample size includes all insect species observed or captured within the sampling period.

3.5 Instrumentation and Data Collection Methods

The main instruments that were used for this study includes:

- Sweep nets: to capture flying insects visiting the plant.
- Pitfall traps: to collect crawling insects near the base of the plant.
- Hand lenses and magnifiers: for closer observation of small insects.
- Insect collection jars and vials: for temporary storage of captured insects.
- Field notebook and data sheets: to record date, time, location, number of insects, behavior, and plant part visited.
- Camera or mobile phone: for photographic documentation of insects for later identification.

Captured insects were temporarily kept and identified based on external features using insect identification guides and available literature. Where needed, expert consultation was sought from entomologists within the Faculty of Biological Sciences.

3.6 Method of Data Analysis

The data collected were analyzed using simple descriptive statistical methods. This includes:

- Frequency tables: to show how often each insect species was observed.
- Percentage distribution to determine the proportion of each insect group (pollinators, herbivores, etc.).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents and discusses the results obtained from the study on insects associated with *Calotropis procera* within three selected locations at Usmanu Danfodiyo University, Sokoto (UDUS). The locations include the Veterinary Department (VET Building), Gidan Yunfa Area, and the Behind Stadium Area (Belunj). Data were collected on the various insect species observed, their frequency and percentage of occurrence, as well as their activities on *C. procera*. The results are presented in tabular form and discussed to highlight patterns of insect diversity, dominance, and ecological roles in relation to the plant.

4.1 List of Insects Associated with *Calotropis procera*

Table 1: List of Insects Associated with *Calotropis procera*

Common Name	Scientific Name
Beetle	<i>Anthophora species</i>
Black Ant	<i>Camponotus sp.</i>
Honey Bee	<i>Apis mellifera</i>
House Fly	<i>Musca domestica</i>

Carpet Beetle	<i>Anthrenus scrophularu</i>
Grasshopper	<i>Caelifera species</i>
Bug	<i>Dysdercus cingulatus</i>
Moth	<i>Danaus chrysippus</i>
Bush Cricket	<i>Tettigonia viridissima</i>
Blister Beetle	<i>Mylabris phalerata</i>
Milkweed Aphid	<i>Aphis neril</i>

The result above shows that a variety of insect species were found associated with *Calotropis procera* across the study areas. These insects belong to different taxonomic groups and play diverse ecological roles such as feeding, pollination, predation, and sheltering. The most frequently observed insects included the honey bee (*Apis mellifera*), bush cricket (*Tettigonia viridissima*), house fly (*Musca domestica*), and black ant (*Camponotus* sp.). The presence of both pollinators (e.g., *Apis mellifera*, *Danaus chrysippus*) and herbivorous insects (e.g., *Dysdercus cingulatus*, *Mylabris phalerata*) shows that *C. procera* supports a complex and diverse insect community.

4.2 Insect Species and Percentage Occurrence at VET Building, UDUS

Table 2: Insects Associated with *C. procera* at VET Building, UDUS

Insect Species	Frequency	Percentage (%)
<i>Apis mellifera</i>	16	21.6
<i>Apis andreniformis</i>	14	18.9
<i>Camponotus</i>	8	10.8
<i>Tettigonia viridissima</i>	8	10.8
<i>Forficula auricularia</i>	8	10.8
<i>Musca domestica</i>	7	9.5
<i>Trithemis arteriosa</i>	6	8.1
<i>Dysdercus angulatus</i>	4	5.4
<i>Mylabris phalerata</i>	3	4.1
Total	74	100

Results from the VET Building show that *Apis mellifera* (honey bee) had the highest percentage occurrence (21.6%), followed by *Apis andreniformis* (18.9%). The least frequent insect recorded was *Mylabris phalerata* (4.1%). Other insects such as *Camponotus*, *Tettigonia viridissima*, and *Forficula auricularia* each had 10.8%.

The high presence of *Apis mellifera* can be attributed to the abundance of nectar and pollen from *C. procera*, which makes it a major foraging site for bees. The moderate presence of ants

(Camponotus) and earwigs (*Forficula auricularia*) suggests that the plant also provides suitable shelter and feeding spots. The relatively low presence of blister beetles (*Mylabris phalerata*) may be due to environmental conditions such as temperature and the plant's latex, which is mildly toxic and may limit feeding frequency.

4.3 Insect Species and Percentage Occurrence at Gidan Yunfa Area

Table 3: Insects Associated with *C. procera* in Gidan Yunfa

Insect Species	Frequency	Percentage (%)
<i>Apis mellifera</i>	13	17.3
<i>Forficula auricularia</i>	9	12.0
<i>Dysdercus angulatus</i>	8	10.7
<i>Apis andreniformis</i>	8	10.6
<i>Rhabdotis obrina</i>	8	10.6
<i>Musca domestica</i>	7	9.3
<i>Trithemis arteriosa</i>	6	8.0
<i>Mylabris phalerata</i>	6	8.0
<i>Camponotus</i>	5	6.7
<i>Tettigonia viridissima</i>	5	6.6
Total	75	10

At the Gidan Yunfa area, *Apis mellifera* again recorded the highest occurrence (17.3%), confirming its dominance and ecological association with *C. procera*. The next most frequent insects were *Forficula auricularia* (12%) and *Dysdercus angulatus* (10.7%). The least recorded species were *Camponotus* and *Tettigonia viridissima*, both under 7%.

The results indicate that the area supports a rich mix of pollinators, herbivores, and predators. The high presence of *Dysdercus angulatus* (red cotton bug) reflects the plant's susceptibility to sap-sucking insects. The abundance of *Forficula auricularia* (earwig) suggests that *C. procera* provides ideal sheltering and breeding sites.

4.4 Insect Species and Percentage Occurrence at behind UDUS Stadium Area

Table 4: Insects Associated with *C. procera* at Behind UDUS Stadium Area

Insect Species	Frequency	Percentage (%)
<i>Apis mellifera</i>	11	16.9
<i>Rhabdotis obrina</i>	9	13.8
<i>Trithemis arteriosa</i>	8	12.3
<i>Tettigonia viridissima</i>	7	10.8
<i>Forficula auricularia</i>	7	10.8
<i>Musca domestica</i>	6	9.2
<i>Dysdercus angulatus</i>	6	9.2

<i>Apis andreniformis</i>	4	6.1
<i>Mylabris phalerata</i>	4	6.1
<i>Camponotus</i>	3	4.6
Total	65	100

At the Stadium area, *Apis mellifera* had the highest frequency (16.9%), followed by *Rhabdotis obrina* (13.8%) and *Trithemis arteriosa* (12.3%). The lowest was *Camponotus* (4.6%). This consistent dominance of honey bees across all sites indicates that *C. procera* is a reliable nectar source for pollinators. The strong presence of *Rhabdotis obrina* and *Trithemis arteriosa* shows that the open and sunny conditions of the Stadium area favor beetles and dragonflies.

4.5 Comparison of Insect Occurrence Across the Three Study Locations

Comparing the data from all sites shows that *Apis mellifera* was the most dominant insect overall, with the highest percentage of occurrence in each location — 21.6% at VET Building, 17.3% at Gidan Yunfa, and 16.9% at the Stadium area. This demonstrates the strong relationship between *C. procera* and honey bees, emphasizing the plant's significance for pollination ecology in the Sokoto environment.

Other insects like *Camponotus*, *Forficula auricularia*, and *Tettigonia viridissima* occurred moderately across all areas, reflecting their adaptability and the plant's suitability as a food and

shelter source. The presence of both herbivores (e.g., *Dysdercus angulatus*, *Mylabris phalerata*) and predators (e.g., *Trithemis arteriosa*) indicates a balanced insect community around *C. procera*. The variation in frequency between the sites may be attributed to differences in environmental conditions, such as vegetation type, humidity, and human activity.

4.6 Activities of Insects Observed on *Calotropis procera*

Table 5: Activities of Insects Observed on *Calotropis procera* in the Study Area

Insect Name	Scientific Name	Common Name	Feeding	Pollination	Shelter	Predation	Time of Activity
Camponotus spp.		Black Ant	1	-	1	1	Morning
Apis mellifera		Honey Bee	1	1	-	-	Afternoon
Musca domestica		House Fly	1	-	1	-	Morning
Tettigonia viridissima		Bush Cricket	1	-	1	-	Morning
Trithemis arteriosa		Dragonfly	-	-	-	1	Afternoon
Mylabris phalerata		Blister Beetle	1	-	-	-	Midday
Dysdercus angulatus		Red Cotton Bug	1	-	-	-	Morning/Afternoon

Forficula auricularia	Earwig	-	-	1	1	Evening/Morning
Rhabdotis sobrina	Flower Beetle	1	1	-	-	Morning/Midday

From the table above, different insects displayed varying activities and behaviors on *Calotropis procera*. The black ants (*Camponotus* spp.) were highly active all day, engaging in feeding and providing shelter, while also preying on smaller insects. The honey bees (*Apis mellifera*) were the main pollinators, active mainly during the daytime.

Musca domestica and *Tettigonia viridissima* used the plant for feeding and resting, especially in the morning. Predatory insects like the dragonfly (*Trithemis arteriosa*) were more active during the afternoon, preying on smaller insects. The earwig (*Forficula auricularia*) showed nocturnal behavior, using the plant for shelter and predation at night and early morning. The flower beetle (*Rhabdotis sobrina*) and blister beetle (*Mylabris phalerata*) were active during midday, feeding and occasionally aiding in pollination.

4.7 Discussion of Findings

The results of this study demonstrate that *Calotropis procera* supports a wide diversity of insect species performing different ecological functions within Sokoto Metropolis. The findings

revealed that the most frequently occurring insect across all study locations was *Apis mellifera* (the honey bee), followed by *Apis andreniformis*, *Rhabdotis obrina*, *Forficula auricularia*, and *Tettigonia viridissima*. The dominance of *Apis mellifera* across all sites confirms the plant's significance as an important nectar and pollen source, contributing greatly to the sustenance of pollinator populations in the semi-arid environment of northern Nigeria. This observation agrees with Adebayo and Kolo (2022), who reported that *C. procera* serves as a reliable floral resource for pollinators during dry seasons when few plants are in bloom. The consistent presence of *A. mellifera* also underscores the ecological importance of *C. procera* as a bridge species supporting pollination continuity and maintaining ecosystem stability in degraded or sparsely vegetated habitats.

The occurrence of *Dysdercus angulatus* (red cotton bug) and *Mylabris phalerata* (blister beetle) indicates that *C. procera* functions as both a feeding and breeding site for phytophagous or herbivorous insects. These insects feed on various plant parts such as leaves, flowers, or pods, potentially influencing the plant's reproductive success. Their association with *C. procera* is consistent with reports by Musa et al. (2023), who noted that the plant often hosts both beneficial and harmful insects due to its chemical composition and latex production. Despite its toxic latex, *C. procera* appears to provide a tolerant microhabitat for species capable of metabolizing or avoiding its chemical defenses.

Predatory species such as *Trithemis arteriosa* (dragonfly) and *Forficula auricularia* (earwig) were also recorded. These insects play essential roles in maintaining ecological balance by preying on smaller herbivorous insects, thereby helping to regulate pest populations naturally. Their presence suggests that *C. procera* does not only attract pollinators and herbivores but also supports higher trophic levels, making it a miniature ecosystem on its own. Similar findings were highlighted by Usman and Lawal (2023), who stated that *C. procera* provides both food and shelter to a range of trophic groups, creating an interconnected web of ecological interactions.

The variation in insect abundance and diversity among the three study locations—VET Building UDUS, Runjin Sambo, and UDUS Stadium (Belunj)—could be attributed to differences in environmental conditions, microclimate, floral availability, and surrounding vegetation. The VET Building area recorded the highest overall frequency of insects, likely due to the presence of multiple flowering plants nearby and reduced anthropogenic disturbances, which favor insect foraging activities. In contrast, Runjin Sambo and Belunj areas exhibited slightly lower frequencies, possibly due to higher human activity and environmental stressors. Okorie et al. (2023) also emphasized that factors such as temperature, soil type, flowering stage, and human interference significantly influence insect diversity and abundance around *C. procera* in urban ecosystems. The activity patterns observed among insects further indicate that different species exploit *C. procera* at varying times of the day. Pollinators such as *A. mellifera* were most active

in the morning and midday when nectar production was likely highest, while predatory species like *T. arteriosa* were more active in the afternoon, coinciding with the movement of smaller prey species. This temporal partitioning of activity suggests that *C. procera* provides continuous ecological services throughout the day, supporting multiple insect guilds. These findings are consistent with those of Bello and Tanko (2024), who observed similar daily activity rhythms among insect visitors on *C. procera* in arid northern Nigeria

4.8 Summary of Results

The study identified a total of eleven insect species associated with *Calotropis procera* across three locations within Usmanu Danfodiyo University, Sokoto. The honey bee (*Apis mellifera*) was the most common and dominant insect species across all study sites, indicating its central role in the pollination of *C. procera*. The plant also hosted herbivores, predators, and shelter-seeking insects, confirming its ecological importance as a multi-functional habitat.

Differences in insect occurrence across sites were attributed to environmental and habitat variations. In general, *C. procera* serves as a critical plant species supporting insect biodiversity in the Sokoto region, providing resources for feeding, pollination, shelter, and predation activities throughout the day.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study was conducted to survey and identify the various insect species associated with *Calotropis procera* (commonly known as Sodom Apple) within Sokoto Metropolis. The plant is widely distributed across different locations and serves as an important ecological resource, attracting diverse insects that interact with it for feeding, shelter, pollination, and other ecological functions.

The study covered three selected locations the Veterinary Building of Usmanu Danfodiyo University Sokoto (UDUS), Gidan Yunfa Area, and behind UDUS Stadium Area. Standard field sampling techniques were used to collect and identify insects visiting or inhabiting *C. procera* in each site. Observations were made on their frequency, abundance, and specific activities on the plant.

The findings revealed that several insect species were associated with *C. procera*, including *Apis mellifera* (honey bee), *Componotus* spp (black ant), *Musca domestica* (housefly), *Tettigonia viridissima* (bush cricket), *Mylabris phalerata* (blister beetle), *Forficula auricularia* (earwig),

Rhabdotis sobrinus (flower beetle), *Dysdercus angulatus* (red cotton bug), and *Trithemis arteriosa* (dragonfly).

Among these, *Apis mellifera* (honey bee) was the most dominant species across the three study sites with the highest frequency of occurrence: 21.6% at the VET Building, 17.3% at Gidan Yunfa, and 16.9% at UDUS Stadium (Belunj). The species *Componotus* spp (black ant) recorded the least occurrence across the study locations. The activities observed among these insects include feeding, pollination, sheltering, and predation, with honey bees being the major pollinators and ants, beetles, and bugs engaging mainly in feeding and sheltering activities.

The abundance of pollinators such as bees and beetles indicates that *C. procera* plays a significant ecological role in sustaining insect biodiversity in semi-arid environments like Sokoto Metropolis.

5.2 Conclusion

The findings of this study have demonstrated that *Calotropis procera* is an ecologically important plant that supports a rich diversity of insects within Sokoto Metropolis. It provides essential resources such as nectar, pollen, and shelter, which sustain the survival of different

insect species. The predominance of *Apis mellifera* suggests that the plant serves as a vital nectar source for pollinators, especially in arid and semi-arid regions where vegetation is sparse.

The variation in insect abundance and diversity across the three study locations may be attributed to environmental factors such as vegetation cover, human activities, and microclimatic differences. The study further highlights the importance of maintaining native flora like *C. procera* as part of biodiversity conservation strategies, particularly in urban ecosystems where natural habitats are increasingly under threat.

Hence, *C. procera* should not merely be regarded as a weed or wasteland shrub but rather as a significant plant species supporting ecological balance and promoting pollination networks essential for ecosystem functioning.

5.3 Recommendations

1. Conservation of Native Plants: Efforts should be made to conserve *Calotropis procera* and similar native plant species in Sokoto Metropolis since they serve as vital habitats and food sources for a wide range of beneficial insects.

2. Further Research: Additional studies should be conducted to investigate the seasonal variation of insect populations on *C. procera* and to identify specific roles of each insect species in pollination and ecosystem services.

3. Public Awareness: Environmental education programs should be introduced to raise awareness among local communities on the ecological importance of *C. procera* and the need to protect native vegetation rather than indiscriminately clearing it.

4. Biodiversity Monitoring: Government agencies and research institutions should establish periodic monitoring of insect diversity associated with native plants to assess environmental changes and guide conservation policies.

5. Integration into Urban Landscaping: The inclusion of native plants like *C. procera* in urban landscaping and green belt planning could enhance biodiversity and promote ecological sustainability within cities.

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