LESSONS LEARNED FROM A BEE SURVEY ON FARMS IN TRINIDAD & TOBAGO 2023

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Inside cover

Citation

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BESNet Biodiversity and Ecosystem Services Network

gef

SGP The GEF Small Grants Programme

UN DP

SwedBio
A programme at Stockholm Resilience Centre

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Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

based on a decision of the German Bundestag

IKI INTERNATIONAL CLIMATE INITIATIVE

CONTENT

ACRONYMS

BES-NET	Biodiversity and Ecosystem Services Network
EMA	Environmental Management Authority
EPPD	Environmental Policy and Planning Division
GEF-SGP	Global Environment Facility Small Grants Programme
GOTT	Government of Trinidad and Tobago
IKI	International Climate Initiative
MALF	Ministry of Agriculture, Land and Fisheries
MPD	Ministry of Planning and Development
PMU	Project Management Unit
TTFNC	Trinidad and Tobago Field Naturalist’s Club
UNDP	United Nations Development Programme

SUMMARY

In 2022, the Trinidad and Tobago Field Naturalists’ Club undertook a year-long project titled "Community Conservation and Management of Native Bee Species in Matura, Trinidad, and Main Ridge, Tobago." This project received funding from the Global Environment Facility Small Grants Programme.

The primary objective was to conduct surveys of indigenous bee species in two distinct locations within Trinidad and Tobago. This endeavor was initiated by and was aligned with the research objectives of the Biodiversity and Ecosystem Services Network Trinidad and Tobago project (BES-Net TT), which spanned from 2021 to 2023.

The project's had four key objectives:

1. Involving local communities in bee surveys within agricultural areas.
2. Gathering and analyzing pertinent data.
3. Conducting training sessions covering bee survey methods, pollinator management, and Meliponini (stingless bee) beekeeping.
4. Creating a comprehensive manual that serves as a replicable model for other regions or locations.

A key project output is a manual that offers a standardised methodology for consistent data comparison over time and location. This creates a robust baseline for potential project replication in Trinidad and Tobago, the broader region, and any other global location where deemed relevant.

Summary of key lessons learned

Key Lessons Learned from the Survey Exercise:

1. Conduct Reconnaissance Visits: Before commencing data collection, it's essential to conduct reconnaissance visits to sampling sites. Terrain and distance to farmers' properties can vary significantly, affecting logistics and access.
2. Select Appropriate Field Vehicle: Proper transportation is crucial. Depending on the location, some sites may require 4x4 vehicles, while others may involve hiking on foot. Ensuring the right vehicle is available is essential for efficient data collection.
3. Opt for the Dry Season: Choose the dry season for data collection to avoid issues related to rainwater filling traps and adverse weather conditions, which can hinder access to sample plots.
4. Early Data Collection: Conduct data collection early in the day to minimize

exposure to the sun. Ensure prompt and reliable attendance of field assistants to maximize productivity.

5. Adapt Equipment as Needed: Be prepared to improvise and modify equipment when necessary. In this case, a hood was designed to prevent rainwater from filling traps using simple, readily available materials.
6. Assure Stakeholders: Assure stakeholders of their ability to participate in field surveys and future projects, especially when issues like land tenure may be a concern for some participants.
7. Understand Stakeholder Concerns: Be mindful of stakeholder concerns, such as road maintenance and trust issues, which can affect their willingness to participate in community-based projects.
8. Leverage Networks: Utilize existing networks and partnerships to maximize benefits and resources, including identifying field coordinators and accessing workshop venues and facilitation.
9. Be Prepared for Extra Work: Anticipate the need for additional work, such as supplemental sampling, to support specific aspects of the project, like orchid bee identification.
10. Keep it Simple: Always try to use common names of species. Avoid technical terms. Never assume that all farmers have the same background knowledge. Always explain.

These key lessons highlight the importance of thorough planning, adaptability, and effective stakeholder engagement in the success of field surveys and related activities.

1. INTRODUCTION

Project Background

The Biodiversity and Ecosystem Services Network Trinidad and Tobago project or BES-Net TT project is a two-year project administered by the Government of Trinidad and Tobago (GOTT), Ministry of Planning and Development (MPD) with the support of the United Nations Development Programme (UNDP). The project is financed by the BES Solutions Fund of the Global Biodiversity and Ecosystem Services Network.

In 2022, the Trinidad and Tobago Field Naturalists' Club, with funding support of the Global Environment Facility Small Grants Programme, undertook a one-year project - Community conservation and management of native bee species in Matura, Trinidad and Main Ridge, Tobago - to survey local bee species at two sites in Trinidad and Tobago. The activity supported research interest of the Biodiversity and Ecosystem Services Network Trinidad and Tobago project (BES-Net TT) which was undertaken over the two-year period 2021-2023.

The BES-Net TT project sought to address issues facing pollinators in Trinidad and Tobago which largely stem from a lack of data, public awareness and pollinator-appropriate management. Key activities undertaken by the project included:

- Assessments of the state of knowledge of pollinators and practices affecting pollinators:
  - Compilation of databases on local plants and pollinators, with attention to crops and horticultural interests.
  - Research on local pollinator species.
  - Development of stingless bee (Meliponini) honey standards.
  - Public awareness and citizen science initiatives.
- Development of educational materials on pollinators and their conservation.
- Development of policy recommendations pertaining to pollinator conservation legislation.

In order to gain information on the status and trends in pollinators and pollination, the project activities included research geared towards bee species identification. The work of the TTFNC with farmers in field work for the bee survey in 2023, helped to enhance this knowledge building effort.

This document shares details about how the survey was done and what we've learned from doing it. We hope this information can offer a practical and proven method for studying bee species in our local biodiversity. Both formal and informal researchers in the future can use this approach to monitor bee diversity in Trinidad and Tobago.

Goals & Objectives

The bee survey exercise was designed to engage communities in the identification, conservation, and improved management of bee species of Trinidad and Tobago. Pollinators are experiencing dramatic declines in terms of diversity and abundance on a global scale, and our islands are no exception. We involved farmers, community assistants, and trained community members in our research on local bee species. Our goal was to gather missing data and also help communities enhance their farming, business, and personal habits. By improving the connection between people and bees, we aimed to conserve bee species.

The main aim of the project was to improve the management of essential bee species for pollination by gathering data and offering education and training to local communities. This goal was effectively achieved by pursuing four core objectives, which included:

- Engaging local communities in bee surveys within agricultural fields.
- Collecting and analysing relevant data.
- Conducting training sessions focused on bee survey techniques, pollinator management, and Meliponini (stingless bee) beekeeping.
- Developing a comprehensive manual that could be used as a blueprint for replication in other regions or areas.

To achieve these objectives, the cooperative endeavors of the TTFNC and BES-Net TT team played a vital role. They conducted thorough research to determine the most effective sampling methods for collecting data on bee species. Moreover, they initiated networking and outreach efforts to identify potential collaborators within the farming community who would engage in bee surveys. Additionally, they coordinated training programs to impart the essential knowledge and skills required for conducting these surveys, equipping the participants with expertise that could be employed in the future.

- **Community conservation and management of native bee species in Matura, Trinidad and Main Ridge, Tobago project was undertaken by the Trinidad and Tobago Field Naturalists' Club (TTFNC) with the assistance of farmers.**
- **The project incorporated field exercises, training and a native bee survey.**
- **The Global Environment Facility Small Grants Programme provided funding support.**
- **The project activity contributed to a component of the Biodiversity and Ecosystem Services Network Trinidad and Tobago (BES-Net TT) project, which is focused on pollinator management in Trinidad and Tobago.**

Justification

The manual serves as a valuable tool for enabling the replication of the project at different locations, including the other four Pilot Protected Areas identified within the framework of the Improving Forest and Protected Area Management of Trinidad and Tobago (IFPAMTT) project. It presents a standardized methodology that can be easily followed, facilitating the comparison of data across different times and places, thereby establishing a robust baseline.

Moreover, the bee survey has equipped community members with a fresh set of skills and knowledge. These newfound abilities can be leveraged for ongoing conservation efforts and as sources of income generation, extending far beyond the scope of Meliponini beekeeping. This knowledge can be applied to various activities and career paths, including but not limited to field safety protocols, roles as field assistants, guiding, and various community-based environmental interpretive activities.

Manual structure

The subsequent section of the document elaborates on the **Methodology** employed during the exercise, which encompasses documenting adjustments made to enhance its success in achieving the intended objectives. This involves detailing field sampling techniques and the training exercises conducted.

The **Survey Outcomes** section presents a concise summary of the preliminary results obtained from the bee survey exercise.

Subsequently, the **Lessons Learned** section offers valuable insights and recommendations from the team, drawing from the execution of the methodology and highlighting key survey outcomes.

Following this, the document provides **Recommendations** for approaching bee surveys in other communities, offering guidance for future endeavors in this area.

The “**Management of Bees and Other Pollinators on Farms**” section aims to provide guidance and tips for promoting pollinator-friendly farming practices.

Within the “**Additional Information”** subsection, you can find links to information sources and video materials produced by the BES-Net TT project, offering supplementary resources for further understanding.

Finally, the **Addendum** contains information on alternative survey methods that could potentially supplement the sampling exercise, even though they were not utilised in this particular survey.

Introduction to Trinidad and Tobago

Trinidad and Tobago are two small islands with a combined land area of about 5100 km^2, lying just off the northeast edge of the South American continent (Fig. 1). Southwest Trinidad is separated from the mainland by an 11-km strait whereas in the northwest there are steppingstone islands between Trinidad and the mainland. Tobago is separated from Trinidad by a 36-km strait.

The islands exhibit moderate topography, with Trinidad reaching a maximum elevation of 940 meters and Tobago reaching 576 meters. Their climate aligns with the tropical latitudes, featuring mean annual rainfall that varies between approximately 125 to 325 cm depending on the location. There is a discernible dry season that extends from around mid-January to late May. The average daily temperature fluctuation is estimated to be 10.4 °C, with minimal seasonal variation. Trinidad and Tobago can be classified as typical continental islands, characterised by limited endemism and a striking resemblance to the biotic composition and diversity found in the nearby Venezuelan mainland habitats.

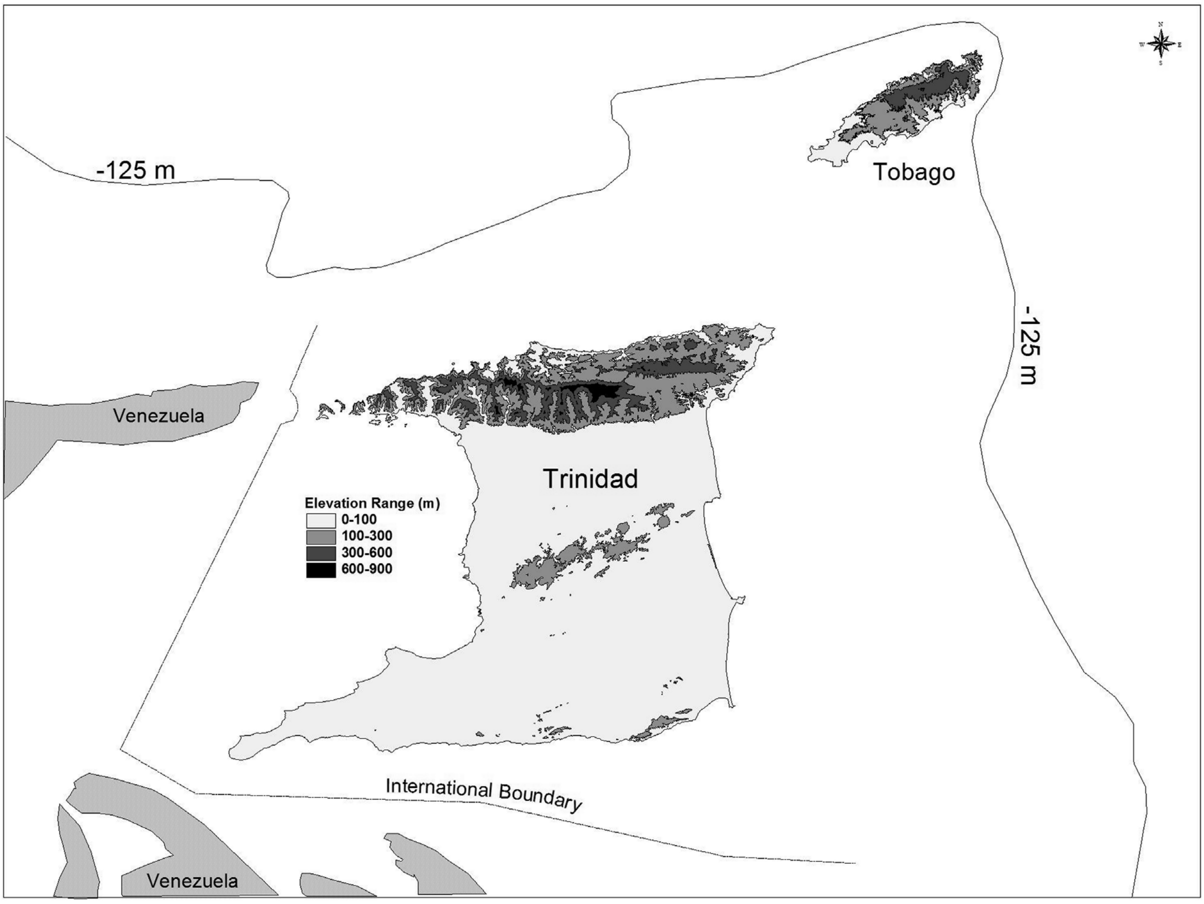

Figure 1 Trinidad and Tobago, position and topography. The present-125-m line approximates the coastline at the height of the most recent glaciation about 20,000 years ago. Map by Bheshem Ramlal.

2. METHODOLOGY

The project proposal submitted to GEF SGP outlined specific outputs upon which appropriate methodology was identified. The expected results were as follows:

- **Output 1: Data collection:**

  The engagement of 20 community assistants and 40 farmers to survey and record native bee fauna composition in agricultural plots surrounding the Matura Forest and Coastal Zone Pilot Protected Area and Tobago Main Ridge Forest Reserve Pilot Protected Area

- **Output 2: Workshops and knowledge management:**

  - To train a minimum of 10 persons per island (including at least 5 women per island) in communities in Meliponini beekeeping and management;
  - To conduct two additional workshops in bee sampling and identification (one on each island) in the communities immediately surrounding the two Pilot Protected Areas.

- **Output 3: Documentation and information sharing:**

  Development of a project manual documenting pollinator and Meliponini (stingless bee) management strategies, including best practices and lessons learned.

The manual will allow for the replication of the project at other sites, including the other four Pilot Protected Areas identified under the Improving Forest and Protected Area Management of Trinidad and Tobago (IFPAMTT) project. It therefore provides a standardised methodology which can be followed, so that data can be compared across time and space, building a solid baseline.

Further to this, the project equips community members with new skills and knowledge, which can be utilised in continuous conservation efforts and as income-generating activities, which go well beyond Meliponini beekeeping. Knowledge can be applied to activities and careers such as field safety protocols, field assistants, guides, and various community-based environmental interpretive activities, to name a few.

Step 1: Selection of sites and field partners

The field survey exercise was constrained by time and cost so the BES-Net TT/ TTFNC team considered the best way to cover sampling in both islands within these constraints.

Given that Protected Areas (PAs) are considered to be natural sites that serve as habitat/havens for biodiversity, the team considered selecting sampling areas that were in close proximity to such sites. The sites selected were farmed areas in the neighbourhood of two PAs: the Matura National Park in Trinidad and the Main Ridge Forest Reserve in Tobago (Figure 2).

The TTFNC assumed a leadership role in establishing connections with farmers who were active in both regions, leveraging partnerships and networks. In Trinidad, their efforts were supported by Ms. Abigail Taylor, while in Tobago, Mr. Darren Henry facilitated interactions with farmers.

From this groundwork, a total of 27 farmers in Trinidad and 26 farmers in Tobago indicated their willingness for engagement in the field survey, allowing the research team to visit the most suitable 20 farms in each island to conduct the research.

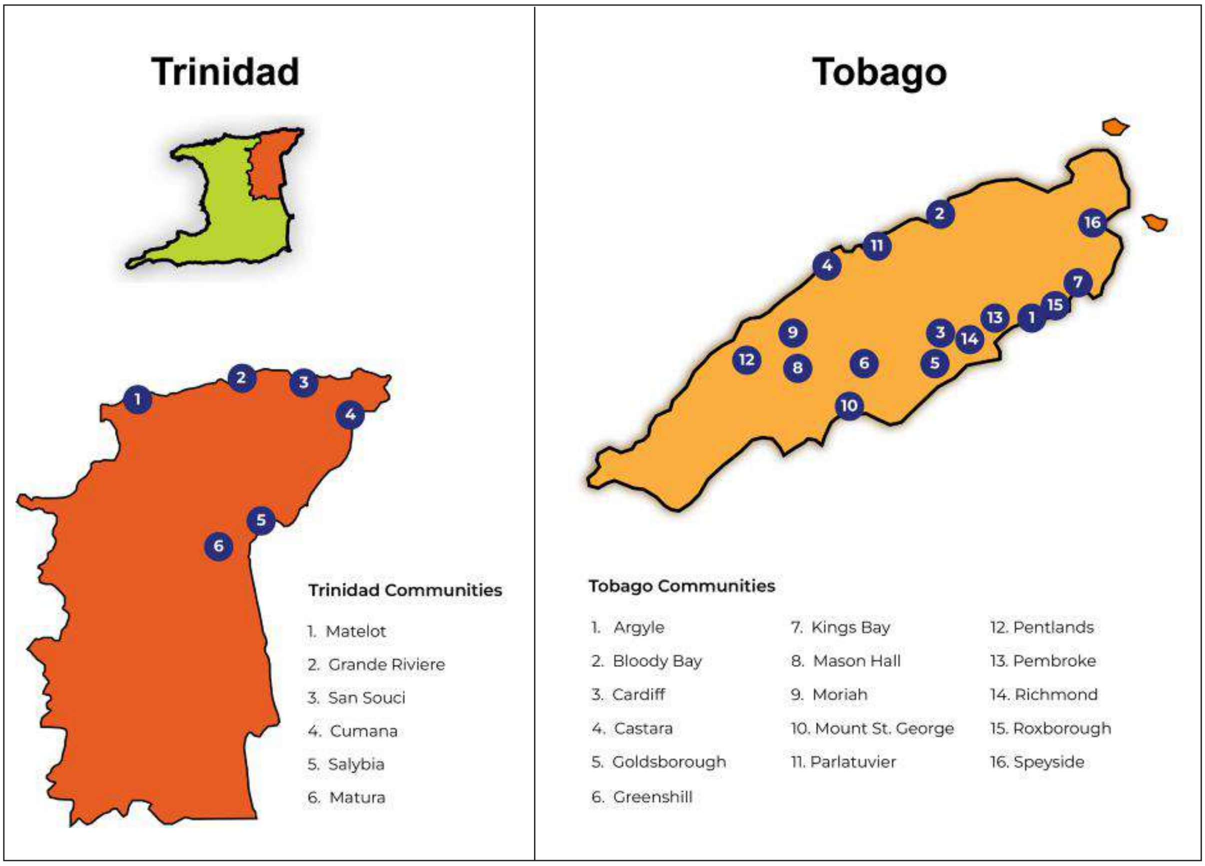

Figure 2 Map indicating the location of communities surveyed in both Trinidad and Tobago.

Step 2: Field equipment and sampling techniques

The BES-Net TT team took the lead in determining the best method for the sampling exercise conducted.

Bee Sampling

A range of sampling options was considered, including: Malaise traps; Blue vane traps; Pan traps and Insect sweep nets.

The team noted the pros and cons of each sampling method and selected the use of **blue vane traps**. The malaise trap also would sample bees but not exclusively of other flying insects and would be less easily deployed in the field. Pan traps ran the risk of becoming filled with water or being accidentally tipped over or trampled on the farms.

Blue vane traps utilised the insect visual system and Ultra-Violet (UV) pigmentation to attract bees and sampled them through passive collection. The traps were filled to a depth of 3 cm with propylene glycol, which attracted and retained the collected specimens. Setting up and dismantling the traps on farms was a straightforward process.

While blue vane traps could be hung from trees, the team chose to pair these with a **shepherd's hook** which could be anchored safely in the field, with the trap hanging safely (Figure 3). In addition, **sweep nets** were included in the sampling exercise to sample other bees that were observed while on the farm during deployment and collection of traps (Figure 4).

Figure 3 Bluevane trap mounted onto Sheppard hook.

Figure 4 Insect sweep net.

Plant Sampling

Plant samples were collected if the pollinator/bee was collected from vegetation on the farm for which the identity was unknown. The samples were transferred to a **plant press** (Figure 5) prior to drying and identification.

For the field collection exercise, **data sheets** were prepared to capture key information on the field visit including field conditions and other relevant data. A sample of the data collection sheet is provided in the Addendum.

The attached Addendum also shows some sampling tools considered for use in the sampling exercise.

Figure 5 Plant press.

Modifications

From several preliminary trails, it was observed that the blue vane traps were filled with water during heavy rainfall episodes (even within the dry season). As such, a 'rain hood' was created for the traps using clear plastic disposable containers (Figure 6). These were lightweight, easily transported and did not block the view of the blue vanes. These were tested in the field and were effective in reducing the volume of water into the traps.

Supplemental sampling of male orchid bees (of the genera *Euglossa, Eulaema* and *Exaerete*) was conducted as the consultant undertaking the bee identification noted that this would aid in species identifications as identification keys for this group of organisms only exists for male samples. Sampling was therefore conducted at sites with known orchid bee presence as indicated by the overall bee survey. **Paper towels soaked with oils** (Figure 7): eucalyptus, peppermint, rosemary, rose and clove were tied to trees to lure male orchid bees which were captured with sweep nets.

Figure 6 Blue vane trap with 'rain hood'.

Figure 7 Oil-soaked paper towels on tree trunk at left.

- **Site selection for the bee survey was linked to opportunities to support monitoring of protected areas.**
- **Training and information sharing opportunities were provided to community members and other stakeholders to enhance knowledge and skills for pollinator conservation.**
- **Blue vane traps were selected as effective sampling tool for easy deployment in the field.**
- **Field testing of equipment was conducted and modifications were incorporated to improve field sampling exercises.**
- **Data collection sheets were designed to capture field conditions during sampling exercises.**

Step 3 - Training workshops

Field techniques

The first set of workshops were undertaken in September 2022 and introduced the project, its partners, the main objective of the bee survey exercise and training in the use of the equipment in the field. This training was important to introduce participants to the equipment and how these worked, and also to emphasise safety in the field.

Some of the farmers who were engaged in the sampling exercise in Trinidad attended the Trinidad workshop and the farmers from Tobago attended the Tobago workshop (Figures 8 and 9).

Additionally, the opportunity was taken to open this workshop to others, and training was made available to members of NGOs in the Matura community, personnel from The University of the West Indies Field Station, staff of the Wildlife Section of the Forestry Division and other NGOs.

The University of the West Indies Field Station assisted in provision of the venue for the Trinidad Workshop, while the Department of Natural Resources and Forestry in Tobago facilitated use of the Bleheim Field Station as the venue for the Tobago workshop.

Figure 8 Top. Participants in first Trinidad workshop - UWI Field Station

Figure 9 Bottom. Participants in Tobago workshop - Blenheim

Insect identifications

The second workshop (undertaken in Trinidad only) was devised to build knowledge of the biological groups that are often engaged as pollinators and equipment used for identification. The information was shared mainly using PowerPoint presentations, however some samples of insects collected in blue vane traps were also placed in trays and workshop participants were able to see these on demonstration using hand lenses. As an academic exercise, participants also learnt how to develop a dichotomous key based on physical attributes of specimens.

The workshop was hosted in collaboration with staff of the Research Division of the Ministry of Agriculture, Land and Fisheries and staff of the Division assisted in delivery. Participants were therefore able to view specimens under a microscope in a laboratory setting, seeing the value of these specialised tools to assist in specimen identification (Figure 10 a-e).

Figure 10a-e Photographs of participants and facilitators at workshop on insect identification

Results and introduction to stingless bee management

The third workshop was designed to share results of the survey with contributors to the exercise and to encourage their conservation of bees. After specimens were sent to an external laboratory for definitive identification and DNA barcoding, some preliminary results of the survey were shared with farmers from the Matura community. Participants in the workshop got insight to the bee species collected during the bee survey. The workshop also offered farmers and other attendees some insight into stingless bee management to generate interest in this activity.

The team was particularly interested in inviting women, in particular to consider becoming engaged in stingless bee management and 25% of workshop attendees were women. Participants were encouraged to join a What's App group of stingless beekeepers which supports the exchange of information and tips for beginning stingless beekeeping.

The venue for this workshop was the library of the Matura Government Primary School; Ms Abigail Bobb was instrumental in obtaining the space for use for this workshop, through the school's Parent Teacher Association (Figure 11 a-d).

Figure 11 a-d Photographs from results sharing workshop in Trinidad

Step 4 - Documentation

Each of the activities undertaken in the course of the project was well-documented in written reports and highlights of activities were captured in Facebook posts on the BES-Net TT Facebook page.

The data generated by the project will form an integral part of the educational and resource material outputs to be developed by the BES-Net TT project including guides and brochures which will target the key stakeholders involved in the project.

This manual is also an output which serves to give an overview of the project and to document the key lessons learned in its execution.

Key publication to be developed utilising the project data

- Pollinator Monitoring Protocols Document
- Meliponini Biology, Identification and Management
- Pocket Guides: Trinidad and Tobago pollinators
- Pocket Guides: Trinidad and Tobago bee taxa
- Pocket Guides: Trinidad and Tobago Meliponini (stingless bees)
- A Manual on the Lessons Learned from a Bee Survey on farms in Trinidad and Tobago

- **Training and information sharing opportunities were provided to community members and other stakeholders to enhance knowledge and skills for pollinator conservation.**
- **Apart from training in use of field equipment, exposure to insect identification tools and facilities was provided through partnerships with various local institutions.**
- **Feedback to farmers was considered to be an important activity and workshops to provide feedback were held after the bee identification was conducted.**
- **An introduction to stingless beekeeping was provided to stimulate interest among farmers in bee conservation to enhance pollinator populations on their farms.**

3. Survey Outcomes

After each field visit, the samples were placed into a reusable, labelled bottle for transfer to BES-Net TT for sorting. The sorting exercise involved examination of the sample to remove all bee species from the catch for shipping and subsequent identification. The bee samples were transferred to vials which were labelled (inside and outside vial) with date and location information. A group of vials were collated over time and a batch of these samples were then conveyed to the Packer Lab at York University in Ontario, Canada.

The samples were examined using powerful microscopes to produce identifications for each specimen. DNA barcoding was carried out for definitive identification and contribution to the BOLD database (https://boldsystems.org/) on a subset of samples. While the final results of this survey exercise will be compiled and shared by BES-Net TT, the following preliminary results (Table 1) are provided in this manual to document the useful outcomes of this sampling method at the two sites.

Table 1. Comparison of known country records and genera identified from survey samples

Family	Number of previously known/ recorded bee genera	Number of genera identified in survey samples
Apidae	37	25
Colletidae	3	0
Halictidae	14	6
Megachilidae	6	2

In summary, representatives of three of four families previously recorded for Trinidad and Tobago were found, and 31 of 60 previously recorded genera as well as possibly 2 new genera. Possibly 16 new country species records were found in the samples processed to date

The BES-Net TT project also includes a special focus on Meliponini/stingless bee management; information on stingless bee species found and identified from the survey are noted in table 2.

Of nine known genera of stingless bees previously recorded for Trinidad and Tobago, eight genera were found in the samples, with possibly new species records for the genera *Lestrimelitta* and *Trigonisca*. The genus *Lestrimelitta* in particular requires further work. It is to be noted once again that results are preliminary and final results will be published once available.

Table 2. Meliponini/Stingless bees identified from survey samples

Genus	Number of previously known/recorded species	Number of previously known species collected in survey	Potential number of species new to TT recorded (to date) from survey
Cephalotrigona	1	0	0
Frieseomelitta	2	1	0
Lestrimelitta	2	0	1
Melipona	3	2	0
Nannotrigona	1	1	0
Partamona	1	1	0
Plebeia	2	1	0
Trigona	2	1	0
Trigonisca	1 **	0	1

**(only genus known, no species has been identified)

Melipona trinitatis
(Guanot, Moko Grande)

Melipona favosa
(Erik, Moko Chiquita)

Trigona amalthea
(Pegone)

Friesemelitta paupera
(Petite Angel)

Partamona nigrior
(Petite Pegone)

Nannotrigona testaceicornis

Figure 12 a-f Local species of stingless bees

Photographs found on iNaturalist - Lena Dempewolf, Linton Arneaud, Amy Deacon, Miguel1080

4. Lessons Learned

The following are the key leasons learned during the conduct of the survey:

Do a reconnaissance visit to sampling sites at the start

Farmers' properties are located on different types of terrain. Farmers from Matura to Cumana have their farm properties near their homes and close to the main road. Farmers from San Souci to Matelot have farm properties on hillsides and these sites are located miles away from their homes and the main road. All potential farmers should be visited before the start of the data collection activities to understand the terrain and distance to their property.

Ensure you have the right field vehicle

Proper transportation was needed for this project. Some of the sample sites required a 4x4 vehicle to gain easy access to the property; in some instances, individuals had to hike on foot to sample sites.

Sampling is best carried out in the dry season

Data collection was not conducted during the rainy season, as the blue vane traps would have been completely filled with rainwater due to the abnormally high level of rainfall. Additionally, adverse weather conditions, closed roads, landslides, fallen electrical wires and flooding sporadically occurred over this period making access to sample plots impossible.

Sampling is best carried out early in the day

Data collection should be done early in the day to avoid the sun. On some days, Field Assistants took a while to arrive on the site; ensure that attendance is prompt and reliable.

Be prepared to "MacGyver"[1] equipment to be effective in the field

When testing the blue vane traps in the field prior to sampling, the BES-Net TT/TTFNC team designed a hood for the traps to reduce the tendency for rainwater to fill the traps when set out in the field. Simple materials were identified (disposable plastic food containers) which could be easily affixed, and which were transparent so as not to obscure the blue colour of the vanes from the bees.

Assure stakeholders of their ability to participate in field survey and associated activities

[1] The term "MacGyver" has now become part of the colloquial American English lexicon. When one "MacGyvers" a solution to a problem, one finds a simple yet elegant solution using existing resources. (Wikipedia)

Not all the farmers were registered due to issues with land tenure, therefore some farmers wanted an assurance that they could participate in future projects and get support on stingless bee management.

Be aware of stakeholder concerns

Farmers in Trinidad were concerned about the maintenance of proper access roads, while some farmers were not keen to have community assistants on their properties due to past run-ins with theft have made them lose their trust in outsiders and even their fellow community members.

Make use of your networks

Networks provide potential opportunities to achieve much when resources are limited. Strong partnerships were leveraged for mutual and maximum benefits including: quick work to identify field coordinators and opportunities for low or no-cost workshop venues and facilitation.

Be prepared for extra work

Supplemental sampling was carried out to support the orchid bee identification process.

5. Recommendations

Based on the undertaking of this bee survey exercise as a collaborative effort of the BES-Net TT team and the Trinidad and Tobago Field Naturalists' Club with local farmers, the following recommendations are distilled for future work of this nature.

Local Adaptations

It is important that the bee survey methods and conservation strategies be tailored to the specific ecological and agricultural context of each community. There is a need for local adaptations to account for variations in bee species, flora, climate, and farming practices. Example: the survey carried out in Matura the proposed methodology for deployment of the blue vane traps had to be adjusted based on the lack of trees in some farms encountered on the ground.

Collaboration and Education:

Collaboration between local farmers, beekeepers, researchers, governmental organisations and funding agencies to promote a holistic approach to bee conservation is encouraged.

Workshops, training sessions, and educational programs be organised to raise awareness about the role of bees in pollination, the importance of native local bees particularly stingless bees and the benefits of bee-friendly farming practices.

Habitat Preservation and Restoration:

Recommend preserving and creating diverse habitats that provide nesting sites and forage resources for native bees. This could involve planting native flowering plants and maintaining natural areas.

Provide guidance on minimising the use of pesticides and promoting integrated pest management strategies to protect bee populations.

Bee-Friendly Farming Practices:

Advise farmers to adopt practices that minimise disturbance to nesting sites and foraging areas for local native bees. This includes reducing soil disturbance, limiting pesticide use, and avoiding unnecessary cutting and trimming.

Suggest implementing crop rotation, cover cropping, and reduced-tillage techniques to improve soil health and maintain diverse flowering plants.

Bee Monitoring and Research:

Stress the importance of ongoing bee monitoring to track population trends, identify potential threats, and assess the effectiveness of conservation efforts.

Encourage researchers and local communities to collaborate on long-term studies to deepen understanding of local bee species and their interactions with the environment.

Policy and Advocacy:

Urge the development of policies that support bee-friendly agricultural practices, habitat preservation, and pesticide regulation at the national level.

Recommend engaging with local authorities and policymakers at the local government level to advocate for the inclusion of bee conservation considerations in agricultural and environmental policies.

Beekeeper Involvement:

Encourage beekeepers to become involved in the management of stingless bees using the guidelines developed under the BES-Net TT project.

Promote information exchange between beekeepers, farmers and the stingless-bee network to build awareness, enhance pollination services and promote sustainable beekeeping.

Community Engagement:

Highlight the benefits of engaging the local community in bee conservation efforts, fostering a sense of ownership and responsibility.

Suggest organising community events, such as planting days or nature walks, to involve and support residents in hands-on conservation activities.

Long-Term Sustainability:

There is a need for sustained commitment to bee conservation strategies and efforts as benefits might take time to become evident.

Periodic reviews of conservation strategies to adapt to changing conditions and incorporate new research findings.

Sharing Success Stories:

Include the example of the successful bee survey to inspire other communities to take similar actions.

Recommendations for replication of this approach to bee surveys in other parts of the country include:

- **Adapt to local conditions of the sampling site**
- **Use the collaborative environment to advise and educate**
- **Build networks and encourage long-term studies with community participation**
- **Support the community in conservation initiatives**
- **Share stories of success to inspire others**

6. Management of Bees and Other Pollinators on Farms

Farms are important ecosystems in which food production is the main focus. These areas however also provide food for animals other than humans, as they seek their nutrition from various parts of the crop. Some of these animals are considered **pests** because they cause damage to the crop by eating its supporting leaves and roots, or they reduce the harvest of useable food by eating the produce itself.

There are however other animals whose visits to the flowering parts of plants is of great benefit to the crop. These animals are usually interested in the nectar of the flowers, using it as a food fuel for their activities. In the process of extracting nectar, these animals also collect and transfer pollen grains between flowers. This action classifies them as **pollinators**, the animals that perform the important act of pollination.

There are simple things that can be done to encourage pollinators to increase their numbers on your farms and other things that can be done to discourage or control pests. Some of these actions are described below.

Create or maintain habits for pollinator species

Old logs and heaps of bare earth that are near to your farms are usually good habitats for native bees. The more undisturbed these areas are, the better they are as a habitat for bees to nest. It may be a little-known fact that as many as 60-70% of bees dig burrows in the ground to create a home. The other 30-40% bees build nests in cavities. Some of these are solitary bees which can create tunnels in wood or use hollow stems, or cavities created and abandoned by wood-boring beetles to be used as their nest. These natural habitats are ideal for bees (Figure 13).

Figure 13 Keep logs as bee habitats

It is also possible to create a habitat for bees. Very popular in Europe are 'bee hotels'. These are small house-like habitats created for solitary bees and possibly other pollinators. These can be constructed from wood, creating a bird house like structure in which hollowed out stems and sticks can be placed to create channels in which the bee can retreat and nest.

They can also be made by drilling holes in a brick (Figure 14), which is then mounted against a wall. Bees can occupy the channels in the brick and be safe from the elements. Bee hotels should be periodically cleaned to ensure that the bees are in

Figure 14 A design of a bee hotel, modified to create habitat for other pollinator species (left) and a brick bee hotel (right).

conditions that are ideal for development.

Another habitat is a wooden hive box, useful for transfer of stingless bee colonies. Sometimes the colony is found in a hollowed-out tree or in a man-made structure such as hollow brick concrete wall. If land is being cleared and a colony is found in a tree, or if a colony is to be removed from a wall, the colony should be transferred to a hive box, as the colony cannot swarm and re-form at another location.

There are a variety of hive box designs that are ideal for particular species of local stingless bees (Figure 15). After transfer, hive boxes can remain in a sheltered area on or near to the farm, so that the bees can assist in crop pollination.

Figure 15 Hive box used for maintaining stingless bee colonies showing colony transferred to box.

Pest control techniques

Farmers usually monitor crops to see whether they are being harmed by pests. If they are, action is taken to remove pests to have the best yield of the crop. Often, this means turning to a pest control method. Many techniques used in pest control require the use of chemicals that will kill the pest, but which may also kill other organisms, including some pollinators. Farmers need to be mindful of the need to protect pollinators. Here are some useful tips that help in targeted control of some pests without using harmful chemicals.

Introduce natural pest repellents

Natural alternatives can be utilised in the control of insect pests (Figure 16 a-b).

Figure 16a Marigold, *Tagetes* sp.

Control of:
aphids, thrips, cabbage worm, knot-root nematodes

- Plant a row of marigold plants as a solid border around your crop beds.
- Marigold sprays deter a wide range of insect pests and nematodes. Crush 150 gm of leaves, flowers and roots. Pour 1 litre of hot water and soak for 24 hrs. Add 1 litre of water to mixture and spray onto plants or mix into the soil.

Figure 16b Garlic, *Allium sativum*

Control of:
aphids, whiteflies, cutworms, mites, knot-root nematodes

- Interplant between rows of crop plants.
- Use a garlic spray solution. Crush 1 bulb of garlic in 1 litre of water. Add 1 tbsp of soap solution and use immediately. [Do not use on legumes as the scent lasts for a long time].
- Garlic is also effectively used with red peppers, onion and marigolds.

Introduce beneficial insects

Some plants attract particular beneficial pests that will control certain pests and serve as pollinators. By adding cosmos, zinnia, parsley and mint plants to your farm, for example on a separate bed or on the perimeter of the farm, you can attract soldier beetles, syrphid flies and ladybird beetles (Figure 17).

Adult ladybird beetles eat pests and are pollinators. Larvae of syrphid flies eat soft-bodied pests like caterpillars and aphids while the adult syrphid flies are pollinators. Adult soldier flies eat aphids and their larvae are also predatory and eat slugs and the larval forms of other pests. In addition, the mint and parsley can be harvested for additional income!

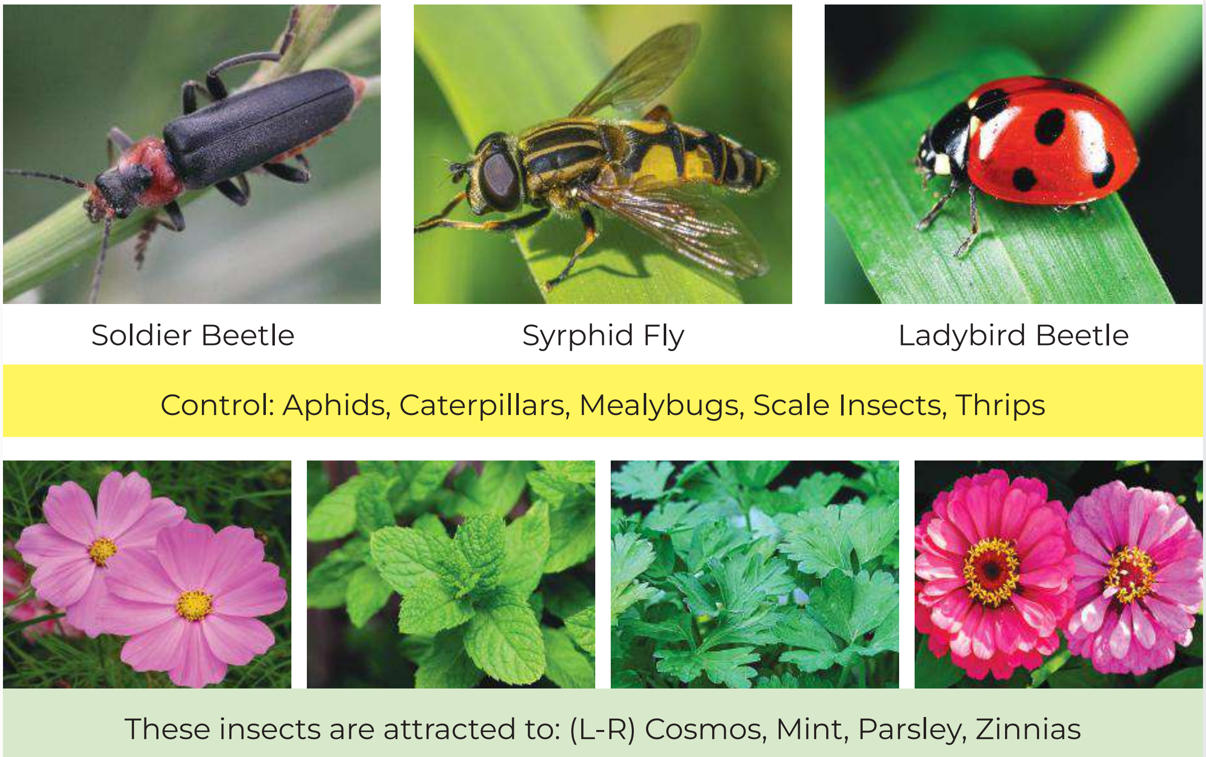

Figure 17 Some beneficial insects and plants

Use safer chemical and benefit from subsidies

If you choose to use chemicals on your farm in pest control, be aware that there are some classes of pesticides which are safer for pollinators and humans, which can be used. An additional benefit is that these chemicals enjoy government subsidies, so you can get cash-back benefits from using them. Consult your local/regional agricultural officer to get advice on the use of class x and class y chemicals. When you visit your agricultural shop to purchase chemicals, present the list of recommended chemicals from these classes. You will be taking a step for a safer environment and saving money.

7. Additional Information

The BES-Net TT project has created educational materials to enhance awareness and understanding of native pollinator species and their management. Find these video resources on the project's YouTube channel: www.youtube.com/@bes-net_tt/videos. The following are some key titles:

- Developing a pollinator garden and an introduction to plants for pollinators — www.youtube.com/watch?v=3EFoTUPqdms
- Designing pollinator garden in Trinidad and Tobago — www.youtube.com/watch?v=Yp7wg2l-Zpc
- Introduction to stingless bee biology and the plants they utilise — www.youtube.com/watch?v=4HegiqPygv0
- Introduction to stingless bees — www.youtube.com/watch?v=swcP9sGnsQs

Furthermore, the project has authored articles on local pollinator conservation, featured in local newspapers. Access via: www.biodiversity.gov.tt
The following list provides key articles on the topic of bee conservation:

- Conserving our local bee species: trinidadexpress.com/features/local/conserving-our-local-bee-species/article_bb7c1c96-b080-11ec-9a65-8f06d7248734.html
- Protecting native bees: newsday.co.tt/2022/05/20/protecting-native-bees
- Stingless bees (Trinidad and Tobago): acboonline.com/stingless-bees-trinidad-tobago
- World Bee Day: Saving stingless bees: newsday.co.tt/2023/05/20/world-bee-day-2023-saving-stingless-bees/

Addendum

The addendum contains information about some other sampling equipment that can be used for biodiversity sampling exercises in pollinator research.

The equipment and collection technique descriptions provided are as follows:

- Malaise trap – for sampling flying insects
- Clinometer – for measurement of slope/inclination
- Pan trap – for sampling organisms that are active at the ground level
- Plant sampling
- Recording of biotic data

Addendum 1 - Malaise Traps

History

Malaise traps are a type of insect collecting device used by entomologists and researchers to capture flying insects, particularly those that fly at low heights, such as flies, wasps, beetles, and other small insects. These traps are designed to take advantage of the natural behaviour of insects to fly upwards when encountering an obstacle. They are named after the Swedish entomologist René Malaise, who first introduced this trapping method in the early 20th century.

They are valuable tools in ecological studies, biodiversity surveys, and population monitoring of insects. They provide insights into insect behaviour, species composition, and seasonal fluctuations. The captured insects can be analysed to study insect community dynamics, population trends, and other ecological patterns.

Function

Malaise traps function as passive devices, capturing insects that fly within approximately 1 meter above the ground—this range corresponds to the zone of most intense insect activity. They also capture insects emerging from below the trap and those ascending from the ground.

Design

The basic design of a Malaise trap consists of a tent-like structure made from a lightweight material such as polyester fabric. This material is usually coloured in a way that contrasts with the surroundings to make it more visible to insects. The trap is composed primarily of a vertical sheet of finely woven dark netting, accompanied by dark end panels that intercept flying insects. These insects ascend toward an angled and slanting roof made of white tent material, which then directs or funnels them upward into a collection container positioned at the highest point of the structure (refer to Figure 1A).

There are various types and variations of Malaise traps including Standard Malaise Trap, Two-panel Malaise Trap, Bucket or Flight Intercept Trap, Cross-Vane Malaise Trap and Floating Malaise Trap. Additionally multiple Malaise traps can be connected to form a Modular Malaise Trap.

For the purposes of the bee survey and training a Townes Malaise Trap was used. This type of trap was designed by the American entomologist Howard Townes. It is a modification of the standard Malaise trap and includes some unique features that make it more effective for capturing certain types of insects.

The Townes Malaise trap design is particularly suited for capturing small flying

Figure 1A. Townes style Malaise trap set-up in the field (Shane T. Ballah)

insects, especially flies (Diptera), parasitic wasps and other Hymenoptera, which can be easily missed by other trapping methods. The folding of the fabric and the placement of the collecting container at the top make it more effective at capturing these insects that tend to fly higher in the environment.

Trapping locations

The trap is set up in a location where insect activity is expected. Finding the optimal location and orientation to achieve maximum insect collection is among the most challenging aspects of setting up a malaise trap. Typically, these traps are positioned perpendicular to the flight path of insects. This task can be straightforward when a natural or man-made passage guides insects, but it can be considerably more complex in other situations. Traps can be situated adjacent to a dense forest edge.

When seeking suitable locations, it is also important to visualize how the area will appear at different times of the day. Many insects tend to congregate in areas with dappled sunlight, for instance, and a location that receives more sunlight over the day will likely yield better results. Additionally, consider the density of the undergrowth and how it might change throughout the trap's deployment. Over time, vegetation could grow so tall that it limits insect movement both to and through the trap.

The nature of the vegetation is also a factor to consider. For instance, if the goal is to collect insects that visit flowering plants, then a location with blooming plants becomes more advantageous. However, for extended sampling durations, this might not carry as much significance, as the timing of the sampling will naturally mirror the flowering cycles of the nearby vegetation.

Trap setup

Malaise traps are commonly positioned in relatively level and open spaces measuring at least 2 meters by 1.5 meters. The apex of each trap is oriented towards the light source (typically northward), while the lower edges are secured by being anchored to the ground. The corners of the roof are fastened to pegs or trees, and in cases where suitable trees are lacking nearby, two poles might be necessary to ensure the tautness of all surfaces. For those insects that have a tendency to fall downward when hitting a barrier, pans containing a preservative can be placed below the central portion of the trap.

The collection container is usually filled with a killing agent which functions to preserve the organisms as well as their DNA. Usual agents include 95% ethyl (ethanol) or isopropyl alcohol and propylene glycol if the trap is to be left unattended for more than 2–3 weeks. The trap has the capacity to remain in use indefinitely, necessitating only the periodic replacement of the container (typically done once a week). This characteristic renders it an exceptionally low-maintenance and cost-effective method of sampling.

Sample collection and storage

To acquire the sample, remove the collection container from the Malaise trap by unscrewing it. Filter the specimens by pouring the sample through a filter (e.g., a fine mesh strainer or cheese cloth) placed in a narrow funnel. Employ the killing agent used to rinse the collection container and repeat the process as necessary to extract any remaining specimens (ref Figure 2 and 3). Another approach is to add more of the killing agent to the collection container (to prevent detrimental movement of the sample) and substitute the collection container with a spare one. For long term sampling, use the same killing agent/collection fluid each time. All samples and any parts of samples (together with the collection label) should be stored in undiluted ethanol (Walker & Crosby 1988). Where the specimens will not be used for DNA analysis (e.g., to be pinned and dried later) use 70% ethanol and add a drop of vinegar (after collection) to retain specimen flexibility for taxonomic purposes (Klimaszewski & Watt 1997).

References:

Klimaszewski, J.; Watt, J.C. 1997: Coleoptera: family-group review and keys to identification. Fauna of New Zealand No. 37. Manaaki Whenua Press, Lincoln. 199 p

Walker, A.K.; Crosby, T.K. 1988: The preparation and curation of insects. 2nd edition. DSIR Information Series 163

Addendum 2 - Clinometer

Background

A clinometer is a device used to measure angles of slope, elevation, or inclination relative to the Earth's surface or a reference plane. It is commonly used in various fields such as surveying, forestry, construction, and outdoor activities. Clinometers are designed to provide accurate measurements of angular deviations from the horizontal or vertical planes.

There are different types of clinometers, but they generally consist of a sighting mechanism, a scale, and a levelling mechanism. The user aligns the device with the target surface or slope and reads the angle measurement from the scale or display. The scale can be marked in degrees, percentages, or other units depending on the intended application.

Clinometers can be handheld or mounted on other instruments such as compasses or theodolites for more advanced measurements. In forestry, for example, a clinometer can help assess tree height or estimate slope gradients for planning purposes. In construction, it's useful for determining the angle of inclination when building ramps, stairs, or other structures. Additionally, hikers and mountaineers often use clinometers to gauge the steepness of trails or slopes for safety and navigation.

Overall, a clinometer is a practical tool for measuring angles of inclination and elevation in a wide range of situations, making it an essential device in various professional and recreational contexts.

How to use

For the purposes of the bee survey and training the use of a Suunto PM-5/360 handheld Clinometer was utilised (Figure 0). The following description and usage are for this make and model, modified from the Forestry Supplies Technical Bulletin M0003: https://www.forestry-suppliers.com/Documents/557_msds.pdf

Figure 2A. Suunto Clinometer
(photo source Forestry Supplies Technical Bulletin M0003)

Clinometer Basics

How To Hold and Read a Clinometer

Keep both eyes open when using a clinometer. Use the sight eye to look through the lens at the scales while the left eye sights alongside the clinometer housing. An optical illusion is created, and the horizontal sighting line will appear to project to the side of the clinometer housing. Place this sighting line on your target and read the scale.

Determining Height Using Percent Scales

To acquire height measurements with a percent scale clinometer, stand any convenient horizontal baseline distance from an object in which you can see both the top and bottom of the object. Then sight the top of the object for the top % reading and the bottom of the object for the bottom % reading. Then follow a simple mathematical formula to calculate the height:

% to top - % to bottom = total % height then total % height x horizontal baseline distance = height.

Using Percent Scale To: Determine Height Measurements on Level Ground and Above a Tree

Using the percent scale and horizontal baseline distance convenient for you to see both the top and bottom of the tree, follow these simple procedures. Back away from the tree the baseline distance. In this example, 80 ft. Sight the top of the tree and read the % scale (63%). Sight the bottom of the tree and read the % scale (-7%). Subtract the bottom reading from the top reading: 63% -(-7%) = 70%. To obtain tree height, simply multiply this percentage times your horizontal baseline distance. 70% x 80 ft. = 56 ft. tree height. (See Figure 2B.)

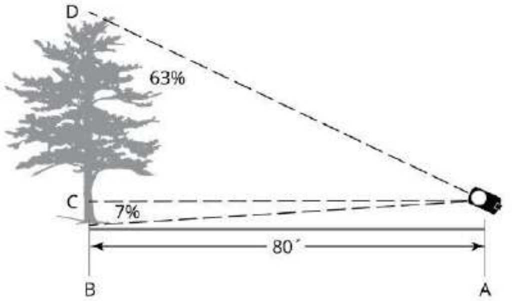

Figure 2B

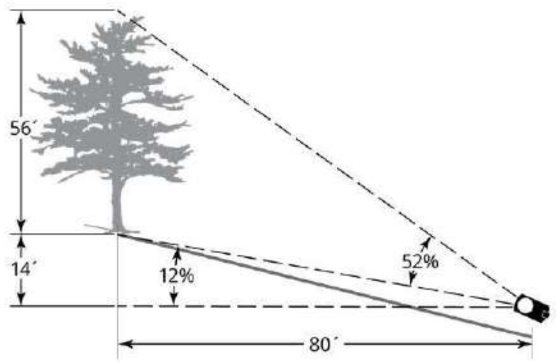

Figure 2C

(photo source Forestry Supplies Technical Bulletin M0003)

Using Percent Scale To: Determine Height Measurements on Sloping Ground and Below a Tree

Using the percent scale and 100' .ft horizontal baseline (or other baseline convenient for you to see both the top and bottom of the tree), follow these simple procedures. When the base of the tree is above eye level, sight the top then sight the base. Subtract the base reading from the top reading.

For example: 52% - 12% = 40%, then, multiply 40% x 80 ft. = 32 ft. (tree height) (See Figure 2C.)

When the base of the tree is below eye level, sight and read the top, then sight the base. Add the bottom reading from the top reading; then multiply by 80 ft. (baseline).

Using a Secant Scale To: Determine Horizontal Distance on Sloping Ground

To find an unknown horizontal distance (C), divide the measured slope distance (A) by the secant value of the slope (B). For example: 100 ft. ÷ 1.05 = 95.24 ft. (horizontal distance) (See Figure 2D.)

Using a Secant Scale To: Correct Slope Distance for a Desired Horizontal Distance

Correct slope distance (C) is determined by multiplying the required horizontal baseline distance (A) times the secant value of the slope (B). For example: 100 ft. x 1.05 = 105 ft. (correct slope distance) (See Figure 2E.)

Using Topographic and Metric Scale To: Measure Height

The topographic scale clinometer is designed to measure heights directly in feet when using a horizontal baseline of 66 ft. Take readings the same way described for the percent scale clinometer. The topographic scale can also be used at a horizontal baseline of 33 ft. or 132 ft., but the reading must be halved or doubled, respectively. The metric scale clinometer is used much the same as the topographic scale clinometer, in that they both read directly when at the horizontal baseline distance

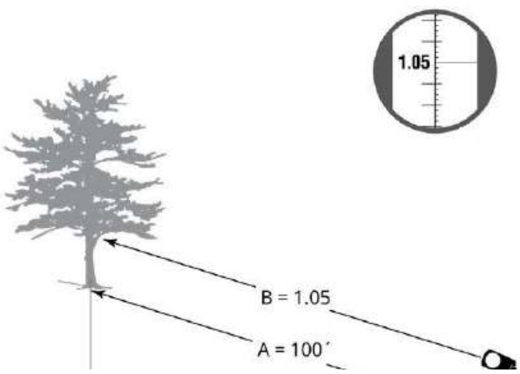

Figure 2D

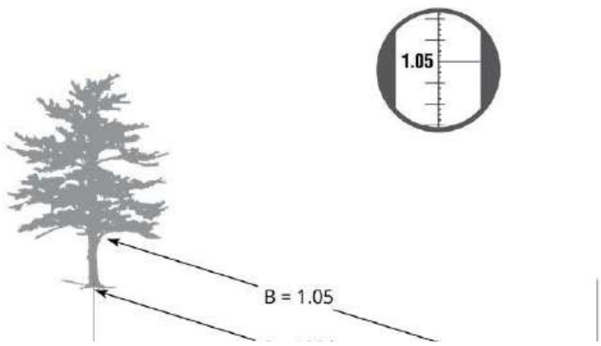

Figure 2E

(photo source Forestry Supplies Technical Bulletin M0003)

prescribed for them. The metric scale clinometer reads heights directly in meters.

Clinometer Scales

Each clinometer has two scales which are available in the following combinations: Percent and Degree, Percent and Topographic, 15m and 20m, or Percent and Secant. Scales are graduated from 0-90° in 1° units; from 0 to 70% in 1% units then in 2% units (72% to 150%). Graduations in the topo scale are 0 to ±200 ft. with a 66 ft. baseline. Scale readings can be estimated to 10 minutes or 1/5%, when readings are made around the zero level.

Measuring Slope

To measure slope, using a percent scale clinometer, sight parallel with the ground (upslope or downslope) to a target, aiming at a point on the target that is equal to the height of your eye above the ground.

Table 2A. Scale to use when measuring slope

Which Scale to Use		
Clinometer Scale Used	**Required Baseline Distance**	**Clinometer Reads In**
Topo	66 feet	feet
15m	15 meters	meters
20m	20 meters	meters
Percent	Any distance in feet, yards, or meters	% of baseline distance you select

Addendum 3 - Pan Traps

Background

Pan traps are predominantly employed to capture micro Hymenoptera, while they also effectively capture a diverse range of other insect species. The construction of a pan trap requires a small, coloured basin containing soapy water. Conveniently, plastic bowls or plates commonly used for eating or for children are well-suited for this purpose. To attract various insect types, different coloured receptacles are employed, with yellow, blue, white, and red being popular selections.

The operational procedure involves positioning a bowl on the ground, partially filling it with a water-soap mixture, and introducing a drop of dish detergent to disrupt the water's surface tension, facilitating insect submersion. It is important to conduct regular inspections of pan traps, ideally on a daily cycle.

Sample Collection and Storage

To retrieve the specimens, the water is strained through a finely meshed strainer or net. Following this, the strainer/net is subjected to a water rinse to guide its contents into a container containing 70% ethanol. Propylene glycol can be employed in place of ethanol.

All samples and any parts of samples (together with the collection label) should be stored in undiluted ethanol (Walker & Crosby 1988). Where the specimens will not be used for DNA analysis (e.g., to be pinned and dried later) use 70% ethanol and add a drop of vinegar (after collection) to retain specimen flexibility for taxonomic purposes (Klimaszewski & Watt 1997).

Figure 2A. Pan trap
(photo source: Lena Dempewolf)

Addendum 4 - Plant Sampling

Plant Collection Process

Step 1 - Planning for the field

Preparing for the conduct of any field collection event is an important step often overlooked by field personnel. Having a plan or checklist will allow for the efficient and timely collection of data and is an effort which will reap rewards for those willing to spend the extra time ahead of the field survey. Some of the items to cover during your preparation include:

▶ Field attire	▶ Equipment	▶ Weather	▶ Export permit
▶ Health & Safety	▶ Reconnaissance	▶ Collection permit	▶ Nagoya Protocols

Field Wear

Proper field wear is important. Comfortable clothing is recommended. Some of the things to consider when selecting your field wear include:

- Consider neon for safety and visibility especially at nights
- Long sleeves to protect against biting insects
- Dry fit fabric for staying cool
- Field pants canvas type, lightweight yet durable, with sufficient pockets
- Hiking boots with ankle support and rubber boots for wet areas

Health and safety

Consider the hazards which may occur during the conduct of your field survey and try to identify ways that these can be reduced or minimised. Don't forget to consider your driving route as well as the need to inform the police or other relevant authorities.

Students and individuals attached to institutions should consider undertaking a risk assessment and conducting a job safety analysis before each field visit.

Equipment

Before your site visit remember to select the appropriate tools for use in the field. At the minimum the following items should be carried:

Basic

- Sturdy backpack
- Plant press
- Blotters
- Notebook
- Straps
- Secateurs
- Plastic bags (various sizes) /Paper bags
- Paper bags (for bryophytes/loose items e.g., seeds)
- Garbage bags (large)
- Pens/pencils/markers
- Corrugates- metal/cardboard
- Hand lens (useful for viewing small specimens)

Additional

- Measuring tape
- Flagging tape
- Maps
- Cutlass
- Handheld GPS unit or GPS App on a mobile phone (if available)
- Handheld compass
- Handheld Weather Meter (if available)
- Clipboard and Data Sheets

Permits

If collecting on private land or protected areas, obtain necessary permissions or permits before collecting.

Be a Responsible Collector! Always check with the relevant local authority for permission to enter Protected Areas, Forest Reserves, Wildlife Reserves and Scientific Areas. Remember that permits may also be required for the export and importation of plant and animal material.

Some of the government agencies to contact for further information include the relevant departments of the:

Ministry of Agriculture Land and Fisheries: https://agriculture.gov.tt/

Tobago House of Assembly, Division of Food Security, Natural Resources, the Environment and Sustainable Development: https://www.tha.gov.tt/divisions/food-security-natural-resources-the- environment-and-sustainable-development/

Forestry Division: https://agriculture.gov.tt/divisions-units/divisions/

Environmental Management Authority: https://www.ema.co.tt/

Step 2 - Collection

Main Reasons for Collecting

The main reasons for collecting plant specimens are:

- To obtain records and specimens of plants, (in an area) either for research purposes, as use in a personal collection or to be stored in a herbarium.
- To identify an unknown specimen.

What to Look for in Collecting a Specimen

When collecting a specimen, one should pay attention to the following:

- Ensure that you accurately identify the plant species you intend to collect. Mistakes in identification can lead to mislabelled and misleading specimens.
- Choose a healthy specimen with flowers, fruits, leaves, and stems if possible. Avoid damaged, diseased, or immature specimens.
- Collect an entire plant if it's small, or representative parts (e.g., leaves, flowers, fruits, stems) for larger plants. Include enough material to provide adequate morphological features for identification. Mosses and lichens should also be taken whole.
- Collect specimens during the plant's flowering or fruiting stage if possible. This provides more comprehensive information for identification.

Important Information to Record

When collecting plant specimens for a herbarium or for further analysis, it is crucial to record comprehensive and accurate information to ensure the specimen's scientific value and proper documentation. The important information you should record are:

1. Collector's Information:
    - Name of the collector(s)
    - Collector's affiliation (institution, organization, etc.)
    - Collector's contact information (email, phone)
2. Collection Number:
    - Assign a unique identifier to the specimen for tracking and reference purposes.
3. Collection Date:
    - Record the exact date when the specimen was collected.

4. Location Information:

- Latitude and longitude coordinates (GPS readings if possible)
- Elevation above sea level
- Detailed description of the collection site, including habitat, vegetation, and nearby landmarks

5. Plant Identification:

- Common name (if applicable)
- Scientific name (genus, species, author)
- Voucher specimen details (a plant specimen used as a reference for identification)

6. Plant Part Collected:

- Indicate whether the whole plant or specific parts (leaves, flowers, fruits, stems) were collected.

7. Habit and Growth Form:

- Describe the plant's habit (shrub, tree, herb, etc.)
- Note the growth form (climbing, creeping, erect, etc.)

8. Associated Species:

- Mention any notable plants, animals, or insects found near the collected specimen.

9. Color and Scent:

- Describe the color and scent of flowers, leaves, or other parts, if relevant.

10. Notes and Observations:

- Include any additional observations, such as ecological notes, habitat characteristics, or unusual features.

11. Photographs:

- Capture clear photographs of the plant in its natural habitat, emphasizing key identifying features.

Remember that accurate and detailed record-keeping is crucial for scientific research, proper identification, and the long-term preservation of plant specimens in herbarium collections. The information you document contributes to our understanding of plant diversity, distribution, and ecology.

Steps 3 and 4 - Pressing and drying plant specimens

Pressing and drying plant specimens is a critical step in preparing them for preservation in a herbarium collection. Properly pressed and dried specimens ensure that the plant's morphological features are preserved accurately and that they can be stored for long periods without deteriorating.

Materials needed:

- ▶ Freshly collected plant specimens
- ▶ Blotting paper or old newspaper or felt drier
- ▶ Corrugated sheets (metal or cardboard)
- ▶ Plant press (consisting of wooden boards and straps or bolts)
- ▶ Heavy weight (If straps are not available, also consider bricks or heavy books)
- ▶ Labels with collection information
- ▶ Small envelopes or paper bags (optional)

Remember that pressing material immediately upon collection results in the best specimens. Samples that are allowed to wilt prior to pressing will generally produce poor specimens.

Use a standard press or a pair of hardboard or plywood boards cut to the same size as the drying paper. Place corrugated cardboard on one press/board, then place one sheet of blotting paper on top of this. Arrange your plant material on blotting paper or newspaper, retaining the character of the plant. Remove leaves and flowers of congested specimens to reduce the bulk without losing the character of the plant. Place the newspaper with the specimen onto the blotting paper and cover with another sheet. Place another corrugated cardboard atop this and repeat the process if you have many specimens. The order of the assembly is shown in Figure 4A.

Once all samples have been laid out, cover with the top press/board and place a heavy object on top, applying pressure evenly throughout, or use straps to keep the press tight. Move to a warm place, such as a drying cabinet, airing cupboard or damp-free room.

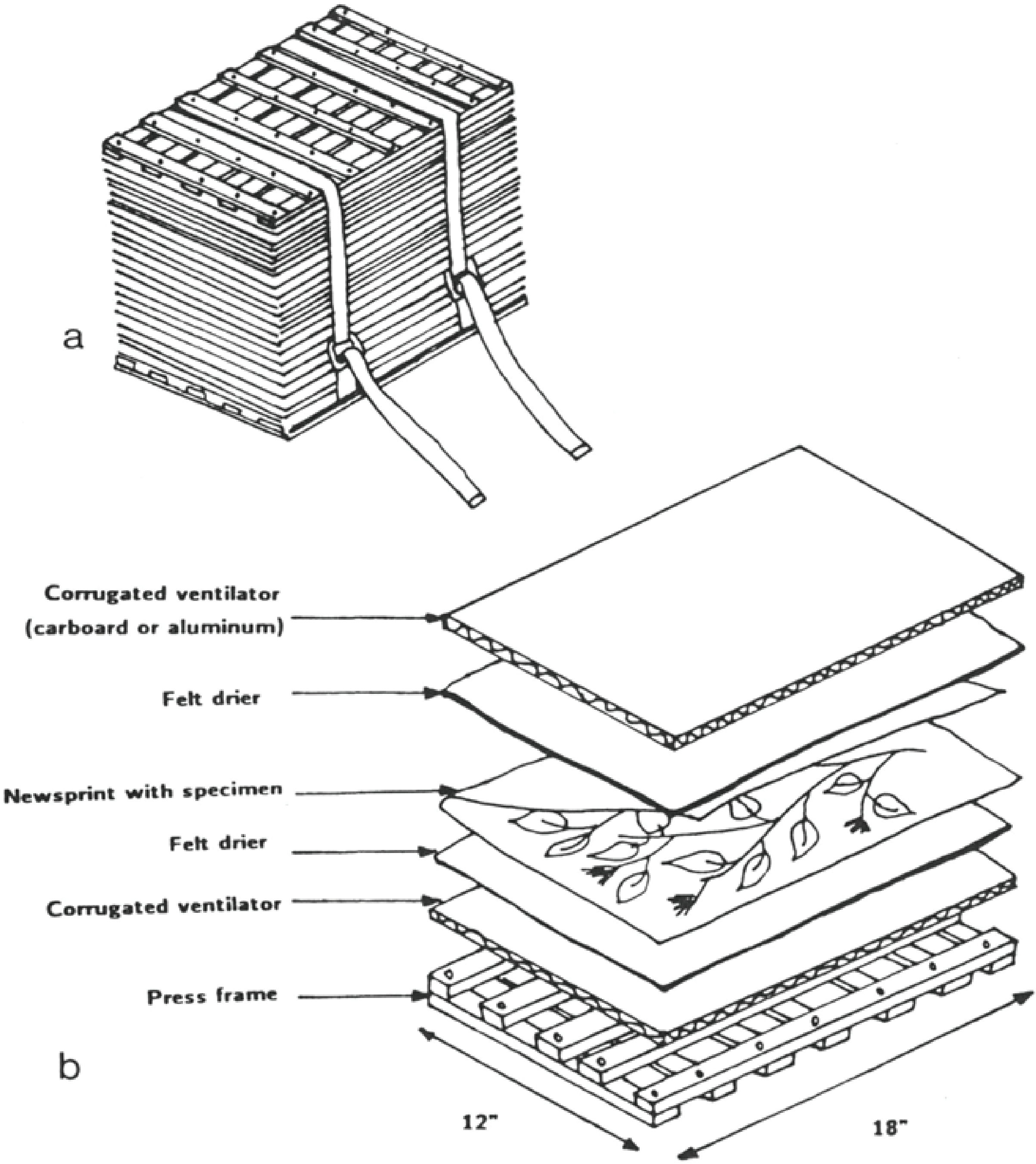

Figure 4A.

The Plant Press. a. Assembled view b. Exploded view showing components (Redrawn from Savile. 1962) Alexiades, Miguel N. “Standard techniques for collecting and preparing herbarium specimens.” Advances in Economic Botany 10 (1996): 99-126.

Addendum 5 - Abiotic Sampling

Abiotic sampling is a scientific method used to collect data and samples from non-living components of an ecosystem or environment. This approach focuses on the physical and chemical factors that affect an ecosystem, rather than the living organisms within it. Abiotic sampling involves the measurement and analysis of various abiotic factors, including:

- **Temperature:** Recording temperature data at different locations and depths can provide insights into thermal gradients and seasonal variations in an ecosystem.
- **pH:** Measuring the acidity or alkalinity of water or soil to assess its suitability for various organisms.
- **Moisture:** Determining the level of moisture or water content in a particular area, which can impact the types of organisms that can thrive there.
- **Salinity:** Evaluating the concentration of salts in water, which is critical in aquatic ecosystems.
- **Oxygen levels:** Assessing the amount of dissolved oxygen in aquatic environments, which is essential for aquatic life.
- **Nutrient content:** Analysing the presence of essential nutrients such as nitrogen and phosphorus in soil and water.
- **Light availability:** Measuring the intensity and quality of light, which is crucial for photosynthesis in plants and algae.
- **Soil texture:** Examining the composition of soil, including its sand, silt, and clay content, which affects water retention and nutrient availability.
- **Geological features:** Studying the physical characteristics of the landscape, such as rock types, soil layers, and landforms, which can influence the ecosystem's structure.
- **Chemical pollutants:** Identifying and quantifying contaminants or pollutants, which can have adverse effects on the environment.

Abiotic sampling is fundamental in ecological and environmental studies, as it helps researchers understand the physical and chemical parameters that shape ecosystems and influence the distribution and behavior of living organisms within them. This data is valuable for ecosystem management, conservation, and environmental impact assessments.

Researchers use a variety of instruments to record abiotic factors. For the conduct of the bee surveys a Kestral® Weather Meter was utilised Figure 5A. Some instrument instruments are also featured.

When measuring abiotic factors, it is important that the equipment used is well maintained and clean. Always record the abiotic conditions using the same method at each sample point to reduce sources of error. An example of a data sheet for record of the data is provided (Figure 5B).

Figure 5A A Kestral® Weather Meter

Project Name: ______________________________

Location Name: ______________ Station/Location ID: ______________

Data Collector's Name: ______________ Institution: ______________

Date: ______________ Time/Duration: ______________

GPS Coordinates: ______________ Elevation: ______________

Weather:

1a. Drizzle ☐ Light rain ☐ Heavy rain ☐ Overcast ☐ Sunny ☐

Other ☐ ______________________________

Temperature: Cool ☐ Warm ☐

With Instrument….

Temperature: ______________ °C @ ______________ (time)

Humidity: ______________ % @ ______________ (time)

Wind speed: ______________ Km/h @ ______________ (time)

Wind Direction: ______________

Note 1: Take photographs to illustrate components wherever possible

General Site Description

1a. 1. What you see (about ¼ of a page):

Figure 5B Sample data sheet

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Inside cover

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IKI INTERNATIONAL CLIMATE INITIATIVE

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