



Smart Hive for the Preservation of Native Stingless Bees in the Face of Climate Change: Innovative Solutions for Enhancing Meliponiculture Sustainability

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Introduction

Stingless bees are vital pollinators for biodiversity, agriculture, and food security, while also providing nutritional and medicinal products. Threatened by habitat loss, chemicals, and climate change, their conservation supports UN SDGs, making monitoring and preservation essential for sustainability and ecosystem resilience.



Problem/Objective

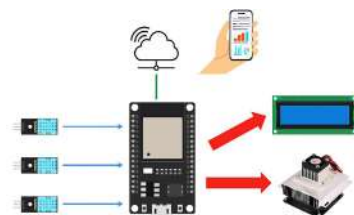
Maintaining optimal hive conditions outside natural habitats is a challenge. Traditional methods often lack proper environmental control, highlighting the need for innovative, technology-integrated solutions in meliponiculture.

Materials and Methods

To optimize hive conditions, two strategies were applied:

- **Monitoring:** Sensors (DHT11) measured temperature, humidity, and bee flow in three areas – hive interior, enclosure, and external environment.
- **Thermal Control:** A thermoelectric module (Peltier plate, heat sink, dual-fan cooler) regulated hive temperature, managed by an ESP32 microcontroller.

Maintaining ~34°C is vital for bee activity, ensuring their well-being, efficiency in nectar/pollen collection, and supporting sustainable meliponiculture.



Results

1 Awareness & Monitoring

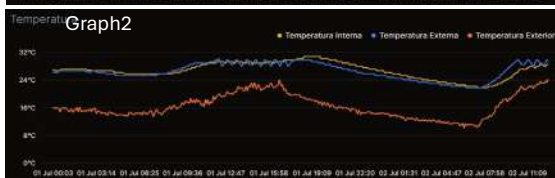
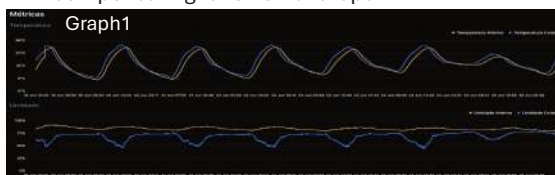
An awareness campaign highlighted the importance of proper management and technology for stingless bee preservation.



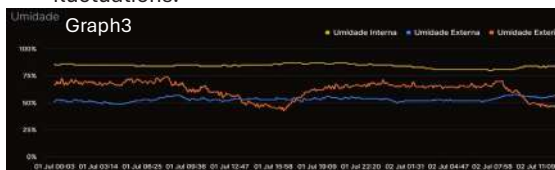
2 Results

Before thermal control (until June 29, 2024): Hive showed sharp fluctuations in temperature and humidity, often below ideal conditions.

- After Peltier module installation:
 - Graph 1 & 2: Stable internal temperature, compensating for external drops.



- Graph 3: Improved humidity regulation, reducing fluctuations.



- Outcome: Enhanced hive stability and improved well-being of the bees.

Conclusion

Temperature control stabilized hive conditions, ensuring the survival and activity of *Melipona quadrifasciata anthidioides*. The Peltier module created a favorable environment by reducing temperature fluctuations, while humidity monitoring improved colony well-being, biodiversity, and sustainable meliponiculture through innovation in hive management.

ONU SDGs Addressed:

- SDG 2: Zero Hunger
- SDG 11: Sustainable Cities and Communities
- SDG 13: Climate Action
- SDG 15: Life on Land



Recognition: 1st place, Scientific Papers, CONBRAPI 2024.



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Stingless bees (Meliponina subfamily) are critical pollinators essential for biodiversity conservation and agricultural productivity. However, they face significant challenges due to climate change, habitat loss, and pesticide use. These environmental stressors impact their survival, making it crucial to develop sustainable methods for their preservation. This project proposes a smart hive system that combines traditional beekeeping knowledge with modern technology to optimize the internal conditions of hives and ensure the health of native stingless bees. Sensors were utilized to monitor temperature, humidity, and bee flow within controlled hive environments, while a thermal control system—comprising a thermoelectric heat sink, dual-fan cooler, and Peltier module—was implemented to regulate internal temperatures. Data collected before and after the installation of the system revealed a significant reduction in temperature fluctuations and humidity instability, creating a more suitable environment for bee activity. The results demonstrate that technological innovation in hive management can mitigate the negative impacts of climate change, enhancing the sustainability of meliponiculture. This study aligns with the United Nations' Sustainable Development Goals (SDGs), particularly goals related to food security, biodiversity conservation, and climate action, highlighting the potential of technological solutions in preserving essential pollinators for future generations. This work, presented at COMBRAPI 2025, was awarded 1st place in the Scientific Papers category for its contribution to beekeeping and meliponiculture research.