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Stingless bee keeping: Biocultural conservation and agroecological education

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Introduction: Stingless bee breeding, also called Meliponiculture, has existed for thousands of years in Mesoamerica among a variety of rural and indigenous cultures. Due to its biocultural importance, it represents a perfect device for agroecological education and scaling, as well as pollinator conservation. At the same time, promoting agroecological transitions are necessary for conserving the cultural heritage that meliponicultures represent.

Methods: We organized a series of activities based on this premise: documenting and dialoguing "*saberes contemporáneos*" (contemporary knowledges), design and implementation of community agroecological workshops, guided visits at the institutional Meliponary at ECOSUR Villahermosa and promotion of agroecological and biocultural school gardens, all in Tabasco, México. We used "*diálogo de saberes*" (knowledge dialogues) as a methodological approach, promoting respect for the contribution of the diversity of ontoepistemologies involved. We drew on the ideas of several pedagogues, mainly from popular education and critical pedagogy frameworks.

Results and discussion: We identified characteristics of stingless bees and meliponicultures that make them excellent mediators for biocultural conservation and agroecological education: the complex, deep and beautiful relation between humans and bees; meliponiculture's ecological and cultural importance; stingless bees as pollinators par excellence, landscape connectors, and charismatic species; the association of bees with values around work and community; meliponicultures' symbolic relevance and emotional significance; meliponicultures as promoters of intergenerational dialogue; bee keeping as an activity of caring for the continuity of life; sensory stimulation through contact with colonies; learning through doing in the practice of beekeeping; meliponicultures as an activity requiring skill but no special equipment; and meliponiculture's productive potential. This confluence of teaching-learning opportunities, cultural and moral values, care for the land and biocultural diversity, and economic potential makes meliponiculture a potent catalyst for agroecological learning and transitions.

KEYWORDS

meliponiculture, meliponini, biocultural conservation, agroecology, pedagogy, biocultural heritage

Introduction

Bees (Hymenoptera: Apoidea) are some of the most efficient pollinators (Klein et al., 2007; Ollerton, 2017; Kevan and Silva, 2020), and play important ecological roles as herbivores, recyclers of nutrients and materials, prey for both large and small organisms, mutualists, parasites, and commensals (Roubik, 2020). Due to these complex interactions and ecosystem functions, they are considered as bioindicators in the Neotropics (Reyes-Novelo et al., 2008). The Meliponini or stingless bee tribe of the Apoidea, is distributed in the tropical and subtropical regions of Africa, Asia, Australia and America (Crane, 1992). The 550 described species (58 genera) of meliponines pollinate the native flora and agroecosystems of these regions with which they have evolved (Grüter, 2020; Real-Luna et al., 2022).

Breeding of meliponines in Mesoamerica has existed for more than 2000 years, according to diverse archaeological records. The oldest evidence for meliponiculture are ceramic effigy hobones[1] and solid limestone disks from the Late Formative period or Late Pre-classic (300 BC–AD 100) (Zrałka et al., 2018; Paris et al., 2020). There are also censers, stunning representations of the Mayan God Ah Mucen Kab. The: Tro-Cortesianus/Madrid Codex even dedicates 10 out of its 112 pages to the detailed description of the bee anatomy and knowledge related to the breeding of *Melipona beecheii*, named Xunaán kaab in Maya (Sotelo Santos, 2021). Nowadays in Mexico, 46 species of meliponines distributed in 6 genera are recognized (Ayala, 1999). Of these, at least 24 species (13 genera) are currently bred or were historically bred across 18 states. Moreover, we have found evidence that meliponicultures are present among at least 20 indigenous groups (Ayala et al., 2013; Vit et al., 2013; Reyes-González et al., 2014; Quezada-Euán et al., 2018; Arnold et al., 2019; Chan Mutul et al., 2019; Aldasoro Maya et al., 2021).

Each indigenous group and rural community presents a different way to interact with the stingless bees and a diversity of worldviews in which the interaction is immersed. These are embedded in "*saberes*": a complex system of knowledge, practice and belief (Berkes, 1999; Toledo and Alarcón-Cháires, 2012) that are a substantial part of the cultural diversity of the country. We propose the use of the term "*saberes contemporáneos*" (instead of traditional knowledge) to emphasize their continued existence and particularly their pertinence for the future, as well as to recognize that they are result of the interchange of ideas and experiences in a globalized world (Aldasoro Maya, 2012; Chan Mutul et al., 2019; Linares-Rosas et al., 2021).

In order to approach the biological as well as the cultural importance of bee breeding, we use the framework of biocultural diversity and heritage studies. This term is based on Nietschmann's (1992) axiom: biological and cultural diversity are geographically coexistent and mutually dependent. We conceptualize meliponiculture as biocultural heritage, using Boege Schmidt's (2017, p. 50) definition: "*all collective material and immaterial wealth that carries a historical process in its conservation and sustainable reproduction, which is under the protection of cultural groups in the use, management and exploitation through their traditional practices and wisdom.*"[2]

We highlight meliponiculture as biocultural heritage because, due to the high prices of honey and other products of the colonies, some regions of the country are experiencing boom of interest around stingless bee breeding solely as a productive activity. These reductionist perspectives tend to dismiss the *saberes* that result from a historical relation that many communities have had for generations with the bees. Sadly, some initiatives manage to impose their technocratic view, and establish unequal power relations that promote cognitive injustice, and eventually epistemicide (Santos, 2009). We have witnessed government and academic initiatives that seek to increase productivity by imposing "improved" hive boxes and schedules for hive maintenance without regard for local knowledge or non-economic values. Thus, they threaten the cultural and historical complexity of stingless bee breeding.

We firmly believe the best way to conserve the worlds' biological and heritages is through innovative education, designed on the basis of specific, well-defined pedagogical models. We draw from *experiential,* cognitive constructivist and social pedagogy models (Flórez, 1995), as well as some more recent proposals such as Pedagogy of resistance and emancipation (Korol, 2006), Decolonial Pedagogies (Walsh, 2013) and Pedagogy of tenderness (Cussiánovich, 2005). The education-pollinator conservation-biocultural heritage conservation nexus has been gaining attention from international policy makers concerned with education for pollinator conservation. At its 14th meeting, the Conference of the Parties to the CBD adopted the Plan of Action 2018–2030 for the International Pollinator Initiative (FAO, 2021, p. 6) and included as one of the four overall objectives that will be implemented: "In promoting education and awareness in the public and private sectors of the multiple values of pollinators and their habitats, in improving the tools for decision-making, and in providing practical actions to reduce and prevent pollinator decline." Also, in the international arena, IPBES (2016) recognized the potential that indigenous and local knowledge have in dialogue with science to face the current situation of pollinators. They endorse practices that enhance abundance and diversity of pollinators by promoting diverse farming systems. This knowledge also has been useful for improvements in hive design, new understanding of parasite impacts and the identification of stingless bees new to science. The importance of indigenous and local knowledge about

1 Hollowed logs for stingless bee breeding, used mainly in the Maya Culture.

2 Translation by the authors.

pollination and pollinators associated with food production all around the world and under very diverse cultural frameworks is increasingly recognized (Lyver et al., 2014).

So, we have serious threats to pollinators and biocultural heritage, caused by several socioecological problems. Many of these challenges are related to agroindustrial food system that pollute, diminish biological diversity and overlook other ways of producing food (frequently referred to as traditional) (Cham et al., 2019; Shanahan, 2022), disregarding *saberes* related to gastronomy and health. Therefore, to conserve pollinators as well as biocultural diversity, we argue that it is urgent to promote agroecological production hand in hand with local/indigenous people as well as with diverse peasant communities. Agroecology "studies the structure and function of agroecosystems both from the point of view of their ecological and cultural relationships" (León Sicard, 2009, p. 9) and "claims the essential link between soil, plant, animal and human beings" (González de Molina, 2011, p. 12).

Thus, we identify a potential positive feedback loop: conservation of biocultural heritage embodied in native beekeeping contributes to agroecological transitions, which in turn improve habitat for bees. Both pollinator conservation and agroecological transitions require educational efforts, and the pollinators and their management are ideal pedagogical devices. Mier y Terán Giménez Cacho et al. (2018) proposed constructivist and horizontal teaching-learning processes as one of eight key drivers for scaling agroecology. Agroecologists identify a pressing need to advance in the design and implementation of avant-garde pedagogical models that promote agroecological transition processes, including a focus on critical food systems education and gender-equality-oriented pedagogy (Rosset, 2015; Meek and Tarlau, 2016; Schwendler and Thompson, 2017; Ferguson et al., 2019). Meliponicultures are a perfect aid. They have cultural meaning and symbolic relevance, and they can be the entry point to ecological themes such as: landscape interconnection, pesticides and their consequences, and the importance of biodiversity, just to mention some examples we will explore.

In the Anthropocene/Capitalocene (Moore, 2016; Malhi, 2017; Ulloa, 2017), our relationships with stingless bees offer potent examples of how humanity can steward life on earth. Here, we present four case studies from Tabasco, Mexico, in which we used biocultural heritage and stingless bee breeding to articulate educational processes that favor pollinator conservation. We then highlight characteristics of meliponiculture that make it a potent pedagogical device for agroecological transitions.

Area of study

The southeastern Mexican state of Tabasco extends from 17°15′ and 18°39′ north latitude and 91°00′-94°07′ west longitude. The state borders the North with the Gulf of Mexico and Campeche; to the South with a mountainous area of Chiapas and Guatemala; to the West with the state of Veracruz, and to the East, with the state of Campeche and the Republic of Guatemala. Tabasco is formed by low, humid, alluvial plains with swampy depressions that can be flooded, both by rivers and by tropical storms and abundant rainfall. It drains into the Gulf of Mexico *via* the two largest rivers in the Republic, the Usumacinta and the Grijalva, and their numerous tributaries. Tabasco has a humid tropical climate, with temperatures ranging from lows of 15°C in December and January to highs of 42°C in April and May (INAFED, 2022). The flora is tropical rainforest, tropical savannah, lowland beach formations, mangrove forest, and swamp vegetation. Among the main activities are: commerce (around 9%), and oil exploration (60%) [SE (Secretaría de Economía)., 2016]. Tabasco had one of the highest rates of deforestation from 2002 to 2021, losing 10% of the total area of primary rainforest (Global Forest Watch, 2022). The state has undergone strong socioenvironmental changes as result of oil exploration activities, as well as governmental programs implemented under the 1960s Chontalpa Plan that aimed to turn the state into the breadbasket of Mexico through agro-industrial food production (Fuentes Aguilar, 1977).

Materials and methods

We worked on four projects centering education through meliponiculture and related biocultural heritage: (1) documentation of "*saberes contemporáneos*" with stingless bee breeders within their communities and promotion of dialogue with peers from other states: Teocelo and Atzalan, Veracruz, and Rancho Nuevo, Oaxaca; (2) design and implementation of community agroecological workshops in Comalcalco, Tabasco; (3) guided visits at the institutional meliponary of ECOSUR, Villahermosa, and (4) promotion of agroecological and biocultural school gardens in Tabasco. The work with bee breeders and their communities and with the biocultural and agroecological school gardens are medium-term processes. By contrast, the guided visits are one-time interventions, in most of the cases. However, we did have repeat visitors who would come back with their families and friends, as well as teachers, who would organize a visit with their students.

1. Documenting and dialoguing "*saberes contemporáneos*"

We started documenting the *saberes contemporáneos* in the Municipalities of Comalcalco and Tacotalpa. We collaborated with managers of three particular meliponaries in Tacotalpa [mainly with colonies of *M. beecheii (mosca real/abeja real*); Figure 1], but also with some *Melipona solani*, *Scaptotrigona pectoralis (pijón, nopa roja)*, *Friesomelitta nigra, Tetragonisca angustula (angelita)* and *Plebeia* spp. Later, the Comalcalco group established community colonies of *Nannotrigona perilampoides* (Sayulita, cigarrera). In Comalcalco, we organized

FIGURE 1
Mosca real o abeja real (in local Spanish; *Melipona beecheii*).

workshops (4) to discuss the information gathered with breeders and others interested in meliponiculture. We later broadened our focus to include several more communities throughout Tabasco (Chan Mutul et al., 2019), and organized a workshop to return our findings to participants in Tenosique, the municipality with the highest number of stingless bee breeders. The fieldwork included interviewing ∼100 stingless bee breeders in the state and from participant observation in workshops and regional meetings. Meliponiculturists represent a considerable cultural diversity that includes non-indigenous rural communities and people mainly from yokot'an (chontales), aktya'ñ (choles) and bats'il k'op (tseltales) indigenous groups.

We followed up with exchanges with other communities, first between Comalcalco and Tacotalpa, Tabasco, and then through regional meetings in the state of Veracruz with participants from the academy and NGO's as well as bee breeders. The first Veracruz meeting, in Teocelo, was organized by INANA A.C., an organization that has been working for at least 11 years with stingless bee breeding with a holistic view, paying particular attention to the importance to the landscape level. They have a program for production of native trees and reforestation in the region of Coatepec, Veracruz and have developed important educational initiatives (INANA, 2022). The second, in Atzalan, was organized by Dr. Luciana Porter Bolland and her research team from INECOL[3] A.C. In these meetings we learned about *saberes* from these regions and the different meanings ascribed to stingless bee breeding, and we reflected on the implications and responsibilities surrounding meliponiculture at the family and landscape levels. After returning from each meeting, we held workshops to share learnings and reflections with the rest of the group. We organized two training courses in Oaxaca on transferring and dividing colonies, held in the meliponary of Mr. Emilio Pérez, an expert Chinantec bee breeder. Members of both the Comalcalco (5) and Tacotalpa (3) groups participated.

2. Design and implementation of community agroecological workshops in Comalcalco, Tabasco

In 2018, we organized a series of seven community agroecological workshops with five communities in Comalcalco. We reflected on stingless beekeeping as biocultural heritage, and from there approached several other agroecological topics.

3 Instituto de Ecología A.C. (https://www.inecol.mx/inecol/index.php/es/).

FIGURE 2
Community agroecological workshops in Zapotal, Comalcalco, Tabasco.

We designed these workshops based on previous research on meliponiculture (Aldasoro Maya et al., 2015, 2016; Aldasoro et al., 2018; Chan Mutul et al., 2019) and related topics such as food culture and home-garden multifunctionality (De León Loera, 2017; Avilez-López et al., 2020). The workshops were designed by the interdisciplinary team formed by the first, second, third and fifth authors. They were based on the aforementioned pedagogical frameworks, and were structured in four key moments: documentation of knowledge, dialogue of knowledge between what was documented and what was contributed from the academy, one of connection of ideas with the emotions and daily life of the people, a practical moment, which implied doing, and finally, one of co-design of proposals and hopes for the immediate present and the future. All of them took place in adapted local spaces, which we considered relevant to create an environment of trust and rapprochement with the communities (Figure 2).

3. Guided visits of the institutional meliponary of ECOSUR, Villahermosa

In 2015 we established an institutional meliponary at Ecosur, Villahermosa, in which we have colonies of four species. Two of these, *M. beecheii* and *N. perilampoides*, are traditionally bred, while the other two, *Trigona corvina* (Figure 3) and *Trigona fuscipennis* (*enredapelo* or *cuajacabeza* in local Spanish), are not and on the contrary, they are commonly destroyed due to the behavior they exhibit: tangling in the hair.

In the meliponary we hosted guided visits through which we dialogued with people from diverse educational levels and sectors (municipal and state-level politicians, ECOSUR Villahermosa's administrative staff, as well as researchers from other research centers). These guided visits covered the cultural and historical importance of meliponines and were designed around observations of the colonies and reflection about what they need to survive. From there, we discussed the necessity of agroecological production and transitions, and the central agroecological principles (Figure 4).

4. Promotion of agroecological and biocultural school gardens in Tabasco

The project implemented school gardens in eight schools of the Centro municipality during 2018–2019 (Aldasoro Maya et al., 2019; Rodríguez-Robles et al., 2019; Montiel Sánchez et al., 2021; Valencia, 2021). The proposal was based on the breeding of native stingless bees as a key point to trigger reflection on the need for the gardens to be

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FIGURE 3
Enredapelo o cuajacabeza (in local Spanish; *Trigona corvina*).

agroecological, in fact the proposal for the gardens arose after a visit by the teachers to the institutional meliponary of ECOSUR. Due to the COVID pandemic, we did not achieve our dream of establishing stingless beekeeping in the school gardens.

In each of these four spaces, we designed and developed methodologies based on the framework of Participatory Action Research (Rahman and Borda, 1988; Fals Borda, 1999, 2007; Ortiz and Borjas, 2008), including dialogues of *saberes*; exchanges of experiences based on horizontal relations that

FIGURE 4
Guided visit at the meliponary of ECOSUR Villahermosa.

promote critical thinking and respect different epistemologies. We designed and carried out diverse activities to create spaces to think about stingless bee breeding's environmental and cultural importance as well as the necessity of learning and using agroecological principles as how those principles can be applied in many different agroecosystems (for e.g., cacao agroforestry systems, home gardens, milpas).

We use Martínez-Torres and Rosset (2014, p. 982), definition of "diálogo de saberes":

> "*A collective construction of emergent meaning based on dialog between people with different historically specific experiences, cosmovisions, and ways of knowing, particularly when faced with new collective challenges in a changing world. Such dialog is based on exchange among differences and on collective reflection, often leading to emergent re-contextualization and resignification of knowledges and meanings related to histories, traditions, territorialities, experiences, processes and actions. The new collective understandings, meanings and knowledges may form the basis for collective actions of resistance and construction of new processes.*"

Using Flórez (2006) categorization, we drew principally from three related models of education: experiential or activist models, cognitive or constructivist models, and social cognitive models.

Experiential or activist models

These models belong to the New School tendency, that conceptualizes the student as a subject that deserves respect and consideration, to whom the educational process should be adapted. The axis of development comes from within the student, who, as the center of the educational process, has an active role of his or her own learning. The teacher facilitates the process, preparing materials that use the students' reality as starting points to allow them to acquire experiences (Vives Hurtado, 2016). One of its main representatives is Ovide Decroly, from who's school of thought we take up the ideas of "education for life, in life," as well as active learning, and respect, freedom, and individual attention for each learner (Trilla, 2001; Gadotti, 2002).

Cognitive or constructivist models

As its name indicates, this has as its main objective the cognitive development of the apprentice and conceptualizes the teaching-learning process as a critical activity. The methods are directed to letting the student build their own knowledge and cognitive structure (Vives Hurtado, 2016). Within this framework we consider the ideas of John Dewey, David Ausbel, and Joseph Novak. Dewey proposes learning by doing. Ausbel argues that action is key for learning and emphasizes that the learning process depends on the sense and significance that the apprentice confers to the new contents. To this, Novak adds the importance of emotions for significant learning. All constructivists recognize that the significance of new contents depends upon previous knowledge. Among these models, we find a social current represented by Lev Vygotsky's assertion that cognitive progress is a socially mediated process, as participants obtain cultural values, beliefs and different skills through interaction with their families and with other knowledgeable members of society (Trilla, 2001; Gadotti, 2002).

Social cognitive model

This model is concentrated on the development of the collective spirit, the foundation of social practices in combining productive work with education (Vives Hurtado, 2016). Paulo Freire is the most important representative of the emancipatory and critical pedagogies from which emerged popular education that is directed to solve problems and hence to action to change society in search of liberation. This is education in which people are fully recognized as subjects and active agents, and in which their *saberes* are respected and considered as the base for the construction of new knowledge throa respectful and inclusive dialogue (Freire, 1970, 2002). Popular education and critical pedagogies have a central objective: the propitiation of the development of critical thinking (McLaren et al., 2001). These pedagogies, focused on solving concrete problems, are commonly used in agroecological education (Rosset and Martínez-Torres, 2012; McCune et al., 2014, 2017; Rosset et al., 2019; Anderson et al., 2020; Goris et al., 2021; Casado et al., 2022).

We integrated elements of newer models, including pedagogy of resistance and emancipation (Korol, 2006), decolonial pedagogies (Walsh, 2013) and pedagogy of tenderness (Cussiánovich, 2005).

A field diary was kept for each of the activities, and then the qualitative information obtained was systematized and organized based on codes that became the axis of the 13 points proposed to explain why meliponiculture is useful for agroecological education, except for the last one, which emerged more from group discussion and reflection, since the economic importance of meliponiculture could not be ignored.

Based on the analysis of the information, a bibliographic review was carried out to support the points outlined.

Finally, we sampled stingless bees from meliponaries throughout Tabasco (except the municipality of Cárdenas). JM identified the specimens and deposited them at ECOAB, the collection of ECOSUR, San Cristóbal de las Casas.

Results and discussion

Meliponiculture as biocultural heritage

After analyzing the situations under which meliponiculture is practiced and promoted in Mexico, we argue that it constitutes a *contested territory*. At risk of oversimplifying, and with the aim of contributing to reflection, we can identify two main trends in meliponiculture. One group of breeders is focused on commercialization and technification, with little regard to non-economic consideration. At the other end of the spectrum are the breeders with whom we work. They focus on guaranteeing access to the products of meliponiculture—honey and, more recently, other products of the colonies such as propolis that they recognize as important for health care—for their families and communities. Their vision is holistic, embracing the multiple, diverse connections that bee breeding has with the environment. It is also historical, as it honors traditional human-bee relations, that are the base for the generation of new knowledge. This is meliponiculture with cultural identity that embraces all the elements of *saberes*: knowledge, practice, beliefs, emotions, and feelings that stingless bee breeding invokes and evokes in different cultural frameworks. As Chan Mutul's et al. (2019) have emphasized, we should talk about meliponicultures, in plural, to acknowledge the impressive diversity of objectives and motivations surrounding bee breeding.

We considered it urgent to promote critical dialogue and learning among beekeepers at both ends of this spectrum. The biocultural diversity theoretical framework (Maffi, 2001, 2005; Mathez-Stiefel et al., 2007; Pretty et al., 2009; Maffi and Woodley, 2012; Gavin et al., 2015; Rotherham, 2015; Vidal and Brusca, 2020) could help build bridges for this necessary dialogue. The biocultural focus is a powerful tool for diminishing the society-nature dichotomy and confronting the idea of the supremacy of humans over other living beings that threatens the conservation of the biological diversity and that compromises its existence for future generations, hence seriously affecting the planet's health. This agenda is particularly relevant in Mexico, as it is considered to be among the countries with the highest levels of biocultural diversity (Toledo, 2003; Loh and Harmon, 2005). Sadly, this biocultural diversity is in peril, as many areas confront a downward spiral of erosion of species diversity, coupled with

loss of cultural diversity as evidenced by endangered languages (Vidal and Brusca, 2020). Stingless bee breeding in particular is considered to be endangered biocultural heritage in different regions of Mexico (Quezada-Euán et al., 2001; González-Acereto et al., 2006; Reyes-González et al., 2020).

Taking a broader view, this is due to several sociocultural, political and economic factors that have led humanity to what Leff Zimmerman (2004, p. 241) has defined as a civilizational crisis: "It is the derangement of the world to which the reification of the self and the overexploitation of nature leads." Thus, we can understand why meliponicultures are so relevant today, as some of them resist this derangement, embodying the recognition of the sacredness in small creatures and our relationships with them. Bioculturalism goes beyond conceptualizations where bees, are just one more natural resource to manage and exploit, to deconstruct the utilitarian thinking that permeates the so called "modern life" and the "development" discourses. A lot of research is needed to better understand Mexico's biocultural diversity, as we hardly know the relation of stingless bees with different indigenous groups and peasant communities; a relation that forces us to rethink ourselves as a species and challenges our disregard for other living beings.

Saberes contemporáneos

The starting point, under the pedagogical framework we proposed is to recognize, study, register, and analyze the *saberes contemporáneos*, as the basis for the construction of new knowledge (Aldasoro Maya, 2012). We propose the re conceptualization of the term *saberes*, to emphasize their constant production and reproduction, rooted in traditional/historical/local/indigenous knowledge and practice, but also modified and re-signified. *Saberes contemporáneos* are the result of a world increasingly interconnected by the mass media, the internet, and mobility. Some call this globalization, but we prefer to think of it as "glocalization" to recognize the interaction between global processes and local agency (Robertson, 1994; Appadurai, 1996). This framework builds from studies of Traditional Ecological Knowledge (TEK), which, according to Berkes' (1999, p. 8) definition is *a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment*. In parallel, Toledo and Alarcón-Cháires (2012), identify knowledge (corpus), practice (praxis) and beliefs (cosmos) as the elements of the *saberes locales* (local knowledges). The *saberes contemporáneos* concept adds the elements of power, emotions, feelings and motivations as the other key elements of these systems of *saberes* or knowledge, and with this we aim to contribute to deepen the comprehension of the saberes, their dynamics and so, ways of reinforcing their use, valuation and thus conservation but according and responding to the context in which they exist and challenges they face (Aldasoro Maya, 2012; Chan Mutul et al., 2019; Avilez-López et al., 2020; Linares-Rosas et al., 2021; Tapia-Hernández et al., 2021; Einbinder et al., 2022; Fisher-Ortíz et al., 2022).

The *saberes contemporáneos* around stingless bee breeding are the spinal column of the present paper. To talk about "*saberes*" instead of "knowledge" is to recognize that what it is known is not "objective" as western science has claimed for centuries, and argues for deconstructing dichotomies such as mind-body, mind-feelings and knowledge-beliefs/worldviews, to embrace humans and their cultures in an integral manner. This view accepts that even scientific knowledge is influenced and determined by scientists' backgrounds, feelings, culture and so forth (Damasio, 1996). It thereby takes an important step toward recognizing the ontoepistemological diversity that exists in the world Gómez Salazar (2009), and that is magnificently represented by meliponicultures. With this term, we refer to all the different ways in which people comprehend, conceptualize and explain the world, and we argue that this ontoepistemological diversity has intrinsic value on itself, beyond its utility from a Western perspective, for the management and conservation of so-called "natural resources" (Huntington, 2000; Shackeroff and Campbell, 2007; Whyte, 2013).

The term contemporary knowledge adequately responds to the dynamics documented in the fieldwork. We had the opportunity to interview young meliponiculturists, who started with the breeding of native stingless bees as a result of training courses, so they do a technified management. However, when we delved into their practice, it was very common that their interest in meliponiculture had its origin in family background, therefore, also in knowledge and in the way of relating to bees, beyond the technical aspects. These young people have, on the one hand, traditional knowledge, technical training, produce new knowledge by doing their own experiments and, on the other hand, as a result of new technologies, they have access to proposals from distant places *via* social networks (facebook groups, whats up groups, instagram) and youtube videos. Therefore, we are talking about knowledge and *saberes* with diverse origins and meanings, which are appropriated and re-signified to the contexts in which they find themselves. Given these scenarios of change, it is relevant to see that what remains are emotions and feelings, a key component of our proposal for the conceptualization of contemporary knowledge.

Meliponicultures in Tabasco

Bee keepers in Tabasco tend 11 species in their meliponaries (*M. beecheii, M. solani, N. perilampoides*, *S. pectoralis, F. nigra, T. angustula, Trigona fulviventris, T. corvina, Cephalotrigona*

zexmeniae, Scaura argyrea and *Plebeia fulvopilosa*[4]). Together, they expressed considerable diversity in motivations and objectives that sustain meliponiculture. We studied breeders' nomenclature, knowledge, practices, and beliefs, as well as their emotions and feelings. Detailed information of these *saberes contemporáneos* has been published elsewhere (Chan Mutul et al., 2019). It is important to determine the species with which people are interacting, as their biology is different and should be considered into account for the breeding. Additionally, the diversity of species is concrete proof of the holistic approach of the meliponiculturists in Tabasco, and the importance of this for the promotion of agroecological transitions. This contrasts with the reductionist views that permeate at the national level and that focus on the species considered the most charismatic *Xunancab*[5] (*M. beecheii*) in the Yucatan peninsula and *Pisilnektsin* (*Scaptotrigona mexicana*) in Puebla, with this promoting reductionist approaches and endangering these species from over-exploitation.

Meliponicultures' benefits for agroecological education and biocultural conservation

The depth of these *saberes* informed the pedagogical models we chose for the design of educational activities. We argue forcefully that education is among the most powerful tools for the conservation of wild pollinators in the short, middle, and long term. It is essential to discuss and define the pedagogical models to use in agroecological and biocultural education in order to work with those that respond to a particular and historical context. Otherwise, we risk developing meaningless activities, or even worse, supplanting *saberes*, as so often occurs under conventional modes of extension. We also agree with Vives Hurtado (2016) that it is possible to combine elements of different pedagogical models that are consistent with each other.

Meliponicultures, biocultural heritage, and agroecological education

Rabelo (2007) approached the possible synergy between meliponiculture and agroecological principles but pointed out this should not be taken for granted. He states the economic, social, ecological, political, cultural, and ethical dimensions of sustainability should be considered for this synergy to materialize. He proposed developing stingless bee breeding in permanently preserved areas, including agroforestry systems, close to vegetables and medicinal plants, in places free of agrochemicals. He also stressed reinforcing and even recreating the trade channels for the products of meliponiculture and considering empirical knowledge of bee breeders. Finally, he argued that breeding systems should be adjusted to agroecosystem heterogeneity, and that breeders should not introduce exotic species and should avoid extracting colonies from trees. Simms and Porter-Bolland (2022) recognized the local ecological knowledge around stingless beekeeping in Atzalan (Veracruz, Mexico) as part of the legacy of biocultural diversity and recognized its importance for integrated landscape planning through the enhancement and safeguarding of agroforestry systems. These are the kinds of meliponiculture that can help articulate processes of agroecological education.

ECOSUR has developed several distinct processes along these lines (Pat Fernández et al., 2021). The Bee Team in San Cristóbal de las Casas has been developing a training proposal since 2016 called Bee Guardians, focused on territorial conservation through sharing knowledge about native bees and promotion of meliponiculture as an activity that responds to a broad set of values (Delfín Fuentes, 2019). Concrete lessons drawn from iterations of this process include avoiding cutting trees, moving colonies more than 50 km from their origin, feeding the colonies as a routine practice or buying colonies that have been extracted from trees (Delfín Fuentes et al., 2019). They invite people interested in stingless beekeeping to consider carefully: the differences with apiculture, the importance of all bees, not only those that can be kept, to be patient as our eyes and heart learn to find and identify the bees, to take care of the physical space need for the colonies and be aware that their care demands time, the need for plating native species of plants, to consider carefully what is and what is not "the rescue" of a colony, learning about meliponine species that can be kept and those that cannot, and the importance of the consumption of the colony products by the families of the beekeepers and avoiding commodification (López Barreto and Pinkus Rendón, 2020). In synthesis, their focus on stingless bee breeding goes far beyond utilitarian and economic motivations (Delfín Fuentes et al., 2021), to embrace ecological and emotional values.

Non-academic actors are also developing educational processes built around meliponicultures. Veracruz-based INANA offers educational practices based on the *diálogo de saberes*. Their School of Native Bees promotes the craft of Meliponiculture with an emphasis on the conservation of the bio-cultural territory. As part of this effort, they have produced educational material that invites critical reflection on the socioenvironmental problems that the region faces. This material has as its main objective to relate *saberes locales* with scientific knowledge, fortifying ancient and contemporary knowledges that value native bees and their habitats together with *buen vivir* (collective wellbeing) rooted in biocultural landscapes (Zepeda García Moreno and Estrada Paulín, 2016; INANA, 2022).

In Santa Lucía, Nicaragua, Luna Delgado and Angulo Sobalvarro (2019) have used stingless bee breeding as a

4 This species has been just confirmed, in Chan Mutul et al. (2019) we only had the genus.

5 The maya name for *Melipona beecheii*.

pedagogical mediator (*sensu* Vigotsky; Gadotti, 2002) for agroecological education. They managed to revitalize the agroecological movement through horizontal peasant-to-peasant methodology integrating popular education, local knowledge, and *diálogo de saberes*. People in the area of study started learning about stingless bee breeding, and this ignited agroecological transitions on their farms. These transitions include use of bioinputs, reducing or eliminating chemical inputs, and farm diversification. In Corozo, Nicaragua, Arauz (2020) looked at how women's contributions to family farming production and crop diversification allow native bee conservation. She further asserts that, through stingless bee breeding, women can defend community heritage more broadly.

The agroecological training center, *U Yits Ka'an*, in Yucatán, México, adds a spiritual element to this work (López Valentín et al., 2020). For *U Yits Ka'an*, spirituality and identity interact with productive activities to sustain a good, full, and dignified life (*Ma'alob Kuxtal* in Maya). Meliponiculture is one of the few activities that the organization identifies as integrating all these dimensions. They approach stingless bee breeding through several activities and perspectives: historical recovery, *Xunancab* day, a honey analysis laboratory, traditional medicine, recuperation of melliferous species, and a group of epigraphers who are analyzing the Madrid codex, including its references to meliponiculture. A key to these learning processes is prioritization of the collective over the individual, working toward emancipation and the reconstruction of the "being," so that individual change makes the group activities possible. This implies conceptual and structural as well as technological changes. The power of training center's work lies in resignifying and reinventing agroecology based on Maya identity (López Valentín et al., 2020).

Now, integrating the above ideas together with our own anthropological and pedagogical approaches and fieldwork, we summarize in 13 points why meliponicultures are an aid for agroecological education.

I. **Relationships among humans and native stingless bees are complex, deep, and beautiful**
   People we interviewed often referred to the meliponines they breed as equals, even relatives. Women in particular referred to bees as friends, sisters, or kin in general and some of them like to think of themselves as bee women. The relation denotes the paradigm from which people relate to other living beings; one based on respect and the recognition of the importance of all living beings, even small insects. Furthermore, it dismantles the human-nature dichotomy, a socio-cultural and historical construction that has had terrible consequences for the use and exploitation of "nature," based on the paradigms of humans' superiority and their power over other living beings. In several indigenous cultures, stingless bees are considered sacred healers connected with higher dimensions of the existence. These conceptualizations contrast with utilitarian views, in which bees are nor treated as living beings, but objectified. These connections with bees help people connect emotionally to ecological relationships that are the foundation for agroecological production.

II. **Meliponiculture is important both ecologically and culturally**
   Because they are important both ecologically and culturally (including the spiritual dimension), meliponicultures allow us to approach agroecological themes from a holistic perspective. This is congruent with the thinking of indigenous and rural people, whose knowledge is not generally fragmented based on academic disciplines or the nature/society, body/mind and reason/feelings dichotomies. This greatly facilitates the co-production of meaningful learning (*sensu* Ausubel and Novak; Gadotti, 2002; Agra et al., 2019) that gives students the capacity to solve problems and acquire cognitive skills that can be applied in different contexts. Learners' cognitive structures expand when new knowledge connects with previously existing knowledge, and with the mobilization of social and affective relationships to the topic.

III. **Stingless bees are pollinators par excellence**
   Stingless bee breeding represents a bridge between polarized views of conservation vs. production that make it difficult to approach both challenges realistically. Both conservation and production are necessary, and both rely on pollination. Meliponiculture, by maintaining pollinator populations, contributes to fruit and seed set of crops, while helping maintain networks of native plants and herbivores as well as bacteria and viruses. Paris et al. (2020) have argued from ancestral times Maya people have been aware of the importance of meliponines as pollinators, as demonstrated by archeological evidence for strategic distribution of meliponaries in urban centers.

IV. **Stingless bees connect landscapes**
   Meliponiculture encompasses the interrelationship between different elements of ecosystems and is therefore ideal for analyzing and questioning the impact of human actions. We have documented through community agroecology workshops and the guided visits in the institutional meliponary, how it is easy for people to understand the interconnection of different elements of ecosystems, of all living beings, when it is explained through bees' way of living. Bees' mobility means that impacts in the surrounding landscape affect them, even those occurring at a certain distance from their colony. A classic example is how agrochemicals can affect bees on neighboring farms. Based on this idea, it is feasible to comprehend the interconnection among all the elements of the landscape, including bees, plants, vertebrates, soil, water, *etc*. Building cognitively from these connections,

we can address biocultural landscapes and the defense of material and symbolic territories.

V. **Stingless bees are charismatic species**

Even though the general public knows little about insect diversity, most people have some connection to and understanding of bees through honeybees. Sumner et al. (2018), studied peoples' perceptions of insects and found that we associate bees with their functional value and with other positive values such as hard work and cooperation. In our experience, stingless bees are undoubtedly charismatic; people fall in love with the idea of a bee that cannot sting, their smaller sizes (compared to *Apis mellifera*) and their diversity of behaviors and colors. This connection can be a starting point for scientific learning as well as longer-term agroecological transformations. One of the most significant experiences that exemplifies this point, was when we hosted deaf students, whose enthusiasm was effusive and evident in their movements at the time of seeing the stingless bees.

VI. **The association of bees with certain values**

Again, for general public, bees have long been associated with values such as solidarity, unity, and hard work for the common good. In particular, we found throughout our fieldwork, that stingless bees are frequently considered an emblem of non-violence, harmony, respect, and good behavior. People have shared with us repeatedly that if the family is not at peace, it is not possible to take care of the bees, as they leave when some member of the family is misbehaving. These associations lend themselves to metaphors for the family and community relationships necessary for agroecological farming and its scaling.

VII. **Meliponicultures have symbolic relevance and emotional significance**

We have already mentioned the historical, symbolic, and cultural importance of stingless bee breeding. Negrín and Sotelo (2016) conceptualized meliponicultures as immaterial cultural heritage and focused on their association with origin myths that account for the sacredness of these invertebrates, as well as how honey is commonly as revered as blood and rain. On more than one occasion, interviewees cried when talking about beekeeping took them to past times memories of deceased loved ones, most commonly grandparents. In our experience beekeeping has a strong emotional charge for people who have already experienced it within their cultural frameworks, and those new to beekeeping can also rapidly develop these associations. Together, these biocultural and emotional connections can help deepen agroecological transitions.

VIII. **Meliponicultures can promote intergenerational dialogue**

Meliponicultures thrive on dialogue through which older and younger people share and enrich their *saberes*. This is particularly relevant where stingless bee breeders are older people. According to Chan Mutul's et al. (2019) typification, for "traditional" breeders meliponiculture is an inheritance, while younger, "resignified breeders" have different objectives and motivations for meliponiculture, but value the experience of older people. We have seen that because these bees do not sting, and because start-up costs are low, people can begin practicing meliponiculture from a very young age, thus creating a common interest between grandparents and grandchildren. This kind of intergenerational learning is key to agroecological learning.

IX. **Stingless bee breeding is a commitment to caring for the continuity of life**

The bee breeders with whom we had the opportunity to share, recognized themselves as caregivers and not as "producers," as they are often labeled. Care makes the reproduction of life possible, and meliponicultures are an astonishing example of it. Aldasoro Maya et al. (2015, 2016) and Chan Mutul et al. (2019) found that many bee breeders in Tabasco are more interested in the care and conservation aspects of their work than in commercializing honey or other products. Care for the planet and for human communities is at the center of agroecological practice.

X. **Meliponiculture stimulates the senses**

Sensory stimulation is necessary for learning, and meliponicultures offer a whole package as they stimulate all five of the commonly recognized senses. During activities such as guided visits and community agroecology workshops, we could appreciate how people enjoy observing bee behavior. We invited them to hold their ear to the hive to listen to the buzzing that many found mesmerizing. Upon opening hives, we appreciated their unique smells and tasted some honey, and finally let some bees to land on our hands or arms to feel their tiny legs going back and forth over our skin. On these occasions we would hear phrases such as "*I will never forget this in my life*" or while looking at the open hive "*this is the most amazing and magical thing I have experienced in my life.*"

XI. **Stingless bee breeding implies doing**

To coproduce knowledge about meliponiculture implies conducting a diversity of activities, lending itself to Dewey's ideas of learning by doing. We applied this principle in the biocultural and agroecological school gardens and the community agroecology workshops in order to approach practical problem-solving hand in hand with theory. We were also inspired by Decroly's proposal to educate "for life and through life," addressing agroecological principles in relation to the realities people were facing in producing their food and maintaining their hives.

XII. **Meliponiculture does not require special spaces or equipment**

In contrast to honeybees, stingless bees can be kept close to spaces inhabitated by humans, such as home gardens,

backyards, and schools. Their breeding does not require beekeeping suits, although veils help in handling some that have defensive behaviors, such as *S. mexicana* and *S. pectoralis*.

XIII. **Meliponicultures can be profitable**

Although our emphasis is on meliponicultures as biocultural heritage, we also recognize their economic importance, and the potential synergy between biocultural and economic values. INANA, for example promotes the commercialization of diverse products of meliponiculture, but within a framework that celebrates biocultural heritage. Where the economic potential of stingless bee breeding has been recommended as the way to guarantee its continuity (Jaffé et al., 2015; Acereto and De Araujo Freitas, 2017), we caution that cultural elements are also crucial for the conservation of stingless bee breeding. Even in regions that do not have traditions of meliponiculture but that do have a considerable diversity of meliponines (Reyes-González et al., 2020; Elizondo-Salas and Jimeno-Sevilla, 2022), we invite promoters to include the history and cultural importance of the relation with bees in other regions of the country and the world together with technical training, as an inspiration for development of biocultural heritage. The confluence of biocultural and economic values in activities such as meliponiculture can be a potent catalyst for agroecological transitions.

For all these reasons, meliponicultures can be excellent pedagogical mediators as conceptualized by Vygotsky in his cultural historical psychology, in which he emphasizes the function of culture and social organization in the development of higher psychological processes (Gadotti, 2002). Combining the idea of pedagogical mediators with more recent, emancipatory pedagogical frameworks such as popular education, we propose a theoretical-methodological approach that uses activities such as meliponicultures for the construction of political, cultural, economic and gender justice (Korol, 2006).

In Walsh's words

> the effort has been to build, position and procreate pedagogies that aim at thinking "from" and "with." It encourages "praxis" processes and practices of theorization -of thinking-doing- and interculturalization that radically challenge theoretical-conceptual and methodological-academic pretensions, including their assumptions of objectivity, neutrality, detachment and rigor. Pedagogies that strive to open cracks and provoke learning, unlearning and relearning, detachments and new attachments; pedagogies that seek to plant seeds, not dogmas or doctrines, to clarify and entangle paths, and to set out horizons of theorizing, thinking, doing, being, being, feeling, looking and listening - individually and collectively - towards the decolonial (2013, p. 66).

Lastly, we want to frame our proposal in the pedagogy of tenderness (Cussiánovich, 2005), as we hope to contribute to the autonomy of learners as subjects responsible for the design of their own lives and history, and in a permanent process of liberation.

Conclusions

Stingless bee breeding is a biocultural heritage that merits appreciation and conservation for the future generations. Meliponicultures are a product of ontoepistemological diversity, and their study and comprehension let us advance in the construction of a world with more cognitive justice. Simultaneously, they represent an ideal aid for agroecological education, based on the ideas of several pedagogical theoreticians.

In combining disparate pedagogical and anthropological frameworks in the context of agroecological transitions and biocultural conservation, we hope to contribute to inter and transdisciplinary approaches to confronting the interconnected crises faced by humanity. By examining from these varied perspectives, the complexity and beauty of the relationships between a group of insects and humans, we have sought to open windows to practical and theoretical frameworks for learning sparked by celebration of biological and cultural diversity.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by El Colegio de la Frontera Sur. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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