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Review

Current Knowledge of the Melliferous Florae in Mexico Using Methodologies to Understand Bee–Plant–Human Interactions

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Featured Application: This study seeks to determine which method for studying melliferous flora is suitable for planning corresponding research.

Abstract: Knowledge of melliferous flora has applications in areas of commercial and scientific interest because pollinators, such as different bee taxa, provide ecosystem services that include the pollination of both agroecosystems and wild ecosystems. In this manuscript, we reviewed research carried out in Mexico on the identification of melliferous flora, emphasizing the methods used and highlighting their implications for bee–plant–human interactions as well as the advantages and disadvantages of the different methods used in the determination of this type of vegetation. Methods such as observations of the foraging process, palynological analysis, and taxonomic determination via genetic sequencing were analyzed. We observed advantages in each method, but better integration between methods would facilitate concrete advances in understanding this type of flora. Ultimately, the determination of melliferous flora is a practical tool that provides useful knowledge in diverse economic and scientific sectors.

Keywords: mellifera; flora; methods

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1. Introduction

In the current context, different products of natural origin are increasingly used every day for nutritional, cosmetic, or medicinal purposes. It is thus necessary to identify the resources used to create such products for various reasons, including the conservation of the primary sources and the physicochemical characterization of the corresponding components [1]. In recent years, beekeeping has become the source for various products that use natural resources such as honey, propolis, wax, royal jelly, bee bread (larval food), pollen, and even the larvae themselves. However, all these products depend directly or indirectly on the nutritional, physical, and chemical properties that the surrounding vegetation provides to the hive [2,3].

The vegetation surrounding the beehive that can provide resources to bees is called melliferous or apicultural flora (MF) and consists of plant species with the ability to produce or secrete substances or elements. For various pollinators such as bees, these substances represent a source of nutrients or structural elements used in food or as construction or maintenance material for nests and hives. Since ancient times, this type of flora (MF) has been of economic interest in the beekeeping field times because it can facilitate honey production [4].

In Mexico, beekeeping is an activity of economic interest with an annual production of 60,000 tons, of which 76.8% is destined for the international market. As of 2022, this level of production situates the country in ninth place worldwide in terms of honey production and thirteenth place in terms of exports [5]. At the national level, this activity provides sustainable resources to beekeepers and various groups of farmers who incorporate this activity to improve their economic results [6,7]. At the ecological level, beekeeping in Mexico provides ecosystem services such as pollination of diverse ecosystems, impacting the biodiversity and health of such areas. With this service, the productivity of diverse crops has increased [8–10]. However, current variation in global temperature has produced essential changes in climatic conditions, promoting exogenous factors such as variations in temperature, precipitation, relative humidity, and photoperiods, which can accelerate or shorten flowering periods, thereby reducing the availability of resources for both honeybees and wild (native) species [11,12].

At the same time, in the social field, the products derived from beekeeping activities promote the identity and customs of different Mexican ethnic groups, with the implementation of products such as honey and wax that are parts of different ancestral rites such as the celebration of death [13]. On the other hand, in the field of medicine, several studies have demonstrated the efficiency of honey and propolis in the treatment of several respiratory, digestive, and cutaneous ailments, demonstrating the antibacterial properties of Mexican honey and propolis, which have activities against Gram-positive and Gram-negative bacteria. Such research has demonstrated the antifungal and antiviral activities of propolis. Against this background, a need arose to characterize the components that give these products such properties; honey, for example, contains a wide range of phytochemicals, such as polyphenols, that act as antioxidants [14]. These studies have demonstrated that phenolic compounds, as well as phenolic acids such as esters contained in propolis, are responsible for the biological activities of this product [15].

The same studies show that these components are acquired from the MF visited by honeybees in their foraging activities. However, despite this knowledge, few studies explored the botanical origins of honey and propolis as sources of such compounds, although there are standardized techniques for this purpose [14,15].

The methodologies implemented to determine the MF related to products such as honey, propolis, corbicular pollen, and larval food range from observing the species foraged by bees to palynological analysis and molecular genetic analysis, which can reveal the botanical and geographical origins of these products. With the subsequent characterization of phytochemical components, this information can determine the botanical origins of such compounds and facilitate analysis of the sources for these compounds. By implementing one or more of these methods, it is also possible to promote quality control protocols in honey and propolis [16].

Another aspect in studying MF is the analysis of ecological interactions. Determining the botanical origins and pollen percentages of species that are sources of honey, propolis, propolis, pollen, and larval food in honeybee colonies and native bee nests can generate sufficient information to analyze ecological interaction networks, thus promoting the necessary knowledge to interpret the bee–plant–human relationship [17].

As Mexico is one of the top countries in terms of honey production at the international level and has tremendous floristic and climatic diversity, it is increasingly necessary to conduct multidisciplinary studies that include the characterization of MF and confirm the species used as sources of input, honey bees or native bees. The majority of studies to date are field observations published by public agencies to promote beekeeping in different regions of the country [18].

Conversely, the results presented in multidisciplinary studies that consider MF not only promote beekeeping but also confirm the botanical and geographical origins of honey and propolis, enabling the classification of bee products. As already achieved with honey, this research process generates more data and valuable information for further research in various fields, such as economic, sociocultural, and ecological and conservation analysis.

Likewise, with this information, quality protocols can be designed to better position national production internationally [19].

This manuscript presents the studies carried out on MF in Mexico, the methods used, and the implications that these studies have on our understanding of bee–plant–human interactions considering the advantages and disadvantages of the different methods used in the determination of this vegetation.

2. Materials and Methods

A systematic search was carried out in primary sources such as scientific journals through the search engines of Pubmed, Google Scholar, and ResearchGate. With the information collected, this list was ordered according to the importance of each study on the subject [20].

3. Results

Methods including observations of bee foraging activity, palynological analysis, and molecular genetic analysis have recently been used to identify MF. However, there are a few studies in which at least two methods interact. In turn, most of the works that characterize the physicochemical properties of honey and propolis do not determine the botanical origins of these substances. However, in the same studies, the importance of MF as a source of such compounds is acknowledged [14,15].

3.1. Field Observations

Much of the knowledge on MF in Mexico has been generated through the observational method, and multiple observational studies have been published to record the MF used by both wild bees and honeybees (Table 1) [4,18,19,21]. However, part of this knowledge has been passed mainly by word of mouth from generation to generation among the different communities and ethnic groups present in Mexico. This knowledge involves not only the recognition of MF but also the close relationship between the flowering periods and the dry and rainy seasons, which interact in the beekeeping cycles (harvest, post-harvest, and pre-harvest). For this reason, the research in [18] is extremely relevant because it promotes the inclusion and verification of this knowledge using more specific techniques such as palynological analysis, thus promoting multidisciplinary analyses to help professionals in the field make better use of natural resources.

Methodologies generally involve the observation and recording of MF species visited by bees in the different seasons of the beekeeping cycle that bees use to obtain resources such as nectar, pollen, resins, and plant exudates. To implement this method, it is necessary to distribute four observation plots of 100 m each, using the apiary or the nest as a central point to record species with melliferous interest within these plots [4,18,19,21,22]. However, this method should be used as a prospective technique because the area of influence of a hive or a nest is usually extensive and can be measured in kilometers. Thus, many of the resources used by bees may not be present in the area designated for observation. On the other hand, it should be considered that not all bees perching on flowers do so to obtain a resource [22].

Despite these limitations, studies based on observations have yielded significant implications and successes. It was demonstrated that both honeybees and native bees forage an average of 90 to 700 species of MF, establishing that bees prefer plant species of the Asteraceae and Fabaceae families, as well as Myrtaceae, Rutaceae, Poaceae, and Lamiaceae. In addition, this type of study applied to native bees made it possible to establish the foraging schedules and hive entrances of different products such as nectar, pollen, resin, and mud, starting around 5:00 a.m. with the introduction of pollen, decreasing around 10:00 a.m., and then continuing with the introduction of nectar given that its collection is reliant on the concentration of sugars, which changes as the day progresses [19,23].

In the specific case of honeybees (*Apis mellifera*), observations of foraging activity in different states of the republic (San Luis Potosí, Estado de México, Morelos, Yucatán, Veracruz, Yucatán, Michoacán, Guerrero, Chiapas, and Tamaulipas) (Table 1) revealed an average of 200 to 250 species of plants visited. Once again, species of the Asteraceae (*Taraxacum officinale*, *Bidens* sp. Tithonia diversifolia) and Fabaceae (*Lonchocarpus long stylus*, *Piscidia piscipula*, *Prosopis laevigata*) families were the most commonly used to collect nectar, pollen, and nectar–pollen. Species of the Asteraceae family are the most commonly consumed, and, in general, the beekeeping zones offer an average of 20% nectar and 10% pollen, while the supply of nectar–pollen-producing plants is 70% (Figure 1) [4,24–26].

Figure 1. Some species of MF with their corresponding pollen grains. (**A**) *Brassica* spp., (**B**) *Callistemon* spp., and (**C**) *Helianthus* spp.

With the establishment of MF species used among bees as well as the flowering periods, for purposes of national economic interest, observational studies have regionalized the country into beekeeping zones divided by the types of honey produced according to the MF of the site, ultimately defining five regions (Figure 2) [27,28].

Figure 2. Beekeeping regions of Mexico with the percentage of production [28].

Recording of Hive Weights

In some cases, once the observational studies are carried out, the weights of the hives before and after the flowering periods, as well as the volume of nectar emitted by the flowers, are recorded. These measurements are performed because increases in the hive's weight indicate the development and progressive accumulation of reserve structures [29,30]. These types of studies have been used to improve apiary production in periods when nectar flows increase due to flowering periods, thereby intensifying the production efficiency per productive unit, or unit productivity, which refers to the honey produced per thousand bees. Thus, it is assumed that production improves if the bee population increases prior to the beginning of the known MF flowering periods. An example of this method can be found in [31]. In the beekeeping region in the highlands of the State of Mexico, with adequate knowledge of MF flowering periods and weighing of the hives, it was possible to implement a double queen system that enabled an increase in the population and, in turn, the unit production, reflecting a better use of available resources [31].

As mentioned, these foundational methods have been essential to identify MF and its product scope. It has also been useful to delimit regions according to the present MF. However, the scope of such studies is limited since these methods, when applied individually, do not allow the participation of a particular species to be quantitatively confirmed. Thus, it is necessary to implement methods that allow greater precision in the determination of MF, as is the case for palynological analyses that reduce the MF species used by bees to a more conservative number [19,32,33].

3.2. Palynological Analysis

Palynological analysis is a method developed by the International Commission of Beekeeping Botany based on the qualitative (morphological characteristics of pollen grains) and quantitative analysis of the pollen content in various bee products produced by bees such as honey, larval food, royal jelly, curbicular pollen, propolis, geopropolis, and even the bee's body [8,34]. Once the pollen content is obtained by means of the technique proposed in [8,34], palynological analysis begins. The purpose of this method is to determine the pollen types by means of the diacritical characteristics of each pollen grain, which can be used to infer the species of origin [8,35].

Once the species of each pollen type is determined, the main pollen constituents can be obtained using the percentages of each pollen species observed. Such percentages are obtained by counting each pollen type in a count of 500 or 1000 pollen grains using three repetitions with equidistant transects in the sample to be analyzed. Each type is classified as follows: predominant pollen, >45%; secondary pollen, 16–45%; important minority pollen, 3–15.9%; and minority or trace pollen, <3% [34]. For honey, after obtaining this information, it has been possible to establish a classification system according to pollen content. Honey is classified as monofloral if the content of the predominant pollen is greater than 45%. If there are several main pollen types, and their percentages are not greater than 35%, the honey is classified as multifloral [36].

Palynological analyses of products such as honey, pollen, nectar, propolis, and larval food have resulted in a more conservative number of species ranging from 30 to 100 different MF species compared to the 90 to 700 species determined in observational field studies. This analysis only considered species that come from the determination of the pollen grains contained in each product. Thus, the number of MF species determined is smaller. At the same time, by using the pollen load count to establish the pollen percentage, the preference among bees for certain MF species has been recognized. This type of analysis revealed that the Asteraceae and Fabaceae families are the most commonly exploited [37].

With this information, it was possible to verify the theory regarding the fidelity of floral resources with these types of pollinators. This theory has been speculated since the time of Linnaeus and Berger in 1756, suggesting that both native bees and honeybees present floral fidelity. This theory suggests that bees do not use floral resources if they can exploit a resource that offers them a more significant benefit derived from each floral species. The factors considered include floral morphology and the type and amount of reward since some species only offer nectar or pollen, while other species offer nectar–pollen. In some cases, given the recent palynological studies of propolis, it was observed that some plant species also offer exudates in the form of balsams useful for the elaboration of propolis [38].

Against this background, for economic and scientific purposes, several palynological analyses have been carried out on honeybee honey and honey from some species of bees of the Meliponini tribe from certain states of the country, qualitatively and quantitatively confirming the main species using MF (Table 1). These studies improve our understanding of MF, thus facilitating the work for beekeepers and research projects with honeybees and wild honeybees, which take advantage of inputs from agroecosystem species and wild ecosystems.

Table 1. Achievements and scope of MF studies in different Mexican states.

Author	Year	State	Method	Contribution
[24]	1966	San Luis Potosí	Field observations	Determined the nectariferous and polliniferous flora of the region.
[25]	1972	México	Field observations	Contributed to the knowledge of the national MF, mentioning the most useful plants for bees.
[26]	1980	Morelos	Field observations	List of melliferous flora through field observations.
[39]	1981	Yucatán	Field observations	List of melliferous flora through field observations.
[40]	1984	Veracruz	Field observations	List of melliferous flora through field observations.
[41]	1998	Yucatan	Field observations	List of melliferous flora through field observations.
[42]	1999	Michoacan	Field observations	List of melliferous flora through field observations.
[43]	2002	Chiapas	Field observations	List of melliferous flora through field observations.
[44]	2002	Guerrero	Field observations	List of melliferous flora through field observations.
[45]	2003	Veracruz	Field observations	List of melliferous flora through field observations.
[46]	2003	Tamaulipas	Field observations	List of melliferous flora through field observations.
[7]	1998	Colima	Collection and observation of species visited by bees as well as pollen analysis of honey; information verified by interviews with beekeepers	List of melliferous flora through field observations.
[47]	2007	México	Palynological analysis	Fifteen families identified that match the vegetation of the area.
[48]	2008	Morelos	Palynological analysis	Twenty-four families identified of which only seven plant species belonging to four families were of importance.
[49]	2010	Yucatán	Palynological analysis	A total of 168 honey samples from the Yucatán Peninsula were analyzed, and it was determined that most of them were monofloral.
[26]	2011	Zacatecas	Palynological analysis	Honey samples from different municipalities were analyzed and the Asteraceae family was determined as the main pollen type.
[17]	2012	Tabasco	Palynological analysis	Forty honey samples from different beekeeping regions of Tabasco were analyzed, and it was observed that the use of floral resources was homogeneous.
[37]	2016	Guerrero	Palynological and molecular analysis	It was determined that the stratum most used by *Apis mellifera* was the herbaceous stratum, followed by the shrub and tree strata.
[36]	2017	Durango	Palynological analysis	A wide variety of flowers used by *Apis mellifera* was identified, including *Prosopis laevigata*.
[50]	2017	Baja California Norte	Palynological analysis	It was determined that the floral resources change according to the seasons.
[33]	2018	Puebla	Palynological analysis	It was determined that the Asteraceae family is the main food source and the grazing habits were determined, exhibiting a polylectic habit.
[51]	2019	Campeche	Interviews with beekeepers as well as reviews in specialized herbaria	Highlighted the importance of indigenous knowledge by revealing species that promote sustainable development within the communities that practice beekeeping.

These studies helped raise awareness about the importance of MF mainly by delimiting the number of MF species used by this group of hymenopterans as well as the through recognition of various species and ecosystems that previously had no relevance to this activity. In arid and semi-arid zones, research (e.g., [36]) has revealed the importance of *Prosopis levigate*, which undoubtedly represents a species of both regional and national interest because it is undervalued in the region but, at the same time, widely used in traditional medicine for various ailments. Several studies on this species have observed anti-inflammatory and antimicrobial properties. As noted by the authors in [14,15], such properties may be present in honey and propolis due to the inclusion of different phytochemical compounds from the species-level resources used in the manufacture of these products. In the same context, a palynological study carried out in the country's northern region in Baja California Norte was able to highlight the high degree of human intervention by determining the species *Tamarix* spp., known in the region as salt pine, an introduced species that has gained ground by displacing species within the area. Together with the low diversity and presence of pollen types of agricultural origin such as *Medicago sativa*, this phenomenon reveals the environmental impact of human activities [50].

Due to the efficiency of palynological analysis results in determining the botanical origin of honey, as of 2018, this method was incorporated into the Mexican Official Standard NOM-004-SAG/GAN-2018 to control quality, originality, and denomination of origin. Therefore, as of this date, palynological analysis became another mandatory test to be performed on honey intended for marketing and importation [52].

For native bees, palynological analyses not only allow us determine the botanical origin of honey, pollen maces, and geopropolis, but also help us clarify and interpret the intricate network of interactions between the ecosystems in which they develop. The importance of native bees in the successful pollination of food plants and the maintenance of ecosystems are topics that have gained considerable relevance. For this reason, various meliponine species used in production greenhouses have been studied, including *Tetragonisca angustula*, *Nannotrigona testaceicornis*, and *Plebeia tobagoensis*. In Mexico, *Melipona becheii* and *Scaptotrigona mexicana* are the most commonly implemented and relevant species in the pollination of wild flora and diverse crops [53,54]. In addition, different products such as honey, propolis, and pollen are widely used in traditional medicine. However, there are few studies or quality standards for this honey or the different products that come from its breeding [54].

Some studies have been carried out in certain regions of the country. For example, a study in Chiapas, Mexico by Martinez-Hernandez et al. [55] analyzed the foraging of four species of meliponines and found that *Coffea arabica* was one of their primary sources of resources such as pollen and nectar. Villanueva [56] determined the nectar resources used by *Melipona beecheii* in the Mesoamerican biological corridor. Ramírez-Arriaga and Martínez-Hernández [57] analyzed the honey of *Scaptotrigona Mexicana* and *Apis mellifera* in 10 localities in Puebla, obtaining a large amount of pollen per gram of honey and high diversity indexes. In the state of Michoacán in the municipality of Nocupétaro, the authors in [58] conducted a physicochemical study on the honey *of Scaptotrigona hellwegeri* and *Frieseomelita nigra*, concluding that the physicochemical properties and characteristics of the honey of stingless bees are unknown and is very different from the honey produced by other apoids. In southern Chiapas, the authors in [59] analyzed the honey of different species of meliponids such as *Melipona beecheii*, *Melipona solani*, *Scaptotrigona mexicana*, *Scaptotrigona pectoralis*, *Tetragonisca angustula*, and *Plebeia* sp., demonstrating the antibacterial effect against *Escherichia coli* and *Staphylococcus aureus*, with the honey of *Scaptotrigona mexicana* displaying the highest activity. In addition, all these studies highlight the importance and relevance of MF as the primary source of the physical and chemical characteristics of the honey analyzed. For example, the physical and chemical characteristics of *Apis mellifera* honey are closely related to the MF used [14].

While the analysis of pollen content in honey provided relevant information to determine the botanical origin of honey from both native bees and honeybees, it also enabled researchers to determine the botanical origin of propolis. Such analysis is made possible using the pollen load that can be extracted through the technique proposed in [35]. Once the pollen load is obtained, it can be analyzed in the same way as the pollen load of honey, making it possible to elucidate the plant species that are sources of resins and balsams for the manufacture of this product. With these studies, it has been possible to correlate some of the biological activities of propolis with some phytochemical compounds, such as phenolic compounds, that come from the floral source. Through these analyses, it has been possible to demonstrate that some propolis comes from the balsams of certain herbaceous plants [3]. As with honey, the palynological analysis of pollen content in propolis can be used to characterize this product qualitatively and quantitatively and thus designate a species as the primary pollen type.

The palynological study of pollen loads is essential for two main reasons: (1) because this product is currently recognized as pollen or corbicular pollen and is marketed as a food supplement, and (2) because this product is part of the nutrition of bees, forming the protein part of their diet. Therefore, this product indirectly allows the development of other bee products, such as royal jelly. Abundant pollen promotes an adequate diet that provides the amino acids and proteins necessary for bee nutrition. This situation enables adequate development of the hypopharyngeal gland, which emits this product. Therefore, it is essential to determine the most important honey flora that provide pollen to the hives to maintain good production of royal jelly, thus promoting greater vitality for the queen bee and the development of subsequent generations [60].

3.3. Molecular Genetic Analysis

Currently, with the implementation of molecular techniques, it is possible to achieve a higher resolution taxonomic determination of the MF used by honeybees and native bees in the feeding and maintenance of their hives. These techniques require DNA to be obtained from the pollen contained in honey and propolis in addition to the pollen incorporated into other products such as larval food (bee bread) and corbicular pollen, as well as pollen attached to the bees' bodies. The use of pollen for DNA extraction is due to the importance of this product for the colonies. Pollen is the main source of amino acids and proteins that the hive needs to sustain itself and is, therefore, found in most of the products produced for feeding the hive. On the other hand, pollen, as a gamete, guarantees that first-line DNA will be obtained, yielding accurate results in the taxonomic determination of the implemented MF [61].

In Mexico, these studies have been implemented to determine species of commercial interest and thus elucidate the presence or absence of this type of species, helping to increase the commercial, nutritional, or biomedical value of honey and propolis. This methodology has also been implemented in the detection of genetically modified organisms (GMO) included in honey and propolis. According to international regulations for these species, when using these techniques for the acquisition of honey and propolis, GMOs should not exceed 0.9% and 0% for products that are intended to be organic [61,62].

The methodology requires pollen grains to be obtained for DNA extraction. Because these grains are enclosed in a solid natural sporopolein matrix, it is necessary to implement standardized treatments involving the use of glass beads specialized for breaking the sporopolein matrix. After obtaining and purifying the DNA, implementation of the methodology using real-time polymerase chain reaction (PCR), also called quantitative PCR or qPCR, is carried out. This technique is highly sensitive and can detect very low levels of DNA that can be easily quantified by constructing a standard curve and comparing the amplification results with the standard values of the curve, in addition to quantifying internal genes of the species [62].

This methodology is used to evaluate the integrity of honey from the Yucatan Peninsula (PY) intended to be exported to the European Union, specifically to Germany. This technique is used to ensure that the honey does not contain genes related to GMOs such as the 35S promoter and t-nos terminator. In addition, the MON 04232-6 event can be used to detect GMOs from *Zea maiz* L. and *Glycine max* L. [61,62].

These methods continue to evolve. With the incorporation of metagenomics, results for the determination of MF can be obtained with higher resolution since molecular genetic analysis through the generation of bar metacodes is used to sequence the pollen contents of bee products. This process offers high-resolution taxonomic classification and can process multiple samples with varied compositions at a milligram scale in a single sequence [61,63,64].

The taxonomic characterization of MF via molecular genetic methods confirmed that the Asteraceae, Malvaceae, and Fabeceae families are the most commonly used by bees; also, it determined the inclusion of genetically modified species such as *Zea maiz* L. and *Glycine max* L. In addition, genes linked to each other by their metabolic activities in the cell wall (actin and profilin) can be used to independently identify the same species in honey samples from different crops. This analysis makes it possible to establish the species with precision. These methodologies constitute a new protocol to help melisopalynology identify MF species, obtaining a resolution of 96% for assignments at the genus level and 70% at the species level. However, taxonomic confirmation of the determined species is required for further validation [61,63,64].

3.4. Implementation of MF Determination Results

With the characterization of melliferous flora and knowledge of the floral cycles among resource-producing species, the seasonality and availability of resources can be established, allowing the recognition of species that provide not only resources such as nectar, pollen, resins, and balsams but also phytochemicals responsible for the biological activities of honey, propolis, and other products of the beehive. Treatments for various respiratory and digestive ailments commonly use these substances because compounds such as phenols and flavonoids (e.g., pinocembrin, pinobanksin, quercetin, kaempferol, chrysin, and galangin) that have the MF collected by honeybees such as native bees. Their biological origins have been characterized in honey and propolis [3].

3.5. Bee–Plant–Human Interactions

Regarding bee–plant–human interactions, MF studies demonstrated that beekeeping and meliponiculture generate benefits for the environment. Indeed, the synergistic interactions between plants and the different bee taxa, both native bees and honeybees, maintain natural ecosystems, such as agroecosystems, contributing to the production of 80% of seeds from more than 25,000 species of flowering plants [65].

The study of melliferous flora applied to various bee taxa revealed not only that *Apis mellifera* contributes to the pollination of agroecosystems, but also that about 65 species of native bees are involved in the pollination of various crops. It was found that pollination by native bees also benefits crops considered to be self-pollinating. Overall, agroecosystems pollinated by native bees experience increased yield and fruit quality [65–67].

The introduction of *Apis mellifera* as a directed pollinator was demonstrated to provide benefits to crops such as red fruits. The strawberry crop (*Fragaria chiloensis*) is most notable, with a significant increase of 98.9% ($p < 0.0001$) in fruit production observed after the adaptation of the pollinator, increasing the yield from 66.72 kg to 133.40 kg per week with the introduction of the honeybee [68]. However, the intervention of other bee species is fundamental for the maintenance of agroecosystems such as the production of species of the Solanaceae family to which a large number of hot bell pepper species belong. These pepper species benefit from bee species of the *Bombus* genus, which have been domesticated to take advantage of this resource. Another example of the behaviors of these apoids is seen in the Cucurbitaceae family, whose members require up to five hundred pollinator visits to complete fruit maturation and achieve benefits from multiple visits from several taxa of native bees [66,67].

Within the same context, the interpretation of MF studies combined with ecological studies suggests that agricultural growth in Mexico reduced the original forests to less than 10%. This reduction had a negative effect on wild apifauna, which are considered a key element in the prevalence of tropical ecosystems. In turn, the loss and retraction of wild apifauna have had a direct impact on agroecosystems since the various native bee taxa provide a greater pollination service than *Apis mellifera* [66,69].

4. Contributions

The main contribution of this research is its reporting of important knowledge related to MF. These florae have both economic and scientific value because related analyses generate helpful information for decision-making in the economic field, as well as answers regarding the origin or relationship of resources used by this type of apoid. Consequently, knowledge of MF helps us understand the origins of the different phytochemical compounds present in honey and propolis that give these products biomedical properties useful in the treatment of various ailments. From an ecological perspective, the importance of the relationship between MF, bees, and the maintenance of various ecosystems was revealed [3,14]. In addition, knowing the available MF allows techniques for maintaining and using resources to be established.

Another benefit of determining the MF is determination of the botanical origins of the active compounds responsible for the biological activities present in honey, propolis, and other beehive products, which are useful in the treatment of digestive and respiratory ailments. By generating this knowledge, specialized markets that promote responsible and adequate consumption of these products can be fostered, and the norms and laws that regulate the quality of these products can be improved [3,14,52].

This research indicated that the methods used in previous studies were applied individually. This shortcoming allowed us to confirm only some of the sectors influenced by MF. However, if these methods were implemented more universally in research, they would allow us to understand and determine not only the MF but also the extension, area of influence, and preferences of both native bees and honeybees [19,32,33].

In Mexico, the most significant number of MF studies have been carried out in the Yucatan Peninsula, which is the most productive beekeeping area in the country. However, most of these studies are observational and designed to identify species of economic interest to promote higher productivity and better prices for honey. On the other hand, palynological analyses can more precisely identify MF, so their implementation allows better use of resources. In turn, the determination and characterization of MF can help interpret the floristic diversity present in the environments of the colonies since the small percentages of pollen detected in palynological analyses usually represent wild species with clear places of origin. Such species are generally characteristic of and specific to their environments, which can usually be confirmed by implementing methods of observation in the field. At the same time, it was demonstrated that these species contribute small percentages of phytochemical compounds that act synergistically with other compounds and provide biological activities to honey and propolis [3,14,35,70].

In addition, new analysis methods, such as genetic sequencing, represent a significant advance. Together with palynological studies, these novel methods can validate the information generated, enabling researchers to highlight species of economic and scientific relevance [61]. In addition, molecular analyses are becoming increasingly relevant due to various transgenic crops in the country since such analyses highlight the presence of transgenic products such as *Zea maiz* or *Glycine max*. The presence of such substances can decrease the commercial value of honey and propolis both nationally and internationally. Therefore, implementing this technique to determine species of economic, medical, or ecological importance would promote specialized markets in different commercial niches, as well as information to facilitate decision-making and the understanding of interactions in the ecological field. For this reason, future research should consider multidisciplinary approaches that can validate each other, thereby improving the analysis and use of MF in the field [63].

This research revealed that the plant–bee–human interactions are very close; as such, arthropods are abundant in the Mexican tropics. Bees are responsible for the pollination of a large number of agricultural products for human and livestock consumption, as well as for the maintenance of forests and rainforests within other ecosystems. Therefore, the population should be encouraged to learn about the diversity of native bees based on the great variety of ecosystemic and economic services provided by these apoids. In the scientific field, the determination of MF as a source for phytochemical compounds that provide honey and propolis with diverse biological activities should be promoted [67,69].

In conclusion, this research showed that the determination of MF is a practical tool that can generate useful knowledge in various areas of both the economic and scientific sectors if the various methodologies for MF determination correspond to comprehensive work that leads to a sustainable use of resources present around the hive.

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