




Review

Biodiversity and Stage of the Art of Three Pollinators Taxa in Mexico: An Overview

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Abstract: The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) confirmed that pollinators have declined in abundance and diversity; additionally, there is insufficient data for Latin America. Thus, we performed a review on scientific studies and databases to determine the state of the art of the diversity of three pollinator animals (bees, hummingbirds, and bats) in Mexico as well as an analysis of relevant public policies to conserve these species. We found 2063 bee species reported to be present in Mexico. The biodiversity of hummingbirds (58 species) and pollinator bats (12 species) is well known. We identified 57 scientific studies published in the last 20 years related to the biodiversity of bees (30 studies), hummingbirds (16 studies), and pollinator bats (11 studies). Relatively few, or no current studies on hummingbirds and pollinators bats at risk as well as for more than 1000 bee species is available. Great efforts have been made about policies and programs to improve the knowledge and conservation of pollinators in Mexico the last years such as the Species at Risk Conservation Program (PROCER), the Species Conservation Action Program (PACE), and the Natural Protected Areas System (CONANP). However, information of the status of many species and regions is still scarce. Thus, more studies about biodiversity, density, and trends as well as studies of the impact of policies and programs on pollinator species in Mexico are needed.

Keywords: pollinators; bees; hummingbirds; bats; biodiversity conservation; IPBES; Mexico



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1. Introduction

Most cultivated and wild plants depend, at least in part, on animal vectors, known as pollinators. Although most animal pollinators are insects (for example, bees, flies, moths, and wasps), some vertebrate pollinators exist (for example, birds and bats) [1]. Pollinators are a key component of global biodiversity, maintenance of ecosystem health and function, wild plant reproduction, crop production, and food security [1–3]. These pollination services depend on both managed (for example, *Apis mellifera* and *Bombus impatiens*) and wild pollinators [4]. However, there is clear evidence of recent declines in both wild and managed pollinators, and the parallel declines in the plants and crops that rely upon them [1,5]. The potential drivers of pollinator loss, include habitat loss and fragmentation, agrochemicals, pathogens, alien species, and climate change [3].

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), an independent intergovernmental body, was established by member States in 2012. The work program of IPBES includes assessing knowledge, policy support, building capacity and communications to identify and promote the scientific assessments about the planet's biodiversity, ecosystems, and the benefits they provide to people, as well as the development of policy instruments, tools, and methods to protect and sustainably use these vital natural resources [6]. The first global thematic assessment from IPBES in 2016,

was the current state of knowledge about pollinators and pollination [4]. It confirmed that wild pollinators have declined in abundance and diversity in Northwest Europe and North America. Although an insufficiency of wild pollinator data (species, distribution, and abundance) for Latin America, Africa, Asia, and Oceania precludes any general statement on their regional status, local declines have been recorded. Long-term international or national monitoring of both pollinators and pollination is urgently required to provide information on status and trends for most species and most parts of the world [4].

Mexico, as an IPBES member, holds an exceptionally rich biodiversity ranking among the megadiverse countries of the world [7]. There are around 1800 species of butterflies and moths, more than 6000 species of bees, wasps, and ants, 58 species of hummingbirds, a dozen species of bats and several hundred species of beetles, that give a pollination service [8].

Nearly 85% of fruit and/or seed consumed species in Mexico depend to some degree on pollinators for productivity [9]. More than 90% of the leading global crop types are visited by bees [4]. Some hummingbird and bat species are important pollinators of food resources in Mexico, such as cactus fruits and agave species (including those used for tequila and mezcal) [4]. The conservation of these pollinators in Mexico is particularly important, not only for food safety but also for the conservation of biodiversity. Although the fauna of Mexico is most likely one of the best studied of Mesoamerica region, the diversity and status of many species is unknown [7]. Moreover, the last major studies related to the conservation status and diversity of species such as bees [10] and pollinating bats [11] were conducted more than 20 years ago.

The conservation of species depends largely on knowledge of their diversity, abundance, and distribution. All possible sources of data and information, including new, fast-growing sources such as citizen science (for example, iNaturalist) and scientific studies are needed to improve the biodiversity conservation and monitoring [12].

To protect and sustainably use pollinators in Mexico, it is important to follow IPBES work program at the regional level. Therefore, the aim of this study was to review the biodiversity and conservation status of three pollinator animals (bees, hummingbirds, and bats) in Mexico, regarding to the complementary areas suggested for IPBES as follows: (1) to determine the diversity and the stage of the art of bees, hummingbirds, and pollinator bats in Mexico. (2) to analyze the relevant public policies related to biodiversity and conservation of pollinators in Mexico.

2. Materials and Methods

Methods for the literature search and collecting data are described.

2.1. Eligibility Criteria

Inclusion criteria. The study was performed in Mexico, focused on biodiversity of bees, hummingbirds, and pollinator bats, and published from January 2001 to October 2020. The study showed identification to species level. The study was written in English or Spanish.

Exclusion criteria. Studies dealing with production, reproductive biology, as well as reviews, or articles that mention pollinators but focused on the reproductive or herbivorous biology of plants were excluded.

2.2. Literature Search

The search was conducted on Google Scholar and PubMed databases. The search terms were: “biodiversity Mexico” or “pollination Mexico” followed by “bees” or “hummingbirds” or “pollinator bats”. The timeframe was set from 2001 to 2020, the search was carried out on 30 October 2020. The search yielded 1774, 529, and 545 results for bees, hummingbirds, and pollinators bats, respectively (duplicates were removed; Figure 1).

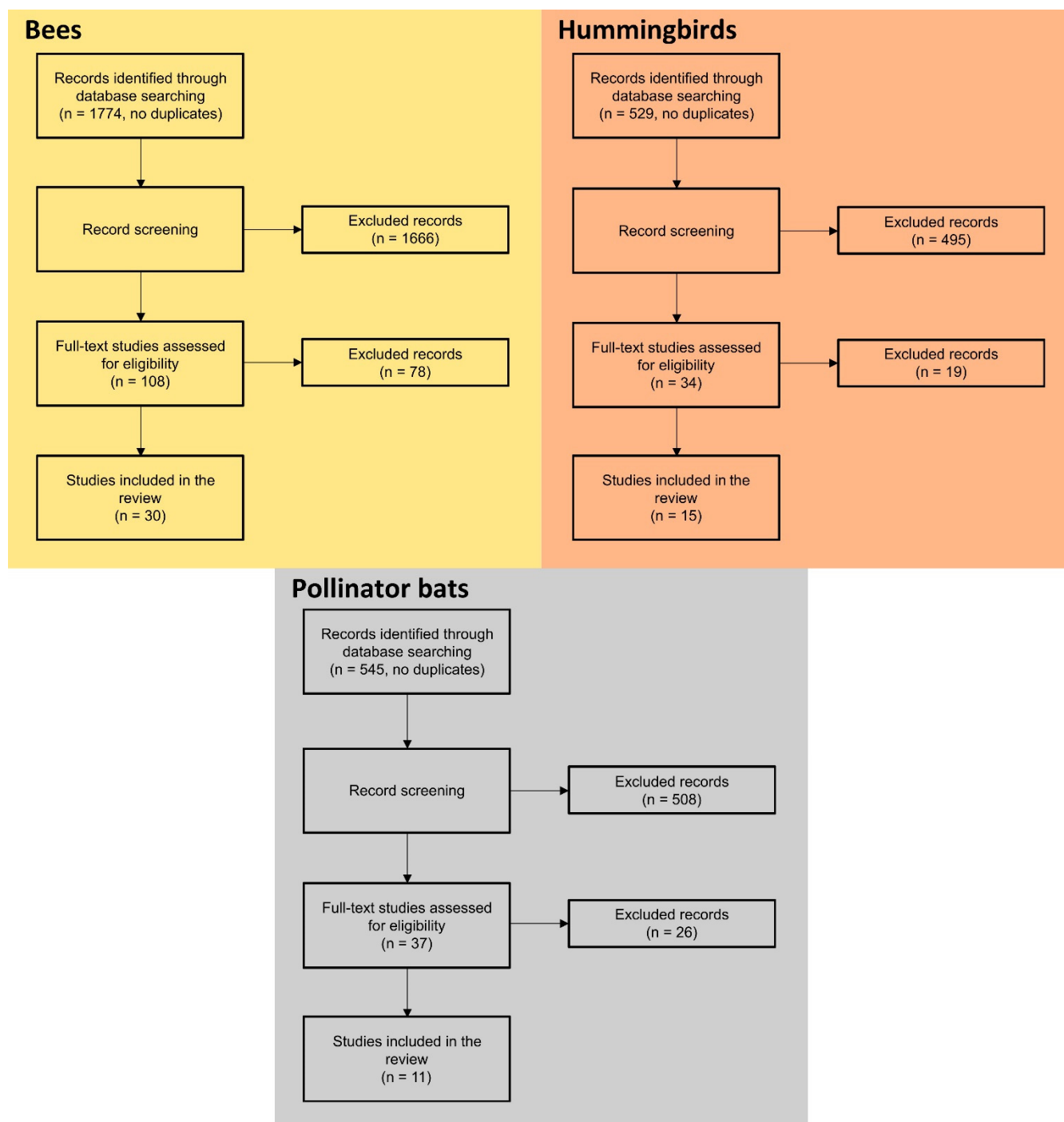


Figure 1. Study identification and screening following the PRISMA methodology.

2.3. Studies Selection

All sources were screened for potential inclusion in the review (on basis of title, abstract, and key words) and a total of 108, 34, and 37 studies were identified as potentially eligible for bees, hummingbirds, and pollinator bats, respectively (Figure 1). The potentially eligible studies were evaluated to identify the studies for eligibility and a total of 30, 15, and 11 studies were included in the review after this step (Figure 1).

2.4. Data Collection

To identify the status of diversity and policy support in Mexico, we performed a search on databases of government and private agencies with jurisdiction in biodiversity and conservation of pollinators.

We compiled a database of all species (bees, hummingbirds, and pollinators bats) reported in scientific studies and as well as species and occurrences recorded in iNaturalist (www.iNaturalist.com.mx; accessed on 31 October 2020), in the Global Biodiversity Information Facility (GBIF) [13] from January 2001 to October 2020. Only the occurrences classified as research grade by iNaturalist were included. The iNaturalist observations recorded in GBIF were discarded. The Integrated Taxonomic Information System (ITIS; www.itis.gov; accessed on 12 March 2021) was used to get valid taxonomy and synonyms.

3. Results and Discussion

3.1. Knowledge Assessment

Several studies have been conducted on the diversity of bees, hummingbirds, and pollinator bats in Mexico. In total we identified 57 scientific studies published in the last 20 years. The main topic was bees with 52.6% (30 studies), followed by hummingbirds with 28.1% (16 studies), and pollinator bats with 19.3% (11 studies; Figure 2A). In the last 5 years, the scientific contributions made on bats have decreased compared to previous years, while in the last years the contributions made on bees seem to be decreasing compared to the period 2012–2016 (Figure 2B). The publications made on hummingbirds seem to be maintained (Figure 2B).

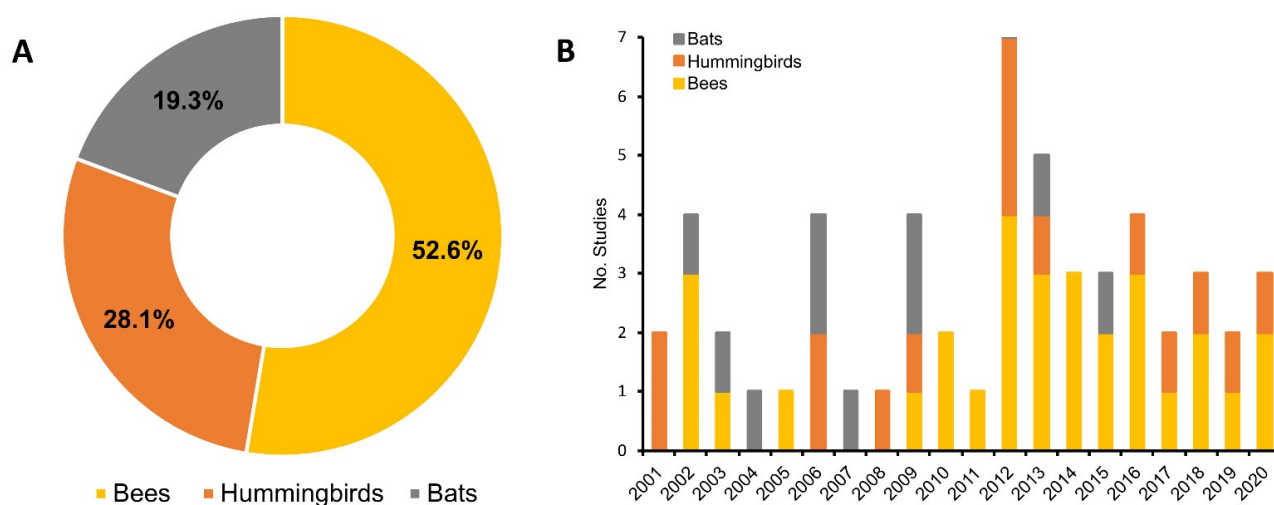


Figure 2. Research effort focused on the biodiversity of three pollinator species in Mexico from January 2001 to October 2020. (A) Pollinators addressed. (B) Scientific studies published over the time.

Most of the publications focused on bee biodiversity were carried out in the south, southeast, central west, and northeast regions of Mexico (Figure 3); in the case of the northeast region, the studies were focused only on Nuevo Leon state (Figure 3). Minckley [14] reported 383 bee species at San Bernardino Valley between Sonora Mexico and Arizona, USA; however, it was not mentioned the species found in Mexico; therefore, this study was not considered for this review. The studies performed on hummingbirds were focused on the Trans-Mexican Volcanic Belt in central Mexico (Figure 3). Whereas the studies performed on pollinator bats were focused on central region. It is clear the need to perform studies in the regions where no studies have been carried out in the last 20 years, especially in the northwest and northeast region due to the richness of bee species in desert regions [10].

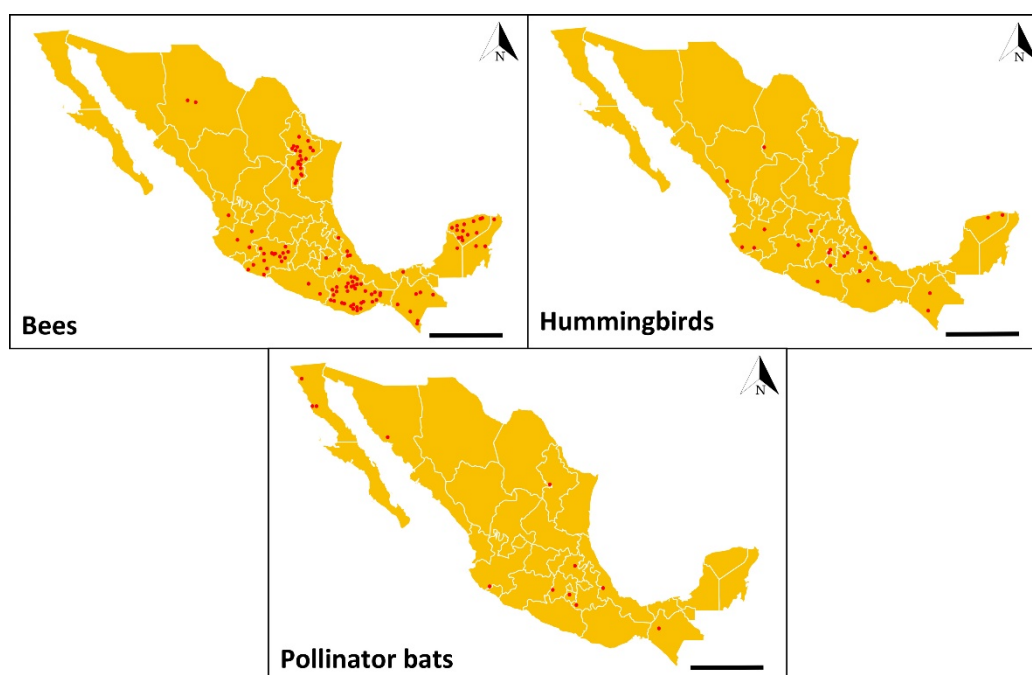


Figure 3. Atlas of biodiversity studies focused on bee, hummingbirds, and pollinator bats in Mexico from January 2001 to October 2020. Red circles indicate study zones. Scale bar, 500 km.

The web platform iNaturalist, is a global community that records observations of organisms and shares them in a database so that in collaboration with the National Commission for the Knowledge and Use of Biodiversity (CONABIO, Mexico) and specialists, they generate information and knowledge related to the identification and distribution of Mexican biodiversity. From January 2001 to October 2020 iNaturalist recorded 10,943, 22,227, and 286 observations of bees, hummingbirds, and pollinator bats, respectively (Table 1). These observations were classified as research grade by iNaturalist, which is the highest data quality assessment and may be used to establish hypothesis and perform studies about the biodiversity, distribution, and abundance of pollinator species. From January 2001 to October 2020 GBIF recorded 72,254, 309,109, and 2152 occurrences of bees, hummingbirds, and pollinator bats, respectively (Table 2). Citizen's science data, collected by collaborating volunteers and professional scientists are now widely used in biodiversity research, providing conservation information at a broad spatial and temporal scales relevant for policy making and management [12].

Table 1. Total number of observations of bees, hummingbirds and pollinator bats recorded in Mexico by iNaturalist from January 2001 to October 2020.

Common Name	Genus *	Species *	Observations *	Observations Requiring ID	Total Observations
Bees	94	213	10,943	8749	19,692
Hummingbirds	26	58	22,227	4818	27,045
Bats	7	11	286	176	462

* Data classified as research grade.

Table 2. Total number of occurrences of bees, hummingbirds and pollinator bats recorded in Mexico by GBIF from January 2001 to October 2020.

Common Name	Genus	Species	Occurrences
Bees	116	714	72,254
Hummingbirds	26	58	309,109
Bats	8	12	2152

3.2. Bees

According to iNaturalist, GBIF, the National Information System on Biodiversity (SNIB-CONABIO) [15] and Discover Life [16] databases, 2063 bee species of 151 genera have been reported in Mexico (Supplement S1). However, just 502 species (Supplementary Table S1 [17–46]) were reported in scientific studies, 714 species were recorded in GBIF (Table 2), and 213 species were recorded in iNaturalist (Table 1) the last 20 years; in total, 933 species were reported in Mexico from January 2001 to October 2020 (crossover between scientific studies, iNaturalist and GBIF information; Supplement S1). Therefore, relatively few, or no current information of more than 1000 bee species is available. Moreover, 850 species studied were reported as morphospecies (Supplementary Table S1), which means that more than 60% of the species reported were not completely identified. In the case of the observations recorded in iNaturalist, 8749 (44.4%) of them were reported as requiring ID (Table 1). Ayala et al. [10] mention that even with the increase of publications and specialist in bees, 56% of genus known in Mexico had not been reviewed. Inappropriate identification can limit the knowledge of the richness and decline of bees [47,48]. Although there have been described 126 new species in the last 20 years that occur in Mexico (Supplement S2), it is clear the need to establish a strategy to improve the identification of collected bees, as well as find out the conservation status of species that have not been studied or observed in the last 20 years.

In the last 20 years the bee genera *Bombus* and *Apis* were among the ones with more occurrences recorded in GBIF/iNaturalist (Figure 4); these genera together with stingless bee species (less than 3% of total bee diversity) concentrated 47% of the occurrences recorded (Supplement S3). Some *Bombus* species have been considered as potential managed pollinators [49]. Globally, the pollinator that is predominantly managed to enhance agricultural production is *Apis mellifera* [1]. Both, wild and managed bees have a significant role in pollination [4] and the increase of the diversity of bee species can improve fruits production [50]. However, the pollination services provided by native species such as stingless bees can be more efficient than *A. mellifera* [51,52]. Moreover, it was observed that the introduction of non-native species can induce a disturbance on bee diversity due to an aggressive competitive behavior between species [34,53]. Therefore, it is important to perform more studies to evaluate the impact of the introduction of productive species on disturbance on bee diversity, as well as to promote the use of native stingless bee species (meliponiculture).

The diversity and distribution of stingless bees present in Mexico is well known [54–57]. The genera *Trigona* and *Scaptotrigona* were among the ones with more occurrences recorded in GBIF/iNaturalist (Figure 4). In Mexico, stingless bees represent a relatively small portion (2.6%) of the highly diverse bee fauna of the country, but the economic, tourism, social, and cultural impacts they have are of great importance [39,56,58]. They are considered among the major pollinators of many native and cultivated tropical plants [59,60]. Through the meliponiculture, the stingless bees could provide an important source of income for peasant farmers in areas where the use of Africanized honeybees is restricted and harnessing these bees to their full potential for honey and wax production [61]. According with SNIB-CONABIO [15] and Discover Life databases [16], 48 stingless bee species are present in Mexico (Supplement S1). The last review of stingless bees in Mexico reported 46 species of 16 genera [56]. The differences found between the sources suggest an improvement in the harmonization and updating between databases, and findings of publications. This pattern

could be repeated for other bee species. Therefore, the 2063 bee species found in Mexico in our study should be a conservative estimate of the real bee biodiversity in Mexico due to outdated data, the unwell studied regions, and the unidentified species.

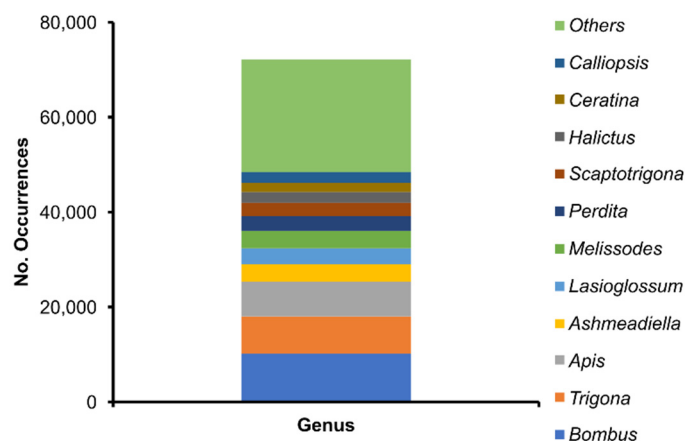


Figure 4. Number of occurrences recorded in GBIF/iNaturalist for bee genera in Mexico from January 2001 to October 2020. Others belongs to genera with less than 2000 occurrences (Supplement S3).

3.3. Hummingbirds

The diversity of hummingbird species in Mexico is well known [62,63]; 58 hummingbird species have been reported [63]. From January 2001 to October 2020, 44 species of 22 genera were reported in scientific studies (Table 3) and 58 species of 26 genera were recorded in iNaturalist and GBIF (Tables 1 and 2). Genera such as *Abellia*, *Eupherusa*, *Florisuga*, *Heliothryx*, *Lophornis*, *Phaeochroa*, and *Thalurania* were not mentioned or just mentioned by one study (Table 3) and they were between the less observed genera (Figure 5).

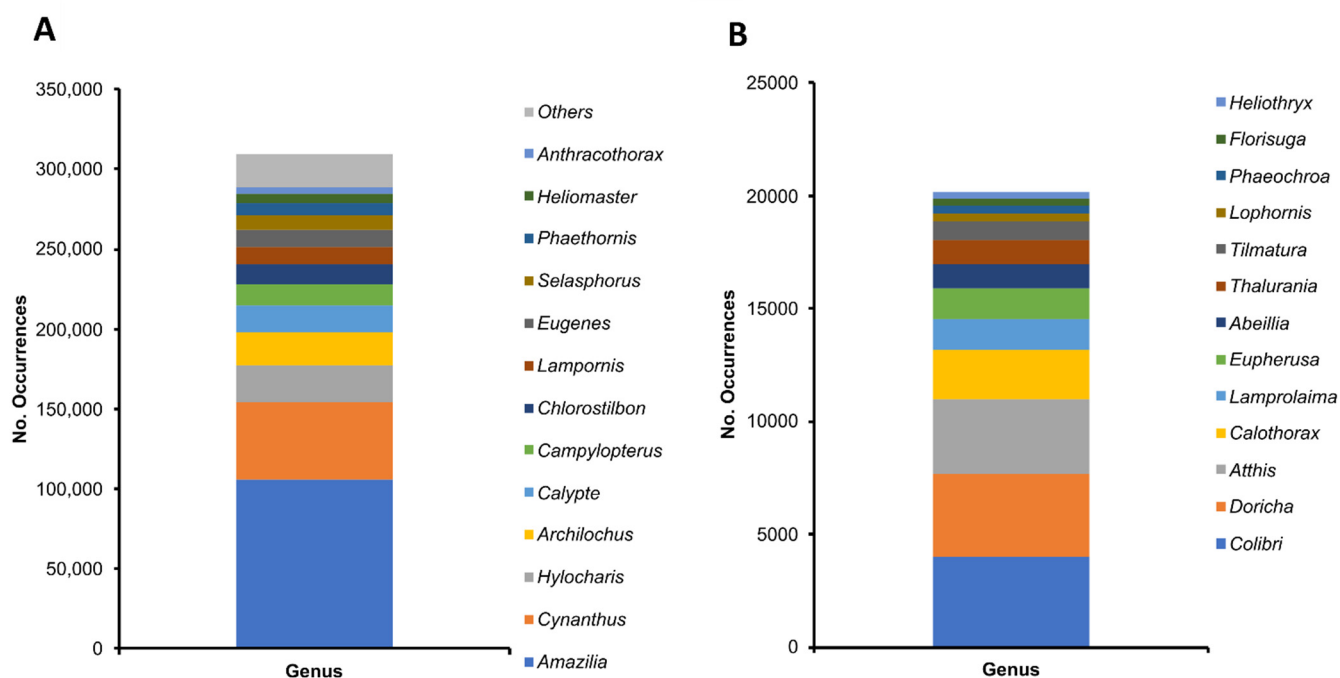


Figure 5. Number of occurrences recorded in GBIF/iNaturalist for hummingbird genera in Mexico from January 2001 to October 2020. (A) Over 4000 occurrences. (B) Less than 4000 occurrences.

Table 3. Total number of genera and species reported in scientific studies focused on hummingbird biodiversity in Mexico from January 2001 to October 2020.

Genus ID	Genus	Species	Reference
1	<i>Abeillia</i>	1	[64]
2	<i>Amazilia</i>	8	[64–71]
3	<i>Anthracothorax</i>	1	[64,66]
4	<i>Archilochus</i>	2	[64–68,70–74]
5	<i>Atthis</i>	2	[64,65,67,69,70]
6	<i>Calothorax</i>	2	[65,67,69]
7	<i>Calypte</i>	2	[70,75]
8	<i>Campylopterus</i>	3	[64,66,69]
9	<i>Chlorostilbon</i>	2	[66,69,71]
10	<i>Colibri</i>	1	[65–67,69,72,73]
11	<i>Cynanthus</i>	2	[65–67,69–71]
12	<i>Doricha</i>	1	[66,68,76]
13	<i>Eugenes</i>	1	[64–67,69,70,72,73,77]
14	<i>Eupherusa</i>	1	[69]
15	<i>Helimaster</i>	2	[64,69,78]
16	<i>Hylocharis</i>	2	[64–67,69,70,72,73,77]
17	<i>Lampornis</i>	2	[64–67,69,70,72,73,77]
18	<i>Lamprolaima</i>	1	[64,69,77]
19	<i>Lophornis</i>	1	[69]
20	<i>Phaethornis</i>	2	[65,66,69]
21	<i>Selasphorus</i>	4	[65–67,70,72,73]
22	<i>Tilmatura</i>	1	[64–66,69,79,80]
		44	

Hummingbirds visit many wildflowers and pollinate many of them [81]. They also pollinate some cultivated plants that are important both ecologically and economically for humans, such as pineapples and cactus [82–84]. In addition to their ecological and economical importance, hummingbirds have always been important to human culture in Mesoamerica, representing gods, soul carriers, and fecundity among prehispanic societies, as well as good luck, love, and wellness, even in modern societies [85]. This may facilitate the recognition of these birds by people, which is reflected in the number of occurrences recorded in the last 20 years (Tables 1 and 2).

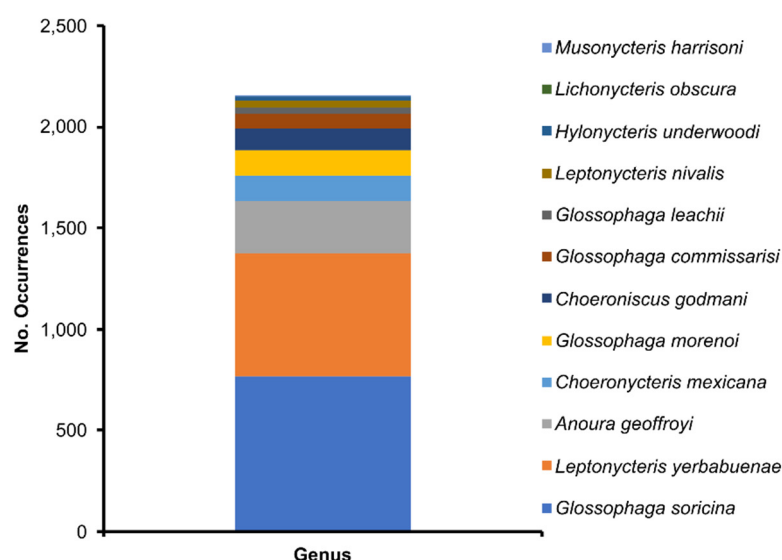
3.4. Pollinator Bats

Among mammals, bats are the principal pollinators [86]. Nectar-feeding bats (tribe Glossophagini) are an important component of the rich chiropteran fauna of Mexico [11]. They pollinate economically important plants such as agave and cactus to provide valuable products to humans, [87–89]. However, ecological attributes of glossophagines suggest that the species in this tribe such as *Leptonycteris yerbabuenae*, *Leptonycteris nivalis* and *Choeronycteris mexicana* might be more susceptible to extinction than other neotropical bats due to their dependence almost exclusively on nectar, pollen, and fruit they consume and their habitat loss where they obtain food [11].

In Mexico, 12 species of pollinator bats have been reported [11,15]. In the last 20 years, 7 species were reported in scientific studies (Table 4), the observation of 11 species was recorded in iNaturalist (Table 1) and the occurrence of 12 species was recorded in GBIF (Table 2). Species such as *Glossophaga commissarisi*, *Glossophaga leachii*, *Glossophaga morenoi*, *Hylonycteris underwoodi*, *Lichonycteris obscura* have not been reported in scientific studies (Table 4) and they were between the less recorded species (Figure 6). The species *Musonycteris harrisoni* was the pollinator bat with fewest records in the last 20 years with only one record (Figure 6).

Table 4. Total number of species reported in scientific studies focused on pollinator bats biodiversity in Mexico from January 2001 to October 2020.

Species ID	Species	Reference
1	<i>Anoura geoffroyi</i>	[90,91]
2	<i>Choeroniscus godmani</i>	[91]
3	<i>Choeronycteris mexicana</i>	[92–94]
4	<i>Glossophaga soricina</i>	[91]
5	<i>Leptonycteris nivalis</i>	[94–96]
6	<i>Leptonycteris yerbabuenae</i>	[94,97,98]
7	<i>Musonycteris harrisoni</i>	[99,100]

**Figure 6.** Number of occurrences recorded in GBIF/iNaturalist for pollinator bat species in Mexico from January 2001 to October 2020.

3.5. Policy Support

IPBES suggest different strategies related to policy and management options to conserve and use the pollinators in a sustainable way such as reduce pesticide use, protect heritage sites and practices, translate pollinator research into agricultural practices, support knowledge co-production and exchange among indigenous and scientists, and support innovative pollinator activities that engage stakeholders [4]. In Mexico there are several programs and systems to know and conserve the biodiversity of species, such as the SNIB-CONABIO, the Species at Risk Conservation Program (PROCER), the Species Conservation Action Program (PACE), and the Natural Protected Areas System (CONANP) [101]. The CONANP comprises 182 areas and 90,839,521 ha of the country's territory that includes biosphere reserves, national monuments, national parks, as well as other state protected areas [101]. Bees, hummingbirds, and pollinator bats have been studied in these protected areas [21,24,63,64,67,79,102,103]. Other pollinators species such as moths (family Sphingidae) [94], flies (family Syrphidae) [104], and wasps (subfamily Polistinae) [94] were also found in these protected areas. These studies have made local efforts to increase the knowledge of pollinators, however, there is currently no national research project to study pollinators in these protected areas. Moreover, more areas should be included in the national system of protected areas to ensure the conservation of endemic species [63,97]. Different Government strategies have been implemented in Mexico to involve the society in the conservation of pollinator species such as digital platforms (www.iNaturalist.com.mx; www.enciclovida.mx; www.ebird.org; accessed on 31 October 2020) and the construction of

gardens for pollinators [8]. However, there are no studies evaluating the impact of current programs, strategies, and policies on the population trends of pollinator species.

The CONABIO was created in 1992 to promote, coordinate, support, and carry out activities aimed to the knowledge, conservation, and sustainable use of biodiversity for the benefit of society of Mexico [8]. As a result, the Mexican Official Norm NOM-059-SEMARNAT-2010 about the environmental protection-native Mexican wildlife species with a list of species at risk was published [105]. Among the species at risk registered by norm, there are 4 pollinator bats species and 20 hummingbird species in different risk categories (Table 5). The bat *Musonycteris harrisoni* and the hummingbirds *Doricha eliza*, *Eupherusa cyanophrys* and *Lophornis brachylophus* are categorized as endangered, they have few observations in the last 20 years, and according to the International Union for Conservation of Nature (IUCN) their population trends are decreasing (Table 5). Special mention is made on the hummingbird *Hylocharis eliciae*, which although not listed as at risk by NOM-059-SEMARNAT-2010 or the IUCN, was recorded only 85 times in GBIF/iNaturalist the last 20 years. On the other hand, 11 *Bombus* species that occur in Mexico are categorized at risk by the IUNC [106]; however, no bee species are considered within the list of the NOM-059-SEMARNAT-2010.

Table 5. List of pollinator species at risk by Mexican laws (NOM-059-SEMARNAT-2010) [104] and their conservation status.

Common Name	Species	NOM-059	IUCN *	Number of Mature Individuals *	Current Population Trend *	Occurrences January 2001–October 2020 **
Bats	<i>Leptonycteris yerbabuenae</i>	++	NT	Unknown	Decreasing	607
	<i>Choeronycteris mexicana</i>	++	NT	Unknown	Unknown	128
	<i>Leptonycteris nivalis</i>	++	EN	Unknown	Decreasing	33
	<i>Musonycteris harrisoni</i>	+++	VU	10,000	Decreasing	1
Hummingbirds	<i>Cynanthus latirostris</i>	+	LC	Unknown	Increasing	41,878
	<i>Amazilia rutila</i>	+	LC	Unknown	Unknown	32,642
	<i>Doricha eliza</i>	+++	NT	2500–9999	Decreasing	3308
	<i>Phaethornis striigularis</i>	+	LC	Unknown	Unknown	3024
	<i>Lampornis viridipallens</i>	+	LC	Unknown	Decreasing	1773
	<i>Campylopterus excellens</i>	+	Unknown	Unknown	Unknown	1587
	<i>Lamprolaima rhami</i>	++	LC	Unknown	Unknown	1367
	<i>Abeillia abeillei</i>	+	LC	Unknown	Decreasing	1104
	<i>Thalurania ridgwayi</i>	++	VU	Unknown	Decreasing	1049
	<i>Amazilia viridifrons</i>	++	LC	Unknown	Unknown	1045
	<i>Helimaster longirostris</i>	+	LC	Unknown	Stable	897
	<i>Tilmatura dupontii</i>	++	LC	Unknown	Stable	833
	<i>Campylopterus rufus</i>	+	LC	Unknown	Unknown	782
	<i>Eupherusa cyanophrys</i>	+++	EN	600–1700	Decreasing	635
	<i>Atthis ellioti</i>	++	LC	Unknown	Stable	558
	<i>Doricha enicura</i>	++	LC	Unknown	Decreasing	362
	<i>Lophornis helenae</i>	++	LC	Unknown	Unknown	301
	<i>Heliothryx barroti</i>	++	LC	Unknown	Decreasing	273
	<i>Eupherusa poliocerca</i>	++	VU	6000–15,00	Decreasing	258
	<i>Lophornis brachylophus</i>	+++	CR	250–999	Decreasing	77

Conservation levels of Mexican laws: + under special protection; ++ threatened; +++ endangered. Conservation levels of IUCN: CR, critically endangered; EN, endangered; VU, vulnerable; NT, near threatened; LC, least concern. * Data from IUCN [106]. ** GBIF/iNaturalist occurrences reported in Mexico from January 2001 to October 2020.

Although there is an overall agreement about the pollinators decline, there are not wild pollinator data for many countries [4], and well documented cases are rare [47]. Our findings showed that there is an underestimation of bee diversity and a large number of bee species have not been studied or observed in the last 20 years. The information on hummingbirds, and pollinator bats diversity in Mexico seem to be more detailed. However, special attention should be paid on hummingbirds and pollinator bats at risk due to the few information and observations in the last years. IPBES mentions the importance of monitoring pollinator species to provide information on status and trends for most species [4]. Therefore, more studies are needed to know the biodiversity, abundance, and trends of bees, hummingbirds, and pollinator bats in Mexico. The knowledge of the status and biodiversity of pollinators species that inhabit Mexico will contribute to make policies and programs for their conservation.

In 2019, the Secretariat of Agriculture and Rural Development (AGRICULTURA) and Secretariat of the Environment and Natural Resources (SEMARNAT) of Mexico formalized the setup of the Coordination Group for the Preservation and Sustainable Use of Pollinators. The measure considers the creation of a national strategy in conjunction with the government, academic, research institutions, producers, and entrepreneurs with the aim to get a realistic diagnosis of the causes for the reduction in the pollinators' population as well as promote research to find new alternatives for the protection of these species [107]. This strategy is considered to start in the next years and together with the growing interest in meliponiculture, tequila and mezcal production, it could be an opportunity to improve the knowledge and conservation status of pollinators species in Mexico.

4. Conclusions

The biodiversity of hummingbirds and pollinator bats is well known but still unknown for bees. We show a list of bee species that occur in Mexico, but it should be a conservative estimate of the real bee biodiversity due to outdated data, the unwell studied regions, and the unidentified species. Relatively few, or no current information of more than 1000 bee species is available. Although great efforts and policies have been made for the biodiversity knowledge and conservation of bees, hummingbirds, and pollinating bats in Mexico the last years, the information and occurrences recorded of many species and regions are still scarce, especially in species at risk. Therefore, the findings of this review might be used to explore further studies on the status of pollinator species with relatively few, or no current information. Moreover, studies of the impact of policies and programs on pollinator species in Mexico are needed.

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References

1. Potts, S.G.; Imperatriz-Fonseca, V.; Ngo, H.T.; Aizen, M.A.; Biesmeijer, J.C.; Breeze, T.D.; Dicks, L.V.; Garibaldi, L.A.; Hill, R.; Settele, J.; et al. Safeguarding pollinators and their values to human well-being. *Nature* **2016**, *540*, 220–229. [[CrossRef](#)]
2. Klein, A.-M.; Vaissière, B.E.; Cane, J.H.; Steffan-Dewenter, I.; Cunningham, S.A.; Kremen, C.; Tscharntke, T. Importance of pollinators in changing landscapes for world crops. *Proc. R. Soc. B Biol. Sci.* **2007**, *274*, 303–313. [[CrossRef](#)]

3. Potts, S.G.; Biesmeijer, J.C.; Kremen, C.; Neumann, P.; Schweiger, O.; Kunin, W.E. Global pollinator declines: Trends, impacts and drivers. *Trends Ecol. Evol.* **2010**, *25*, 345–353. [\[CrossRef\]](#)
4. IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). *The Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on Pollinators, Pollination and Food Production*; Potts, S.G., Imperatriz-Fonseca, V.L., Ngo, H.T., Eds.; Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: Bonn, Germany, 2016; 552p.
5. Garibaldi, L.A.; Aizen, M.A.; Klein, A.A.; Cunningham, S.A.; Harder, L.D. Global growth and stability of agricultural yield decrease with pollinator dependence. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 5909–5914. [\[CrossRef\]](#) [\[PubMed\]](#)
6. IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). Available online: <https://ipbes.net/> (accessed on 27 July 2020).
7. Martínez-Meyer, E.; Sosa-Escalante, J.E.; Álvarez, F. El estudio de la biodiversidad en México: ¿una ruta con dirección? *Rev. Mex. Biodivers.* **2014**, *85*. [\[CrossRef\]](#)
8. CONABIO (National Commission for the Use and Knowledge of Biodiversity). Available online: <https://www.gob.mx/conabio/prensa/los-polinizadores-nos-necesitan-y-nosotros-tambien?idiom=es> (accessed on 20 August 2020).
9. Ashworth, L.; Quesada, M.; Casas, A.; Aguilar, R.; Oyama, K. Pollinator-dependent food production in Mexico. *Biol. Conserv.* **2009**, *142*, 1050–1057. [\[CrossRef\]](#)
10. Ayala, R.; Griswold, T.L.; Yanega, D. Apoidea (Hymenoptera). In *Biodiversidad, Taxonomía y Biogeografía de Artrópodos de México*; Llorente, B.J., García, A.N., González, E.S., Eds.; UNAM-CONABIO: Ciudad de México, Mexico, 1996; pp. 423–464. (In Spanish)
11. Arita, H.T.; Santos-Del-Prado, K. Conservation biology of nectar-feeding bats in Mexico. *J. Mammal.* **1999**, *80*, 31–41. [\[CrossRef\]](#)
12. Chandler, M.; See, L.; Copas, K.; Bonde, A.M.; López, B.C.; Danielsen, F.; Legind, J.K.; Masinde, S.; Miller-Rushing, A.J.; Newman, G.; et al. Contribution of citizen science towards international biodiversity monitoring. *Biol. Conserv.* **2017**, *213*, 280–294. [\[CrossRef\]](#)
13. GBIF (Global Biodiversity Information Facility). Available online: <https://www.gbif.org> (accessed on 10 March 2021).
14. Minckley, R. Faunal composition and species richness differences of bees (Hymenoptera: Apiformes) from two north American regions. *Apidologie* **2008**, *39*, 176–188. [\[CrossRef\]](#)
15. SNIB (Sistema Nacional de Información Sobre Biodiversidad de México). (In Spanish). Available online: <http://www.snib.mx> (accessed on 11 July 2020).
16. Discover Life. Available online: <https://www.discoverlife.org/> (accessed on 31 October 2020).
17. Ramírez-Freire, L.; Alanís-Flores, G.J.; Ayala-Barajas, R.; Quiroz-Martínez, H.; Velazco-Macías, C.G. Las abejas del género *Agapostemon* (Hymenoptera: Halictidae) del estado de Nuevo León, México. *Rev. Mex. Biodivers.* **2012**, *83*, 63–70. (In Spanish) [\[CrossRef\]](#)
18. Meléndez-Ramírez, V.; Magaña-Rueda, S.; Parra-Tabla, V.; Ayala, R.; Navarro, J. Diversity of native bee visitors of cucurbit crops (Cucurbitaceae) in Yucatán, México. *J. Insect Conserv.* **2002**, *6*, 135–147. [\[CrossRef\]](#)
19. Vergara, C.H.; Ayala, R. Diversity, phenology and biogeography of the bees (Hymenoptera: Apoidea) of Zapotitlán de las Salinas, Puebla, Mexico. *J. Kans. Entomol. Soc.* **2002**, *75*, 16–30.
20. Novelo-Rincón, L.F.; Delfín-González, H.U.G.O.; Ayala, R.; Contreras-Acosta, H.H. Community structure of native bees in four vegetation types in the dry tropics of Yucatan, Mexico. *Folia Entomol. Mex.* **2003**, *42*, 177–190.
21. Reyes-Novelo, E.; Meléndez-Ramírez, V.; Ayala, R.; Delfín-González, H. Bee faunas (Hymenoptera: Apoidea) of six natural protected areas in Yucatan, Mexico. *Entomol. News* **2009**, *120*, 530–544. [\[CrossRef\]](#)
22. Calvillo, L.M.; Ramírez, V.M.; Parra-Tabla, V.; Navarro, J. Bee diversity in a fragmented landscape of the Mexican neotropic. *J. Insect Conserv.* **2010**, *14*, 323–334. [\[CrossRef\]](#)
23. Balboa, A.C.C. Diversidad de Abejas (Hymenoptera: Apoidea) de la Reserva de la Biosfera “La Sepultura” Chiapas, México. Master’s Thesis, El Colegio de la Frontera Sur, Campeche, Mexico, 2010. (In Spanish)
24. Vandame, R.; Ayala, R.; Esponda, J.; Balboa, C.; Guzmán, M.A. Diversidad de abejas: El caso de la reserva de la Biosfera El Triunfo. In *La Biodiversidad en Chiapas: Estudio de Estado*; Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Ed.; CONABIO: Ciudad de México, Mexico, 2013; Volume 2, pp. 233–240. (In Spanish)
25. López, G.J. Diversidad de Abejas (Hymenoptera: Apoidea) Asociadas a Milpas en Paisajes con Diferentes Niveles de Antropización. Master’s Thesis, El Colegio de la Frontera Sur, Campeche, Mexico, 2014. (In Spanish)
26. Bonet, F.M.E. Biodiversidad de Abejas (Hymenoptera: Apoidea) de la Flora Acompañante en un Cafetal con Manejo Rústico y Ecológico de la Región Subcaribeña (México, Mesoamérica). Ph.D. Thesis, Universidad Complutense de Madrid, Madrid, Spain, September 2015. (In Spanish).
27. Razo, L.A.E. Abejas Silvestres (Hymenoptera: Apoidea: Anthophila) y Sus Interacciones con la Flora en la Sierra de Quila, Tecolotlán, Jalisco. Master’s Thesis, Universidad de Guadalajara, Guadalajara, Mexico, July 2015. (In Spanish).
28. Ramírez-Freire, L.; Quiroz-Martínez, H. *Informe Final SNIB-CONABIO, Proyecto No. JF185. Abejas Silvestres (Hymenoptera: Apoidea) de la Región Praderas de Tokio-El Potosí—Sierra Mazmorras-Cañón de Iturbide, Coahuila y Nuevo León*; Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas: Ciudad de México, Mexico, 2016. (In Spanish)
29. Ruiz-Toledo, J.; Vandame, R.; Penilla-Navarro, P.; Gómez, J.; Sánchez, D. Seasonal abundance and diversity of native bees in a patchy agricultural landscape in Southern Mexico. *Agric. Ecosyst. Environ.* **2020**, *292*, 106807. [\[CrossRef\]](#)

30. Ramírez, F.L. Abejas Nativas (Hymenoptera: Apoidea: Anthophila) Asociadas a la Vegetación del Estado de Nuevo León, México. Ph.D. Thesis, Universidad Autónoma de Nuevo León, Nuevo León, Mexico, November 2012. (In Spanish).
31. Vergara, C.H. Diversity and Abundance of Wild Bees in a Mixed Fruit Orchard in Central Mexico. In *Pollinating Bees: The Conservation Link between Agriculture and Nature*; Kevan, P., Imperatriz-Fonseca, V.L., Eds.; Ministry of Environment: Brasília, Brazil, 2002; pp. 169–176.
32. Ramírez, V.M.; Ayala, R.; González, H.D. Temporal variation in native bee diversity in the tropical sub-deciduous forest of the Yucatan Peninsula, Mexico. *Trop. Conserv. Sci.* **2016**, *9*, 718–734. [\[CrossRef\]](#)
33. Rios-Velasco, C.; Berlanga-Reyes, D.I.; Ayala-Barajas, R.; Salas-Marina, M.A.; Ibarra-Rendón, J.E.; Flores, P.B.Z.; Romo-Chacón, A.; Acosta-Muñiz, C.H. Identification of megachilid species (Hymenoptera: Megachilidae) and other pollinators in apple orchards in Chihuahua, México. *Fla. Entomol.* **2014**, *97*, 1829–1834. [\[CrossRef\]](#)
34. Cairns, C.E.; Villanueva-Gutierrez, R.; Koptur, S.; Bray, D.B. Bee Populations, Forest Disturbance, and Africanization in Mexico. *Biotropica* **2005**, *37*, 686–692. [\[CrossRef\]](#)
35. Grajales-Conesa, J.; Meléndez-Ramírez, V.; Leopoldo, C.L.; Sánchez, D. Native bees in blooming orange (*Citrus sinensis*) and lemon (*C. limon*) orchards in Yucatán, Mexico. *Acta Zool. Mex.* **2013**, *29*, 437–440.
36. Vides-Borrell, E.; Porter-Bolland, L.; Ferguson, B.G.; Gasselin, P.; Vaca, R.; Valle-Mora, J.; Vandame, R. Polycultures, pastures and monocultures: Effects of land use intensity on wild bee diversity in tropical landscapes of southeastern Mexico. *Biol. Conserv.* **2019**, *236*, 269–280. [\[CrossRef\]](#)
37. Arnold, N.; Ayala, R.; Mérida, J.; Sagot, P.; Aldasoro, M.; Vandame, R. Registros nuevos de abejas sin aguijón (Apidae: Meliponini) para los estados de Chiapas y Oaxaca, México. *Rev. Mex. Biodivers.* **2018**, *89*, 651–665. [\[CrossRef\]](#)
38. Reyes-González, A.; Camou-Guerrero, A.; Reyes-Salas, O.; Argueta, A.; Casas, A. Diversity, local knowledge and use of stingless bees (Apidae: Meliponini) in the municipality of Nocupétaro, Michoacan, Mexico. *J. Ethnobiol. Ethnomedicine* **2014**, *10*, 1–12. [\[CrossRef\]](#) [\[PubMed\]](#)
39. González, R.; Camou-Guerrero, A.; Gómez-Arreola, S. From extraction to meliponiculture: A case study of the management of stingless bees in the West-central region of Mexico. In *Beekeeping and Bee Conservation—Advances in Research*; Chambó, E.D., Ed.; IntechOpen: London, UK, 2002; pp. 201–223. [\[CrossRef\]](#)
40. Gonzalez, V.H.; Amith, J.D.; Stein, T.J. Nesting ecology and the cultural importance of stingless bees to speakers of Yolochochitl Mixtec, an endangered language in Guerrero, Mexico. *Apidologie* **2018**, *49*, 625–636. [\[CrossRef\]](#)
41. Reyes-González, A.; Camou-Guerrero, A.; Del-Val, E.; Ramírez, M.I.; Porter-Bolland, L. Biocultural Diversity Loss: The Decline of Native Stingless Bees (Apidae: Meliponini) and Local Ecological Knowledge in Michoacán, Western México. *Hum. Ecol.* **2020**, *48*, 411–422. [\[CrossRef\]](#)
42. Macías-Macías, J.O.; Quezada-Euán, J.J.G.; Contreras-Escareño, F.; Tapia-Gonzalez, J.M.; Moo-Valle, H.; Ayala, R. Comparative temperature tolerance in stingless bee species from tropical highlands and lowlands of Mexico and implications for their conservation (Hymenoptera: Apidae: Meliponini). *Apidologie* **2011**, *42*, 679–689. [\[CrossRef\]](#)
43. Fierro, M.M.; Cruz-López, L.; Sánchez, D.; Villanueva-Gutiérrez, R.; Vandame, R. Effect of biotic factors on the spatial distribution of stingless bees (Hymenoptera: Apidae, Meliponini) in fragmented neotropical habitats. *Neotrop. Entomol.* **2012**, *41*, 95–104. [\[CrossRef\]](#)
44. Reyes-González, A.; Ayala, R.; Camou-Guerrero, A. Nuevo registro de abeja sin aguijón del género *Plebeia* (Apidae: Meliponini), en el alto Balsas del estado de Michoacán, México. *Rev. Mex. Biodivers.* **2017**, *88*, 464–466. [\[CrossRef\]](#)
45. Hurtado-Burillo, M.; Ruiz, C.; May-Itzá, W.D.J.; Quezada-Euán, J.J.G.; De La Rúa, P. Barcoding stingless bees: Genetic diversity of the economically important genus *Scaptotrigona* in Mesoamerica. *Apidologie* **2013**, *44*. [\[CrossRef\]](#)
46. Ramírez-Freire, L.; Flores, G.J.A.; Barajas, R.A.; Martínez, H.Q.; Macías, C.G.V. The large carpenter bees (Hymenoptera: Apidae: *Xylocopa* spp.) of Nuevo León, Mexico. *J. Pollinat. Ecol.* **2012**, *7*, 1–4. [\[CrossRef\]](#)
47. Freitas, B.M.; Imperatriz-Fonseca, V.L.; Medina, L.M.; Kleinert, A.D.M.P.; Galetto, L.; Nates-Parra, G.; Quezada-Euán, J.J.G. Diversity, threats and conservation of native bees in the Neotropics. *Apidologie* **2009**, *40*, 332–346. [\[CrossRef\]](#)
48. Gonzalez, V.H.; Griswold, T.; Engel, M.S. Obtaining a better taxonomic understanding of native bees: Where do we start? *Syst. Entomol.* **2013**, *38*, 645–653. [\[CrossRef\]](#)
49. Torres-Ruiz, A.; Jones, R.W.; Barajas, R.A. Present and Potential use of Bees as Managed Pollinators in Mexico. *Southwest. Entomol.* **2013**, *38*, 133–148. [\[CrossRef\]](#)
50. Vergara, C.H.; Badano, E.I. Pollinator diversity increases fruit production in Mexican coffee plantations: The importance of rustic management systems. *Agric. Ecosyst. Environ.* **2009**, *129*, 117–123. [\[CrossRef\]](#)
51. Canto-Aguilar, M.A.; Parra-Tabla, V. Importance of conserving alternative pollinators: Assessing the pollination efficiency of the squash bee, *Peponapis limitaris* in *Cucurbita moschata* (Cucurbitaceae). *J. Insect Conserv.* **2000**, *4*, 201–208. [\[CrossRef\]](#)
52. Rincón-Rabanales, M.; Roubik, D.W.; Guzman, M.A.; Salvador-Figueroa, M.; Adriano-Anaya, L.; Ovando, I. High yields and bee pollination of hermaphroditic rambutan (*Nephelium lappaceum* L.) in Chiapas, Mexico. *Fruits* **2015**, *70*, 23–27. [\[CrossRef\]](#)
53. Pinkus-Rendon, M.A.; Parra-Tabla, V.; Meléndez-Ramírez, V. Floral resource use and interactions between *Apis mellifera* and native bees in cucurbit crops in Yucatán, Mexico. *Can. Entomol.* **2005**, *137*, 441–449. [\[CrossRef\]](#)
54. Ayala, R.A. Revisión de las abejas sin aguijón de México (Hymenoptera: Apidae: Meliponini). *Folia Entomol. Mex.* **1999**, *106*, 1–123. (In Spanish)

55. Yáñez-Ordóñez, O.; Ortega, M.T.; Bousquets, J.L. Patrones de distribución de las especies de la tribu Meliponini (Hymenoptera: Apoidea: Apidae) en México. *Interciencia* **2008**, *33*, 41–45. (In Spanish)
56. Ayala, R.; Gonzalez, V.H.; Engel, M.S. Mexican stingless bees (Hymenoptera: Apidae): Diversity, distribution, and indigenous knowledge. In *Pot-Honey: A Legacy of Stingless Bees*; Roubik, D., Vit, P., Pedro, S.R.M., Eds.; Springer: New York, NY, USA, 2013; pp. 135–152.
57. Yurrita, C.L.; Ortega-Huerta, M.A.; Ayala, R. Distributional analysis of Melipona stingless bees (Apidae: Meliponini) in Central America and Mexico: Setting baseline information for their conservation. *Apidologie* **2017**, *48*, 247–258. [\[CrossRef\]](#)
58. Lemelin, R.H. Entomotourism and the stingless bees of Mexico. *J. Ecotour.* **2020**, *19*, 168–175. [\[CrossRef\]](#)
59. Slaa, E.J.; Chaves, L.A.S.; Malagodi-Braga, K.S.; Hofstede, F.E. Stingless bees in applied pollination: Practice and perspectives. *Apidologie* **2006**, *37*, 293–315. [\[CrossRef\]](#)
60. Cauich, O.; Quezada-Euan, J.J.G.; Macias-Macias, J.O.; Reyes-Oregel, V.; Medina-Peralta, S.; Parra-Tabla, V.; Quezada-Euán, J.J.G. Behavior and pollination efficiency of *Nannotrigona perilampoides* (Hymenoptera: Meliponini) on greenhouse tomatoes (*Lycopersicon esculentum*) in subtropical Mexico. *J. Econ. Entomol.* **2004**, *97*, 475–481. [\[CrossRef\]](#)
61. Quezada-Euán, J.J.G.; May-Itzá, W.D.J.; González-Acereto, J.A. Meliponiculture in Mexico: Problems and perspective for development. *Bee World* **2001**, *82*, 160–167. [\[CrossRef\]](#)
62. Arizmendi, M.C.; Berlanga, H. *Colibríes de México y Norte América/Hummingbirds of Mexico and North America*; CONABIO: Ciudad de México, Mexico, 2014.
63. Arizmendi, M.D.C.; Berlanga, H.; Rodríguez-Flores, C.; Vargas-Canales, V.; Montes-Leyva, L.; Lira, R. Hummingbird Conservation in Mexico: The natural protected areas system. *Nat. Areas J.* **2016**, *36*, 366–376. [\[CrossRef\]](#)
64. Partida-Lara, R.; Enríquez, P.L.; Pérez, J.R.V.; de Bonilla, E.P.D. Estructura espacio-temporal de la diversidad taxonómica y funcional de colibríes en la reserva de la biosfera el Triunfo, Chiapas, Mexico. *Ornitol. Neotrop.* **2018**, *29*, 37–50. (In Spanish)
65. Arizmendi, M.D.C. Multiple ecological interactions: Nectar robbers and hummingbirds in a highland forest in Mexico. *Can. J. Zool.* **2001**, *79*, 997–1006. [\[CrossRef\]](#)
66. Ortiz-Pulido, R.; Díaz, R. Distribución de colibríes en la zona baja del centro de Veracruz, Mexico. *Ornitol. Neotrop.* **2001**, *12*, 297–317. (In Spanish)
67. Ortiz-Pulido, R.; Díaz, S.A.; Valle-Díaz, O.I.; Fisher, A.D. Hummingbirds and the plants they visit in the Tehuacán-Cuicatlán Biosphere Reserve, Mexico. *Rev. Mex. Biodivers.* **2012**, *83*, 152–163. [\[CrossRef\]](#)
68. Van Berkum, P.M.; Parra-Tabla, V.P.; Leirana-Alcocer, J.L. Recursos florales y colibríes durante la época seca en la Reserva de la Biosfera Ría Lagartos, Yucatán, México. *Huitzil* **2016**, *17*, 244–250. (In Spanish)
69. Morales, P.S.; Almazán-Núñez, R.C.; Beltrán-Sánchez, E.; Ríos-Muñoz, C.; Arizmendi, M. Distribución geográfica y hábitat de la familia Trochilidae (Aves) en el estado de Guerrero, Mexico. *Rev. Biol. Trop.* **2016**, *64*, 363–376. (In Spanish) [\[CrossRef\]](#)
70. López-Segoviano, G.; Bribiesca, R.; Arizmendi, M.D.C. The role of size and dominance in the feeding behaviour of coexisting hummingbirds. *Ibis* **2017**, *160*, 283–292. [\[CrossRef\]](#)
71. Díaz, I.S.; Lara, C.; Arizmendi, M. Temporal dynamics of the hummingbird-plant interaction network of a dry forest in Chamela, Mexico: A 30-year follow-up after two hurricanes. *PeerJ* **2020**, *8*, e8338. [\[CrossRef\]](#) [\[PubMed\]](#)
72. Lara, C. Temporal dynamics of flower use by hummingbirds in a highland temperate forest in Mexico. *Écoscience* **2006**, *13*, 23–29. [\[CrossRef\]](#)
73. Lara, C.; Lumbreras, K.; González, M. Niche partitioning among hummingbirds foraging on *Penstemon roseus* (Plantaginaceae) in central Mexico. *Ornitol. Neotrop.* **2009**, *20*, 81–91.
74. Patiño-González, B.I.; Pineda-López, R. Registro del colibrí barba negra (*Archilochus alexandri*) en el estado de Querétaro, México. *Huitzil* **2019**, *20*. (In Spanish) [\[CrossRef\]](#)
75. Valdés-Perezgasga, F. Presencia y anidamiento del colibrí cabeza roja *Calypte anna* en la Comarca Lagunera (Durango y Coahuila), México. *Huitzil* **2017**, *18*, 238–241. (In Spanish) [\[CrossRef\]](#)
76. Santamaría-Rivero, W.; MacKinnon, B.; Leyequién, E. Registros de anidación del colibrí tijereta mexicano (*Doricha eliza*) en el estado de Yucatán, México. *Huitzil* **2013**, *14*, 139–145. (In Spanish)
77. Lara, R.P.; Enríquez, P.L.; Rangel-Salazar, J.L.; Lara, C.; Ico, M.M. Abundancia de colibríes y uso de flores en un bosque templado del sureste de México. *Rev. Biol. Trop.* **2012**, *60*, 1621–1630. (In Spanish)
78. Abad-Ibarra, C.; Navarro-Abad, M.; Navarro-Sigüenza, A.G. El colibrí picolargo (*Helimaster constantii*) en el Distrito Federal, México. *Huitzil* **2008**, *9*, 4–5. (In Spanish)
79. Valenzuela-Galván, D.; Mariano, N.A.; Osorio-Berinstai, M.; Urbina, F. First record of the sparkling-tailed hummingbird (*Tilmatura dupontii*, Trochilidae) for Sierra de Huautla Biosphere reserve, Morelos, Mexico. *Huitzil* **2006**, *7*, 15–17.
80. Díaz-Valenzuela, R.; González-García, F.; Núñez, R.M. Primer registro del colibrí cola pinta (*Tilmatura dupontii*, Trochilidae) en la Sierra Juárez, Oaxaca, México y algunas notas sobre su alimentación. *Huitzil* **2012**, *13*, 68–73. (In Spanish)
81. Arizmendi, M.C.; Rodríguez-Flores, C. How many plant species do hummingbirds visit? *Ornitol. Neotrop.* **2012**, *23*, 71–77.
82. Cabral, J.R.S.; D'Eeckenbrugge, G.C.; De Matos, A.P. Introduction of selfing in pineapple breeding. *Acta Hort.* **1998**, *529*, 165–168. [\[CrossRef\]](#)
83. Díaz, L.; Cocucci, A.A. Functional Gynodioecy in *Opuntia quimilo* (Cactaceae), a Tree Cactus Pollinated by Bees and Hummingbirds. *Plant Biol.* **2003**, *5*, 531–539. [\[CrossRef\]](#)

84. Dar, S.; Arizmendi, M.D.C.; Valiente-Banuet, A. Diurnal and nocturnal pollination of *Marginatocereus marginatus* (Pachycereeae: Cactaceae) in Central Mexico. *Ann. Bot.* **2006**, *97*, 423–427. [\[CrossRef\]](#)
85. Mazariégo, O.C. Of birds and insects: The hummingbird myth in ancient mesoamerica. *Anc. Mesoam.* **2010**, *21*, 45–61. [\[CrossRef\]](#)
86. Regan, E.C.; Santini, L.; Ingwall-King, L.; Hoffmann, M.; Rondinini, C.; Symes, A.; Taylor, J.; Butchart, S.H. Global trends in the status of bird and mammal pollinators. *Conserv. Lett.* **2015**, *8*, 397–403. [\[CrossRef\]](#)
87. Kunz, T.H.; De Torrez, E.B.; Bauer, D.M.; Lobo, T.; Fleming, T.H. Ecosystem services provided by bats. *Ann. N. Y. Acad. Sci.* **2011**, *1223*, 1–38. [\[CrossRef\]](#)
88. Trejo-Salazar, R.-E.; Eguiarte, L.E.; Suro-Piñera, D.; Medellín, R.A. Save our bats, save our tequila: Industry and science join forces to help bats and agaves. *Nat. Areas J.* **2016**, *36*, 523–530. [\[CrossRef\]](#)
89. Borbón-Palomares, D.B.; Laborin-Sivirian, F.; Tinoco-Ojanguren, C.; Peñalba, M.C.; Reyes-Ortega, I.; Molina-Freaner, F. Reproductive ecology of *Agave colorata*: The importance of nectar-feeding bats and the germination consequences of self-pollination. *Plant Ecol.* **2018**, *219*, 927–939. [\[CrossRef\]](#)
90. Caballero-Martínez, L.A.; Rivas-Manzano, I.V.; Aguilera-Gómez, L.I. Hábitos alimentarios de *Anoura geoffroyi* (Chiroptera: Phyllostomidae) en Ixtapan del Oro, Estado de México, Mexico. *Acta Zool. Mex.* **2009**, *25*, 161–175. (In Spanish) [\[CrossRef\]](#)
91. Castro-Luna, A.A.; Galindo-González, J. Enriching agroecosystems with fruit-producing tree species favors the abundance and richness of frugivorous and nectarivorous bats in Veracruz, Mexico. *Mamm. Biol.* **2012**, *77*, 32–40. [\[CrossRef\]](#)
92. La Garza, R.C.-D.; Flores-Rojas, E.; Briones-Escobedo, N.; Angel, E.H.-D.; Martínez-Gallardo, R.; Aguilera, J.C.L. Current records of the Mexican long-tongued bat, *Choeronycteris mexicana*, in Baja California, Mexico. *West. N. Am. Nat.* **2006**, *66*, 265–267. [\[CrossRef\]](#)
93. Riechers-Pérez, A.; Vidal-López, R. Registros de *Choeronycteris mexicana* (Chiroptera: Phyllostomidae) en Chiapas. *Rev. Mex. Biodivers.* **2009**, *80*, 879–882. (In Spanish)
94. Trejo-Salazar, R.E.; Scheinvar, E.; Eguiarte, L.E. ¿Quién poliniza realmente los agaves? Diversidad de visitantes florales en 3 especies de *Agave* (Agavoideae: Asparagaceae). *Rev. Mex. Biodivers.* **2015**, *86*, 358–369. [\[CrossRef\]](#)
95. Moreno-Valdez, A.; Honeycutt, R.L.; Grant, W.E. Colony dynamics of *Leptonycteris nivalis* (Mexican long-Nosed bat) related to Flowering *Agave* in northern Mexico. *J. Mammal.* **2004**, *85*, 453–459. [\[CrossRef\]](#)
96. Sánchez, R.; Medellín, R.A. Food habits of the threatened bat *Leptonycteris nivalis* (Chiroptera: Phyllostomidae) in a mating roost in Mexico. *J. Nat. Hist.* **2007**, *41*, 1753–1764. [\[CrossRef\]](#)
97. Stoner, K.E.; Karla, A.S.; Roxana, C.F.; Quesada, M. Population dynamics, reproduction, and diet of the lesser long-nosed bat (*Leptonycteris curasoae*) in Jalisco, Mexico: Implications for conservation. *Biodivers. Conserv.* **2003**, *12*, 357–373. [\[CrossRef\]](#)
98. Peñalba, M.C.; Molina-Freaner, F.; Rodríguez, L.L. Resource availability, population dynamics and diet of the nectar-feeding bat *Leptonycteris curasoae* in Guaymas, Sonora, Mexico. *Biodivers. Conserv.* **2006**, *15*, 3017–3034. [\[CrossRef\]](#)
99. Stoner, K.E.; Quesada, M.; Rosas-Guerrero, V.; Lobo, J.A. Effects of Forest Fragmentation on the Colima Long-nosed Bat (*Musonycteris harrisoni*) Foraging in Tropical Dry Forest of Jalisco, Mexico. *Biotropica* **2002**, *34*, 462–467. [\[CrossRef\]](#)
100. Orozco-Lugo, C.L.; Valenzuela-Galván, D.; Lavalle-Sánchez, A.; Mora-Delgado, A.; Ocampo-Ramírez, C. Primer registro del murciélago platanero *Musonycteris harrisoni* (Chiroptera: Phyllostomidae) en Puebla, México. *Rev. Mex. Biodivers.* **2013**, *84*, 709–712. [\[CrossRef\]](#)
101. CONANP (Comisión Nacional de Áreas Naturales Protegidas). (In Spanish). Available online: <https://www.gob.mx/conanp> (accessed on 20 October 2020).
102. Plasencia-Vázquez, A.H.; Escalona-Segura, G.; Cú-Vizcarra, J.D.; Borges-Jesús, K.P.; Serrano-Rodríguez, A.; Ferrer-Sánchez, Y.; Vargas-Contreras, J.A. Diversidad de murciélagos en la selva baja inundable del sureste de México. *Rev. Biol. Trop.* **2020**, *68*, 623–640. (In Spanish) [\[CrossRef\]](#)
103. Buenrostro-Silva, A.; Antonio-Gutiérrez, M.; García-Grajales, J. Diversidad de murciélagos de la cuenca baja del Río Verde, Oaxaca. *Therya* **2013**, *4*, 361–376. [\[CrossRef\]](#)
104. Martín-Park, A.; Delfín-González, H.; Sosenski, P.; Reyes-Novelo, E.; Meléndez-Ramírez, V.; Navarrete-Carballo, J.; Ibáñez-Bernal, S.; Dzúl-Manzanilla, F.; González-Moreno, A.; Manrique-Saide, P. Diversity of Tabanidae, Asilidae and Syrphidae (Diptera) in natural protected areas of Yucatan, Mexico. *J. Insect Conserv.* **2018**, *22*, 85–97. [\[CrossRef\]](#)
105. DOF (Diario Oficial de la Federación: NORMA Oficial Mexicana NOM-059-SEMARNAT-2010). (In Spanish). Available online: https://dof.gob.mx/nota_detalle_popup.php?codigo=5173091 (accessed on 22 October 2020).
106. IUCN (International Union for Conservation of Nature: The IUCN Red List of Threatened Species. Version 2020.2). Available online: <https://www.iucnredlist.org> (accessed on 17 January 2021).
107. SENASICA (Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria). (In Spanish). Available online: <https://www.gob.mx/senasica/prensa/instalan-sader-y-semarnat-grupo-de-coordinacion-para-proteger-a-polinizadores-203953> (accessed on 24 September 2020).