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BRAZILIAN BEE SURVEYS: STATE OF KNOWLEDGE, CONSERVATION AND SUSTAINABLE USE

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ABSTRACT

The understanding of bee communities and their association with particular habitats can prove to be a very useful tool in identifying the vulnerability of these organisms to landscape changes and is also fundamental to assess the potential of bees for sustainable use in agriculture. Data on bee communities have been collected in Brazil for more than thirty years and are mainly bee species lists, information on bee abundance, seasonal and daily activity, and lists of mellitophilous plants. A local picture of community composition and structure can be drawn although proper species identification impedes a detailed analysis and limits comparisons among areas. Our intention here is to present overviews of the information on native bees gathered from surveys on bee communities and discuss the implications of the status of current knowledge to native bees conservation and its potential sustainable use.

INTRODUCTION

The knowledge about Brazilian bees can be obtained from works of the naturalists in the beginning of the century, like Cockerell (1900), Ducke (1906, 1907), Friese (1910), Schrottky (1902), from bee collections, private (Moure 1943, 1944) or in museums; from works on bee biogeography and from bee community surveys (Aguiar 1995; Aguilar 1998; Albuquerque 1998; Albuquerque and Mendonça 1996; Alves dos Santos 1996; Barbosa and Laroca 1993; Bortoli and Laroca 1990, 1997; Brito 1994; Camargo and Mazucato 1984; Campos 1989; Carvalho and Bego 1998; Cure *et al.* 1993; Cure *et al.* 1992; Faria and Camargo 1996; Gottsberger *et al.* 1996; Hoffman 1990; Hakim 1983; Knoll 1985; Laroca 1974; Laroca and Almeida 1994; Laroca *et al.* 1982; Martins 1990; Mateus 1998; Oliveira and Campos 1995; Orth 1983; Ortolan 1989; Pedro 1992, 1996; Pesenko 1978; Primack 1995; Ramalho 1995; Raw *et al.* 1998; Sakagami *et al.* 1967; Schlindwein 1995; Schwartz-Filho 1993; Silva 1998; Silveira 1989; Silveira and Cure 1993; Silveira *et al.* 1993; Silveira and Campos 1995; Sofia 1996; Taura 1990; Wilms 1995; Wittman and Hoffman 1990; Zanella 1991). This information is scattered over different kinds of published and unpublished material, unfortunately, the knowledge on Brazilian bees is lacking a synthesis. Particularly, the understanding of bee communities and their association with particular habitats can prove to be a very useful tool in identifying the vulnerability of these organisms to landscape changes and is also fundamental to assess the potential of bees for sustainable use in agriculture.

Systematic bee assemblages surveys were first carried in the late 60´s by Sakagami *et al.* (1967), when a standard sampling methodology was proposed. Basically, bees were netted on flowers or nearby them with limited time spent on each flower. Since then most bee surveys applied this methodology, although authors often mention modifications.

Data produced by these works are bee species lists, information on bee abundance, seasonal and daily activity, and lists of mellitophilous plants. Local pictures of community composition and structure can be drawn, but proper species identification impedes a detailed analysis and limits comparisons among areas. Ramalho (1995) presented a synthesis of available data on Brazilian bee communities pointing out a gradient of species richness for each family according to latitude.

Our intention here is to present overviews of the information on native bees gathered from surveys on bee communities and discuss the implications of the status of current knowledge to native bee conservation and its potential for sustainable use.

We intend to answer the following questions about Brazilian bees' diversity, which we use to suggest some guidelines for a bee conservation policy:

1. How extensive has been the effort to survey bee communities in Brazil's regions and ecosystems?
2. What are the main groups accounting for the alpha diversity in each region?
3. What can surveys in disturbed and undisturbed areas tell us about bee communities?
4. What are the bee-plant potential associations between bees and plants and what are the perspectives of the sustainable use of native bee fauna in agriculture?

The Surveys

In Brazil the interest on systematic surveys started thirty years ago and since then more than 46 studies have been completed. Many of those studies were made by graduate students as dissertation projects. This resulted in a clumped distribution of sampling effort in the states where universities are located. Surveys are often conducted independently by each major academic working group, and are not part of a broader diversity inventory effort or planning. The resulting data frequently remain unpublished, being accessible only from the original dissertations and thesis, usually only available at universities sponsoring the survey. These surveys are snap shots and give us spatially and temporarily restricted information on bee communities. Only in two studies (Siveira and Campos 1995; Wittman and Hoffman 1990) did authors attempt to present data in a larger geographical scale. Monitoring programs have not been established, although three sites in South Brazil have been sampled in different years (Laroca and Orth, this book).

Brazil is a large country ranging from latitudes 5°N to 34° S. Many biomes are contained within its frontiers. In order to present data on the distribution of surveys and describe the results we use the classification of Udvardy (Udvardy 1975) of Biogeographical Realms and Provinces cited on the Global Biodiversity Assessment published by the United Nations Environment Programme (Heywood 1995). For each biogeographical realm a description of local vegetation types is provided, in some cases local vegetation may differ from the general description of Udvardy's category. According to this classification, 27.8 % of the surveys were carried out in the Tropical Savannas, 24.1% in Tropical Humid Forests, 31.5% in Subtropical/Temperate Rainforests/Woodlands, 13% in the Temperate Grasslands and 3.7% in Tropical Dry Forest/Woodlands. (See Fig.1)

a) Tropical savanna

The Tropical Savanna realm comprises more than 2 million km^2, and is locally called "cerrados". Many different physiognomies, from open grasslands to woodlands are found, but a floristic identity is recognised. Patches of deciduous or semi-deciduous forests and gallery forests also occur. The cerrado is intensively exploited for agriculture and cattle grazing which has resulted in the loss of around 37% of its original cover (Dias 1994). The bee surveys were conducted in disturbed fragments relatively clumped in the vicinities of the cities and one in high altitude rocky fields (Brito 1994; Camargo and Mazucato 1984; Campos 1989; Carvalho and Bego 1998; Faria and Camargo 1996; Martins 1990; Mateus 1998; Pedro 1992; Raw *et al.* 1998; Rego 1998; Silveira 1989; Pinheiro-Machado in prep.).

b) Tropical Humid forests.

Amazon region

The Tropical Humid forests in Brazil are represented by two major vegetation continuums. One is the Amazonian Forest, a recognised centre of biodiversity world-wide, where not a single bee community survey has ever been conducted. Information about bees from Amazon region are derived from early collections by Ducke (1906) and other such studies on specific groups such as Euglossinae (Oliveira 1995) and Meliponinae (Camargo 1970), among others.

Atlantic Rain Forest.

The other major forest continuum is the Atlantic Rain Forest, which extended originally along the Brazilian Coast from the northeastern to the southern regions of Brazil, and is presently reduced to 9% of its original distribution. The Atlantic Rain Forest comprises the forests on the slopes of the coastal mountains, the vegetation on the coastal sand plains and dunes. This is also an internationally recognised hotspot of biodiversity. The main threats to this formation are due to human occupation. The sampling effort was concentrated on the southern portion of its distribution where habitat disturbances were greatest. In the last decade the bee sampling efforts in the Atlantic rain forest have increased, (Aguilar 1998; Alves dos Santos 1996; Ramalho 1995; Wilms 1995), and new techniques for canopy sampling are being used for the first time.

c) Subtropical/Temperate Rain Forests.

The Subtropical/Temperate rain forest realm is characterised by semidecidous and altitudinal forests located on the Brazilian Southern Plateau. All surveys conducted in these formations were in the Southeast region, the most economically developed part of the country. There are no primary forest left in this region, but there are important secondary growth forests where natural reserves have been established.

d) Tropical Dry Forest/Woodlands.

The Tropical Dry Forest/Woodlands realm is locally called "caatinga" vegetation. This is a vegetation that grows under very irregular pluvial regime and passes through long droughts. It is a habitat with very typical physiognomy and floristics, with characteristically thin, thorny branched, low-lying trees.

e) Temperate grassland.

The last realm is Temperate Grassland, located in South Brazil. A variety of habitats are found in this region. Bee inventories were carried out in 7 different regions (Sazima 1989). These regions comprise the Southern-most distribution of the Atlantic Forest, the *Araucaria* Plateau, deciduous forests, open fields (pampas), disturbed secondary growth subtropical rain forest and coastal plain forests.

Although more than 46 studies may sound like a lot, in a large country like Brazil, this number was not enough to sample uniformly the variety of different landscape and ecosystems. A glance at the map presented in Fig.1 reveals very large gaps in regions of high diversity .The Amazon Forest, the *Pantanal* and the Atlantic Forest between the States of Rio de Janeiro and Espírito Santo are examples.

If one considers the sampled areas based on environmental disturbance, we should find that 63% of the studies were conducted in areas covered with natural vegetation of primary or secondary growth, 10% were in agroecosystems and 27% in urban areas. Unfortunately, around 70% of these natural areas are secondary growth fragments and the other 30% are not pristine areas, but are areas within reserves where man's interference has been minimal. The data highlight the idea that the Brazilian bee communities are in fact still poorly known, based on the hypothesis of loss of diversity associated with habitat disturbance presented in a conservation biology text (Meffe 1994).

The following conclusions are derived from the data presented above. To achieve a sound knowledge on Brazilian bee fauna a general plan of sampling sites is to be proposed. If data necessary to provide an overview of bee biodiversity is to be obtained by academics, a co-operative program between universities and environmental agencies must be established. Data produced should be published or made available in a national database, to allow comparisons, monitoring changes, and avoid undesirable repetitive samplings. Hotspots of diversity should be considered priority areas for sampling and collections at these sites should be encouraged. Collections should be properly housed and arrated in recognised entomological museums.

Bee fauna diversity
Six families, Andrenidae, Anthophoridae, Apidae, Colletidae, Halictidae, and Megachilidae, 42 tribes and 219 genera were found in Brazilian surveys. Anthophoridae accounts for 70 genera, Halictidae for 34, Colletidae for 30, Andrenidae for 30, Megachilidae for 28 and Apidae for 27.

The total number of species accounted by each family in Brazilian bee inventories is not an information that can be promptly assessed. The species list resulting from all bee community surveys sum up more than 3,000 names. Moreover, only 1,000 names correspond to identified species. The rest are species that could not be properly identified (Silveira *et a.*, this book) and many of them probably belong to the same species.

The overview of Brazilian bee diversity based on the surveys of communities produced till now may be subject to some bias. Surveys of regional distribution may have produced underestimates of some groups, depending on their biogeographical distributions. This could be the case of Apidae-Meliponinae known to be richest in species around the latitude 0º (Ramalho 1995). The taxonomic status of the group, meaning how much effort has been put into taxonomic description and revisions, may also have a significant effect on results. Well-studied groups may end up with greater numbers of species than poorly studied ones. Taxonomic revisions may recognise more species in what has been considered a single species. Demographic characteristics of some groups, as low-density populations, or crepuscular habits, may influence the final result depending on the sampling methodology and sampling effort.

Bee community diversity can be estimated in many ways. A simple one is through the *alpha* diversity, or the number of species found in the area. Inventories in Brazil found from 35 up to more than 300 species in single sites. The sites where fewer species were found are in dunes and in caatinga vegetation (see chapters in this book), habitats with very seasonal and harsh environmental conditions as temperature, humidity and wind speed. Harsh environments, otherwise, cannot be immediately assumed to contain fewer species. Michener (1979) has already pointed out that xeric temperate regions are where the greatest diversity of bees is found. The number of species found in surveys carried in dunes and caatingas range from 35 to 41 species. Surveys in coastal islands resulted in 57 and 75 species (Schwartz-Filho 1993). In the continent the number of species obtained is often superior to 100 species for surveys with at least one year of sampling. It is not possible to point out specific sites of greatest species richness based on raw data from surveys because of important differences in collecting methodology and sampling efforts.

Some authors have presented the Shannon-Wienner (H') diversity and evenness indices from their samples, and they range from 2.11 in the caatingas to 4.48 in cerrado fragments and 0.53-0.80 of evenness for studies with one year of sampling. One pattern in bee communities seems to be that there are few species with great abundance and many species with only a few individuals. This pattern still holds if eusocial species are kept aside. However, more detailed studies are needed to confirm this apparent generality for the Brazilian apifauna.

We have attempted to provide a description of bee diversity in the main vegetation types found in the biogeographic realms presented above and point out what groups better explain the diversity of the bee fauna in these macro-regions. For this purpose we counted the number of species presented by authors in each survey, which we used to obtain an average number of species for each taxonomic group for the chosen macro-environment. This was the way we found to avoid recounts of non identified species and a misleading panorama if we used only well identified species. The six families were found in all biogeographic realms, although they have not been present in every survey.

The Tropical Savanna.
We have selected 9 surveys carried on *cerrado* remnant areas (Campos 1989; Carvalho and Bego 1998; Martins 1990; Mateus 1998; Pedro 1992; Rego 1998; Silveira 1989; Pinheiro-Machado in prep). Family rank based on the average number of species shows Anthophoridae with 45.5%, Halictidae with 20.7%, Megachilidae with 18.2%, Apidae with 17.6%, Colletidae with 4.1% and Andrenidae with 1.2%. A total of 32 tribes and 119 genera were found in these 9 surveys. Eight tribes with the greatest number of species account for 70% of the total species. These tribes are Augochlorini (16.1%), Centridini (15.1%), Megachilini (14.0%), Exomalopsini (11.9%), Trigonini (10.5%), Ceratinini (5.4%), Halictini (4.5%) and Eucerini (3.4%).

The genera with the greatest number of species are *Megachile* (ME) with 11.1%, *Centris* with 10.2%, *Paratetrapedia* with 8.2% and *Augochloropsis* with 6.3% of the species. The eight richest genera account for 53.5% of the species richness in Tropical Savannas, and they are, besides those mentioned above, *Epicharis* (5.1%), *Augochlora* (5.1%), *Ceratina* (3.9%) and *Exomalopsis* (3.6%).

Tropical Humid Forests.
Nine areas of Atlantic Rainforest were selected (2,5,29,30,47,55,56,64,66). The richest family is Halictidae, with 30.9% of the species, followed by Anthophoridae with 30.1% of the species, Megachilidae 14%, Apidae 12.7%, Colletidae 7.7% and Andrenidade 4.2% of the species. Bees' species belong to 32 tribes and 131 genera.

The tribes with more species are Augochlorini (22.8%); Megachilini (12%); Halictini (8.3%), Ceratinini (6.6%), Trigonini (6.3%); Exomalopsini (5.9%), Centridini (4.7%), Hylaeni (4.0%), Eucerini (3.7%), Panurgini (3.6%). These 10 tribes account for 71.6 % of the total species richness.

The genera with more species area *Megachile* (10.1%), *Augochloropsis* (8.3%), *Augochlora* (7.0%), *Dialictus* (5.3%), *Centris* (4.8%), *Ceratina* (3.9%), *Paratetrapedia* (3.8%), *Hylaeus* (3.9%), *Ceratinula* (3.5%). It is necessary to pick up 9 genera with the greatest number of species to achieve fifty percent of the number of species.

Subtropical /Temperate Rainforests.
Most surveys in this biogeographic realm were conducted in disturbed areas that were originally covered by the Araucaria forests. We based the estimate presented above in 9 surveys, but only one was in natural vegetation remnant (6,8,9,26,30,32,41,42,63). The rank based on the average number of species are 46.1% of the species in Halictidae, 18.3% in Anthophoridae, 12.0% in Megachilidae, 10.9% in Andrenidae, 4.8% of the species in Colletidae , and 4.6% in Apidae. Bees' species belong to 31 tribes and 107 genera.

The six richest tribes account for 79.9% of the species in the samples, which are: Halictini (25.1%), Augochlorini (20.5%), Megachilini, (11.4%), Panurgini (10.1%), Eucerni (6.5%), Ceratinini (6.3%).

The six genera with greatest number of species account for 50.9% of the sampled species. The richest genera are *Dialictus* (21.5%), *Augochloropsis* (9.2%), *Megachile* (8.2%), *Ceratina* (4.4%), *Psaenythia* (4.2%), and *Augochlora* (3.4%).

Tropical Dry Forests.

This biogeographic realm has been sampled only 2 times until now, being each sampling period restricted to one year (Aguiar 1995; Mares 1986). Therefore, data in this particular case should be regarded as preliminary data. The species richness is much more concentrated in Anthophoridae, with 38.8% of the species, Apidae with 17.6% of the species, Megachiliade with 16.5%, Halictidae with 12.9 % of the species, Andrenidae with 8.2% and Colletidae with 5.9% of the sampled species. The bee species found in the caatinga was represented in 17 tribes and 37 genera.

The seven richest tribes account for 76.5% of the total number of species. Trigonini and Megachilini are the richest tribes both with 14.1% of the species, followed by Centridini with 12.9%, and Halictini with 10.6%, Augochlorini with 7.1%, and Eucerini, Panurgini, Exomalopsini with 5.9% of the species each. The genera with more species are *Centris* with 12.9% of the species, *Megachile* with 11.8% of the species, *Dialictus* with 4.7%, and *Exomalopsis* and *Augochlora* with 3.5 % of the species each, and *Ceratina* with 2.4% of the species.

Temperate Grasslands.
Bee species caught at the various habitats from South (Hoffman 1990; Schlindwein 1995; Wittman and Hoffman 1990) belonging to six families are 29.8% Anthophoridae; 25% Megachilidae; 23.3%, Halictidae, 22.7%; Andrenidae 9.5% Colletidae 8.7%; Apidae, 5.9%. Species found in 33 tribes and 95 genera.

The tribes that contribute most to the species richness are Megachilini, with 17.4%, Augochlorini with 17.1% of the species, Eucerini, with 6.1%, Halictini with 5.2%, Ceratinini with 4.7%, Exomalopsini with 4.6%; Melitomini with 4.1% Xylocopini with 4.0%, Trigonini with 3.8% and Centridini with 2.5% of the species. These 10 tribes account for 69.5% of the species.

Fifteen richest genera account for 50% of the number of species. These are *Megachile* (13.9%), *Augochloropsis* (8.0%), *Ceratina* (4.4%), *Augochlora* (4,3%), *Dialictus* (3.4%) and *Psaenyhia* (3,2%), among others.

Taxonomic groups explaining the alpha diversity in the various regions of Brazil are affected by Family species richness. The importance of Augochlorini (*Augochloropsis*) and Megachilini (*Megachile*) is a constant in almost all biogeographic realms, except in the areas of caatingas in the Tropical Dry Forests where Augochlorini is not as well represented as in the other areas. Unfortunately the reduced number of surveys do not allow further discussions.

Comparing savanna like vegetation (cerrados) and rainforest bee fauna it is possible to notice that the species richness in cerrado is more evenly distributed than in rainforests, where Augochlorini has a major role. The increased contribution of Centridini and Exomalopsini for the number of species in the cerrados is an evident difference. The importance of oil collecting species, common in the two above mentioned tribes, has been related to the presence of many species of Malpighiaceae in the cerrados (Ramalho 1995). Ceratinini and Eucerini make a similar contribution to species number in both habitats, while Panurgini is important only in the rainforests sample. Trigonini accounted for a higher percentage of species in the cerrados than in the rainforests, while the contrary is noticed for Halictini.

In the habitats in South Brazil, we can see the decrease in importance of Centridini and Trigonini. Ceratinini and Eucerini are similarly important in percentage of species, although their contributions are larger than in the above mentioned habitats. Panurgini is much more represented in the South than in the other regions so far surveyed. Most samples taken in the Subtropical/Temperate rainforest realm were in urban or suburban areas, and this might be the cause of the great percentage of Halictini species. One forth of the species are Halictini, and the majority of them are *Dalictus*. Megachilini has the greatest percentage of species in the surveys carried in the Temperate Grassland Realm.

It is worthy mentioning that the above presented rank for the number of species per family is not necessarily the same presented by authors in each original work. This could result for many reasons, but one should be highlighted. It is probably related to particular features of sampled habitats, once the heterogeneity in the local scale is enough to result in diverse faunal compositions.

Habitat alteration and bee communities

The very issue in conservation biology is to reveal what are the effects of human activities on the various levels of life is organisation, from species to ecosystem (Primack 1995). The three guiding principles of this science stated by Meffe and Carrol (1994) embrace a) the role of evolutionary processes, b) the idea of a "dynamic and largely non-equilibrium" world and c) the importance of including the human presence in conservation planning.

Habitat conversion to agroecosystems or to urban landscapes may affect bees in many different manners. Habitat loss and population isolation of the bee colonies is easy to picture in these scenarios. Bees are a large group with an enormous potential for a variety of demands that may be more or less affected by habitat changes. The nesting demands, dependence of particular food resource, physiological and behavioural constraints are examples of biological features that can influence the persistence of a particular taxon.

What we know so far about Brazilian native bee biology is far short of placing us in a comfortable position to determine or identify species sensitivity or vulnerability to any sort of human activity. What we can do is to look for clues in the available knowledge to ask new questions and to set some starting hypotheses to be properly tested opportunely.

Bee surveys have been conducted in more or less disturbed areas. The most disturbed areas are cities, where the original cover was not only removed, but in many cases the native plants have been replaced by exotic. Microclimatic changes are severe. Even with this disturbance, some groups were able to persist in cities and others seemed to have increased their relative abundance. Halictidae is the most represented family in samples taken from both urban areas and agroecosystems. But this trend could be challenged as most surveys in the disturbed areas were done in southern Brazil where Halictidae is known to be the most diverse (Eickwort 1969). Some authors (Pedro 1992; Taura 1990) refer to Pesenko's (1978) work to support the idea that Halictidae may be related to disturbed or open areas. The available data in the literature is not conclusive in this way, as for instance Halictidae was the family found most frequently in two areas of well-developed Atlantic Forests (Ramalho 1995; Wilms 1995).

Another novel and interesting approach would be to investigate bees according to their behavioural, morphological and functional perspectives. The effects of habitat change on bees could be more easily detected at a species level that share common demands rather than using a taxon that may embrace bees with differing requirements.

Potential bee plant association

We have looked in all surveys for information about the main flower resources used by bee families in order to highlight groups that could play an important role in bee fauna for sustainable use in agriculture. Not all works present such data. The available data are the proportions of individuals of each bee family that were caught in each plant family. Authors usually present their data as the "main plant families" used by bees. We have established that the main plant families are the ones where most individuals were caught up to 70% of the individuals. Two major biogeographical realms of special interest to conservation issues were considered: the Tropical Savannas and the Tropical Humid Forests. For each biogeographical realm we recorded the number of many surveys that record a bee family that uses a named plant family as a main food resource. So the frequency we refer hereafter is the number of surveys a bee-plant pair appears out of the total number of surveys considered. Six surveys were considered in each biogeographical realm. This number represents the number of surveys that had the information promptly available.

In the Tropical Savannas the most important plant families to Anthophoridae were Malpighiaceae, Asteraceae and Lamiaceae. Apidae frequented the broadest spectrum of plant families, but Malpighiaceae and Asteraceae were the most frequent association. Halictidae also frequented a broad spectrum of plant families, but Asteraceae and Malpighiaceae were the most frequent. Megachilidae is the bee family with the narrowest spectrum of important families. Asteraceae is where more than 50% of all Megachilidae were caught in surveys considered. Leguminosae is the second most frequent pair with Magachilidae. Both Malpighiaceae and Asteraceae were where large numbers of bees in the surveys were found and thus are important sources to all families. If later work surveyed bees down to genera, potential associations could be better envisioned.

In the Tropical Humid Forests Anthophoridae bees were found in Asteraceae and Rubiaceae most frequently as well as in Euphorbiaceae and Leguminosae. Apidae were mainly caught in Asteraceae, Melastomataceae, Sapindaceae and Leguminosae. Halictidae were most frequently associated with Asteraceae, Rubiaceae, and Leguminosae. The most important plant source for Megachilidae was Asteraceae, as it was in the Tropical Savannas, but Megachilidae also frequented Rubiaceae and Leguminosae.

The data presented above are useful in our preliminary approach, which has no intention of being conclusive. We believe that it possible to identify and determine potential associations in a more accurate and precise manner from data that have already been collected and that this could be a starting point for the investigation of how native bees could be better utilised in agriculture.

Constraints to a synthesis of Brazilian Bees Communities

The most evident difficulty is dealing with data on Brazilian bees is finding them. A major setback is that so much data either remains unpublished or takes too long to become available to the public. Consequently, this hinders the development of bee inventory and methodology which raises pertinent questions. If data cannot be exposed to criticisms, the same mistakes will keep reocurring. The limitations of present applied sampling methodology on bees has been known for a long time, but new alternatives or adjustments have not been proposed or discussed.

The common complaint of authors is the difficulty of comparing samples and identifying patterns because of methodological constraints. Silveira and Campos (1995) and Silveira *et al.* (1993) proposed some statistical techniques to improve data analyses from bee inventories. Cure *et al.* (1993) started a discussion on the influence of the sample size on richness estimates. These are problems that need to be addressed.

The important constraint imposed by methodological differences or absence of well-established techniques for dealing with different samples is to the synthesis of knowledge needed to provide an overview of Brazilian bees. This is exactly the problem we faced here. Results can only be presented in a preliminary or partial way. Until much more data are available these problems will persist, as they do throughout the rest of the world.

Another difficulty arises from the description of the habitat were samples were taken. Descriptions are usually partial or incomplete. A very detailed description of the area would include not only the characteristics of the sampled areas but also of the surrounding environment that may influence faunal composition. Even the size of the sampled areas is often not clear. The total area of the landscape unit or the portion that was sampled is to be informed. Curves of species area are useful tools for conservation biologists and are based on this information. Better descriptions of previously sampled sites are needed by botanists and other natural scientists. However, assembling such teams is difficult.

CONCLUSIONS

Much effort has been put into the study of bee communities in Brazil. Nevertheless, because of its continental dimension much is still to be done. Many particular habitats, areas of plant endemism, natural remnants of different vegetation are expected to provide a great contribution to the total diversity of bees in Brazil. Although the state of Rio Grande do Sul, South Brazil, has been surveyed for a long time, sampling in particular habitats can bring out many new species (Oliveira and Campos 1995). Surveys in more pristine areas are lacking.

A co-ordinated effort to provide a complete overview of the Brazilian fauna has already started with the National Biota project, supported by FAPESP (Research Foundation of São Paulo State). The work is carried by University groups as part of a major biodiversity inventory program. The next step to be taken in Brazilian surveys is the establishment of a standard methodology that could be applied effectively in all types of Brazilian habitats to allow comparisons among areas and biodiversity diagnoses. Proper analyses are also needed to assure the data are as useful as possible. Data on populations should be encouraged because such data are the fundamental tool for conservation and management.

The sustainable use of native fauna in agriculture is still poorly investigated. For historical reasons the idea of increasing agricultural production is often associated to more land being cultivated. Greenhouses are probably a costly alternative for a country like Brazil with great expanses of land and economic difficulties. The introduction of exotic pollinators is absolutely not recommended as the local fauna has proven to be rich, both in species and in behavioural and morphological features.

What then, could be said about the use of bee pollinators in agriculture? The studies of communities showed us that even in very disturbed areas bees are found. Because of lack of data from more undisturbed areas and other constraints discussed above, it is not correct to say anything about how great the diversity is except in a few places. But if remnants of native vegetation are maintained in agriculture properties a great deal of bee fauna could be conserved. That is the very same fauna, which has a potential for agriculture use. Experiments are needed to evaluate the impact of the native bee presence and their absence in the production of surrounding agriculture fields. Stingless bees are easy to manipulate, thus making them an interesting starting group. They have been a well studied ecologically, behaviourally and physiologically. The role of stingless bees for pollination has been questioned, because of their illegitimate behaviour at flowers (Renner and Feil 1993), but no sound evidence exists that they are more opportunistic than useful for plants. Stingless bees can also be used in a very interesting manner for the cause of pollinator conservation. The idea of a bee, for the laymen, recalls the exotic *Apis mellifera*. A huge part of the population does not even know that this is not a Brazilian bee, and that the country is home to a great diversity of bee species. Mares (1986) has pointed out the importance of "people who bring accurate scientific information and explain the importance of conservation programs to the society at large, without which work, society would not support programs that limit free access to resources". The stingless bees are easily kept in experimental boxes and have a good appeal in educational exhibits.

Megachilidae are bees well explored as pollinators in the Northern Hemisphere. The importance is well established. In Brazil, as shown above, Megachilidae bees are a significant part of the biota, and seem to be an interesting alternative to be explored. The importance of other taxa is already known, as Xylocopini bees and Passifloraceae (Sazima and Sazima 1989). The use of these native bees in small properties could have a positive impact on household economy.

The Brazilian bee fauna has an enormous potential for agricultural production enhancement, but the studies and projects must be framed in the Brazilian perspective. The Northern Hemisphere models are probably not the best alternatives, but the lessons are there so that local alternatives and solutions can be pursued. The potential use of bee groups as pollinators in agricultural systems should take into account bee distribution and local bee plant associations. Preliminary data presented above indicate that there may be differences in bee-plant family associations according to the vegetation type or ecosystems the pair occurs.

It is clear from the Brazilian bee literature that we do not have information on communities and population processes, and this should be a warning to the possible negative or positive impacts of native bee population management. Although the use of native bee fauna as pollination services is recommended as opposed to the introduction of exotic pollinators, we shall not forget that even the management of native populations can result in undesirable effects on the total biodiversity.

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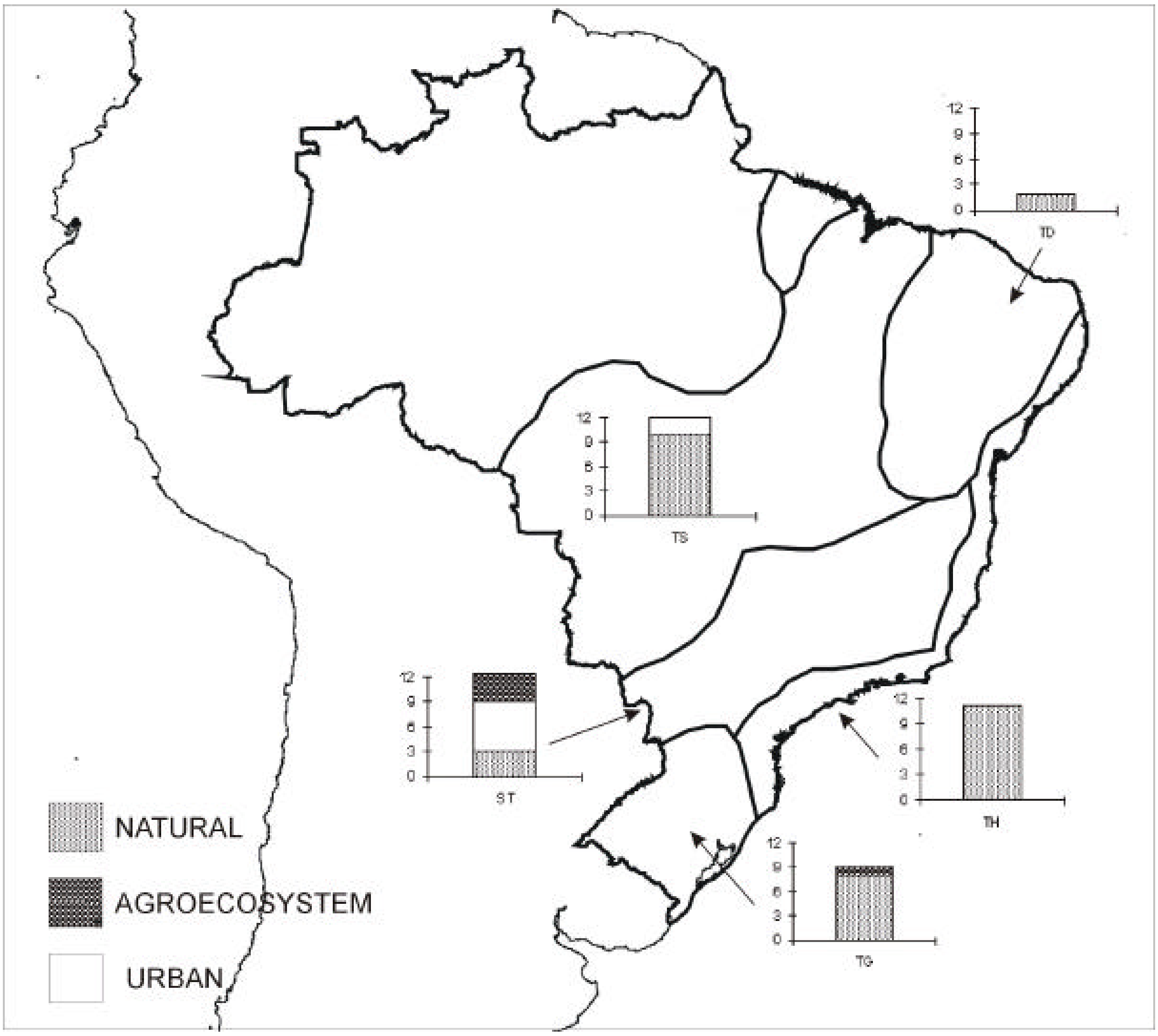

FIGURE 1 . Number of bee community surveys carried out in Brazil in each Biogeographical Region (According to Udvardy, 1975). TS = Tropical Savannahs; TG= Temperate Grasslands; TH= Tropical Humid Forests; TD=Tropical Dry Forests; ST=Subtropical/Temperate Rainforests.