



TEMPORAL ANALYSIS OF THE USE AND VEGETAL COVERAGE AND THE HONEY POLLEN DIVERSITY IN CÁCERES (MT)

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Abstract

This study was conducted to evaluate the influence of the use dynamics and the vegetation cover during the years 2005, 2006, 2008 and 2009 on vegetal diversity as well as its influence on pollen types found in honey of *Apis mellifera* during two periods, in Cáceres- Mato Grosso State. The use and vegetation cover were analyzed, using the software SPRING and ArcGIS. The collection of both honey and flowers were monthly sampled during the periods from July/2005 to June/2006 and January/2008 to October/2009 in a commercial apiary located in Cáceres. Both qualitative and quantitative analyses of the pollen grains were accomplished in 98 honey slides. The diversity of the pollens was compared between crop and non-crop cycles, using the similarity coefficient. The honey samples were similar between crop cycles/2008 and crop/2005 ($S_s=0,29$) and between the crops cycles and crop/2008 ($S_s=0,35$). The crop/2009 was not similar to other periods. The important species for honey were *Cecropia pachystachya*, *Mimosa pudica* and *Myracrodruon urundeuva*, which were not affected both by the use dynamics and vegetation cover. The temporal dynamics of the use and vegetation cover caused low variation in the human-affected and Savannah areas, unlike pollen diversity of the honey which was similar in this research.

Key words: *Apis mellifera*. Vegetation species. Temporality. Geographic Information System. Geo-Technologies.

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Resumo

Análise temporal do uso e cobertura vegetal e a diversidade polínica do mel em Cáceres (MT)

Objetivou-se avaliar a influência da dinâmica do uso e a cobertura vegetal nos anos de 2005, 2006, 2008 e 2009 sobre a diversidade de plantas e a influência de ambos sobre os tipos polínicos encontrados no mel de *Apis mellifera* L. em dois períodos em Cáceres (MT). O uso e cobertura vegetal foi realizado por meio da utilização dos SIGs SPRING e ArcGIS. As coletas de méis e flores foram amostradas mensalmente em um apiário comercial em Cáceres, de julho/2005 a junho/2006, janeiro/2008 a outubro/2009. As análises qualitativas e quantitativas dos grãos de pólen foram realizadas em 98 lâminas de méis. A diversidade de pólen foi comparada entre safra e entressafra por meio do índice de similaridade. A similaridade nos méis ocorreu entre a safra/2005 e a entressafra/2006 ($S_s=0,29$) e entre a entressafra e a safra/2008 ($S_s=0,35$). A safra/2009 não foi similar aos outros períodos. As espécies importantes para o mel foram *Cecropia pachystachya*, *Mimosa pudica* e *Myracrodruon urundeuva*, as quais não foram influenciadas pela dinâmica do uso e a cobertura vegetal. A dinâmica temporal do uso e cobertura vegetal ocasionou pouca variação nas áreas antrópicas e de Savana, ao contrário da diversidade polínica do mel que foi similar nessa pesquisa.

Palavras-chave: *Apis mellifera*. Espécies vegetais. Temporalidade. Sistema de informação geográfica. Geotecnologias.

INTRODUCTION

The disordered occupation processes of the landscape cause significant changes in ecosystems, such as the loss of native vegetation areas (WANG et al., 2010, p. 973) reducing the floristic diversity of the natural areas (BARBOSA et al., 2006, p. 189). According to Figueiredo et al. (2005, p. 572), the agricultural sector in the State of Mato Grosso presents a relevant economical potential, which reflects negatively on local biodiversity, since it promotes alterations in the natural landscapes.

According to Santos-Filho et al. (2008, p. 636), the habitat fragmentation provokes the decrease of the wealth and abundance of small mammals. The changes caused in the vegetation cover can also reduce the species with apicultural potential. According to Bastos et al. (2003, p. 599), the diversity of the apicultural species occurring in the Savannah fragments are related to the preservation level of the vegetation cover in surroundings of the apiaries, which are the source for the maintenance of the beehives.

In this sense, the honey can be used as an indicator of the vegetal species found in phyto-physiognomies around apiaries. Hjelle (1997, p. 5) showed that the pollen analysis reflects the occurrence of the local vegetation in landscapes that were exposed to human activities such as the pollen types Asteraceae, Poaceae, *Oxalis*, *Polygala*.

The species *Astronium* sp., *Alternanthera* sp., *Schinus* sp., *Serjanea* sp. (BASTOS, et al., 2003, p. 599) and *Cissus simsiana*, *Melochia tomentosa*, *Portulaca elatior* (CARVALHO e MARCHINI, 1999, p. 338) can be mentioned as indicative for both Savannah and Thorn forest fragments in the boundaries of the apiaries.

According to Souza (2004, p. 70, 71), the honey production is related to ecological conditions of the place where apiaries are set up, namely to variables such as presence of good flowering and water availability. According to Raffo and Paula (2009, p. 6, 10), the use of the Geographical Information Systems (GIS) can be helpful for the evaluation of land use/land cover, and as a tool to choose those places for the implantation of apiaries with the availability of apicultural floral resources. So GIS can be used to determine the places for installation of apiaries with minimum presence of native vegetation.

The use of geo-technologies as a tool for environmental analysis has also been used in several studies contemplating the area of planning applied to the environment and the management of natural resources (DONHA, et al., 2006, p. 176; ZURLINI, et al., 2006, p. 122; GRAYMORE et al., 2009, p. 455; AMARAL, et al., 2009, p. 317).

In Mato Grosso State, the beekeeping has acquired an important role as an alternative source of income. It is the second highest producer of honey of Brazilian Central-West region, with approximately 494 t in 2008 (IBGE, 2008, p. 26). The use of geo-technologies for the vegetal cover mapping helps the installation of apiaries in places presenting vegetal diversity, which locally contributes to the apicultural activity in the municipality of Cáceres. The replacement of native vegetation areas by a human-altered one can reduce the apicultural floral resource.

Thus this study was carried out to evaluate the influence of the dynamics of land use/land cover in the years 2005, 2006, 2008 and 2009 on the diversity of plants as well as the influence of both on the pollen types found in the honey of *Apis mellifera* L. during two periods in Cáceres (Mato Grosso State) municipality.

METHODOLOGY

AREA UNDER STUDY

This study was carried out in a commercial apiary located at coordinates S 16° 04' 52 '' and W 57° 36' 56 '' on dry land at Girau Farm, in the municipality of Cáceres, SW Mato Grosso State.

GENERATION OF THEMATIC MAPS

The land use/land cover was analyzed considering a 3km ray around the Girau apiary. The procedures for elaborating the thematic maps of land use/land cover began with geo-referencing from bands 3, 4 and 5 of the Landsat 5 TM images, Orbit/Point 227/71, with 30m spatial resolution, referring to the dry period of the years 2005, 2006, 2008 and 2009, using control points obtained in the field survey and processed with software SPRING. A second-grade polynomial transformation and the next neighbor pixel re-sampling technique were applied for geometric correction of the images (NEVES, 2006, p. 56).

To accomplish the segmentation of the image from the area under study, some tests were made to define the similarity values that delimit better the types of land use/land cover and concomitantly would not cause high fragmentation in these areas. It was verified that the value 10/25 is more acceptable, since it correctly separated the visually different gray levels.

The segmentation was followed by the creation of the context file, region extraction, training using the Bhattacharya classifier, and by the procedure for mapping the classes and prepare a thematic map. The elaboration of the layouts of the thematic maps and the quantifications were accomplished in ArcGis.

The toponymy (highways, rivers, localities, etc.) used as references in the interpretation process were compiled from the topographical map Cáceres (Sheet SE. 21-V-B-II) elaborated by the Cartography Service from the Army (*Diretoria do Serviço Cartográfico*

do Exército), at scale 1:100,000. This map was digitized, vectored and its information was associated to the geographical database in ArcGis.

The field works allowed the identification land use/land cover in the apiary surroundings, applying the methodology described in the technical manuals referring to it, elaborated by IBGE (1992, p. 26 and 1996, p. 27, 29, 32, 35). In this stage, the information contained in the Conservation Plan for the Upper Paraguay Basin (*Plano de Conservação da Bacia do Alto Paraguai- PCBAP*, 1997, p. 18) were also used as a reference.

COLLECTION OF HONEY AND PLANTS

The flowery species and the honeys were monthly collected during the time-span from July/2005 to June/2006 and from January /2008 to September/2009 in the municipality of Cáceres.

The flowery species were collected observing a radius of 3km around apiaries, a distance corresponding to twice the performance area of the bees (SANDE et al., 2009, p. 2704). The honeys were collected in three fixed beehives of *A. mellifera* type Langstroth in the chosen apiary.

The species of the collected plants were botanized, identified according to POTT & POTT (1994, p. 21 to 311) and by a specialist. They were deposited in the reference collection of the CETAPis Laboratory, in the University Campus of the Mato Grosso State University (UNEMAT) in Cáceres. The list of plants obtained was adapted to that one presented by Cronquist (1981, p. 268).

For the identification of the pollen types in the honey, some honey slides were mounted, adopting the fresh-preparation method, following the technique developed by Louveaux et al. (1970, p. 125, 138). The flowery plants were used to make floral buds, removing pollen from the closed stigma.

Qualitative and quantitative analysis of the pollen grains in the honey slides were made. The qualitative analysis was done by taxonomic identification of the pollen types at family and gender levels, as well as at specie level when possible, using the slides of the floral buds and specialized literature (BARTH; MELHEM, 1988, p. 11, 63, 69, 73; ERDTMAN, 1952, p. 11, 25; ROUBIK; MORENO, 1991, p. 43, 61, 77, 99).

The quantitative analysis was accomplished, by observing the frequency at which each pollen type occurs in the honey samples. The pollens were classified as dominant (frequency above 45%), accessory (frequency from 15% to 45%) and isolate (frequency lower than 15%) (BARTH, 1989, p. 13, 14, 16). The classification of the pollen types allows the determination of the vegetal species that are important for honey production.

The quantification of the vegetation diversity was based on the number of vegetal species found annually. To classify monthly the frequency of the pollen types in honey, the average of the quantitative analysis result of two honey slides was used. The seasonal frequency of the pollen types was accomplished during the periods of crop cycle (November to April) and crop (May to October), following the method previously described.

The analyses done during the periods of crop cycle and crop were the possible comparisons for the honeys collected in this study. The similarity of the vegetal species found in honey were compared between the crop cycle/2006 (November/2005 to April / 2006) and 2008 (November/2008 to April/2009) and the period of crop/2005 (July to October), 2008 (May to October) and 2009 (May to October). The comparison was made using the distance coefficient that was obtained by the Sorensen similarity index (Ss), which considered

both presence and absence of vegetal species. The distance coefficient was analyzed for the variation of the data to zero value (KREBS, 1998, p. 379).

The similarity analysis of the apicultural flora was done, using the Genes software (CRUZ, 2001).

RESULTS AND DISCUSSION

In this study, the following thematic classes were registered: Forested Savannah, Pasture, Degraded pasture, Wetlands and Water (Figure 1).

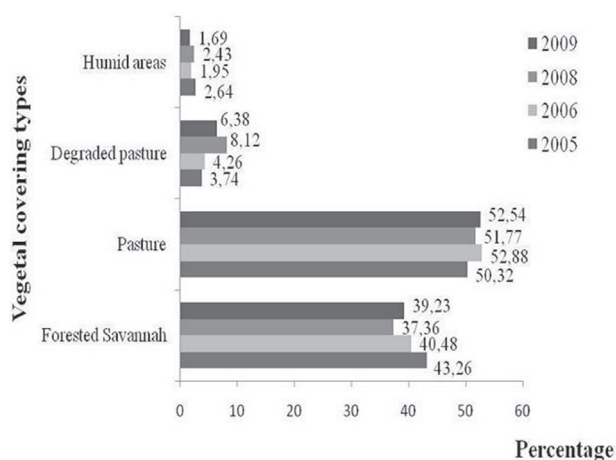


Figure 1 - Alteration dynamics of the vegetative cover types by percentage, in the apiary under study, Cáceres, Mato Grosso, Brazil among the years 2005, 2006, 2008 and 2009. Places with presence of ponds were not shown in the figure because corresponding to less than 1% of the area (0.04 to 0.43%)

In the years under investigation, a decrease in the size of the native vegetation areas as well as an increase in areas with human activities were observed. The vegetation formation of the Forested Savanna type presented variations in 2005 (1,227.02 ha), 2006 (1,148.10 ha), 2008 (1,059.62 ha) and 2009 (1,112.74 ha) (Figure 2). During the years under investigated, it was verified that those areas with native vegetation decreased from 43.26% (2005) to 39.23% (2009).

The dynamics of areas used as pasture presented relevant occurrence, but with little variation in 2005 (1,427.04ha), 2006 (1,499.64ha), 2008 (1,468.22ha) and 2009 (1,489.98ha). Similarly the pasture degraded along these years, respectively 105.98ha, 120.88ha, 230.22ha, and 180.89ha. The smallest area with human activity in the composition of the vegetation cover occurred in 2005 (54.06%) and the largest one was in 2008 (59.89%) (Figure 2).

Those results show the beginning of the process of natural vegetation substitution due to livestock implantation with the use of pastures. The livestock is the main economical activity in Cáceres municipality (IBGE, 2010), which favors the change of land use/ land cover. If the dynamics of the areas with livestock remains with an increase similar to the

investigated years, only isolated fragments from the Forested Savannah cover would remain. According to Fahrig (2003, p. 491), the environmental fragmentation causes negative effects on the biodiversity, such as the habitat loss, increased fragment numbers, decreased size and higher isolation among fragments.

Variations of the dynamics during these years were also found in those places with presence of water, namely 1.15 ha/2005; 12.17 ha/2006; 9.01 ha/2008 and 4.47/2009 and in the humid areas: 74.91 ha/2005; 55.31 ha/2006; 69.03 ha/2008 and 48.01 ha/2009 (Figure 2).

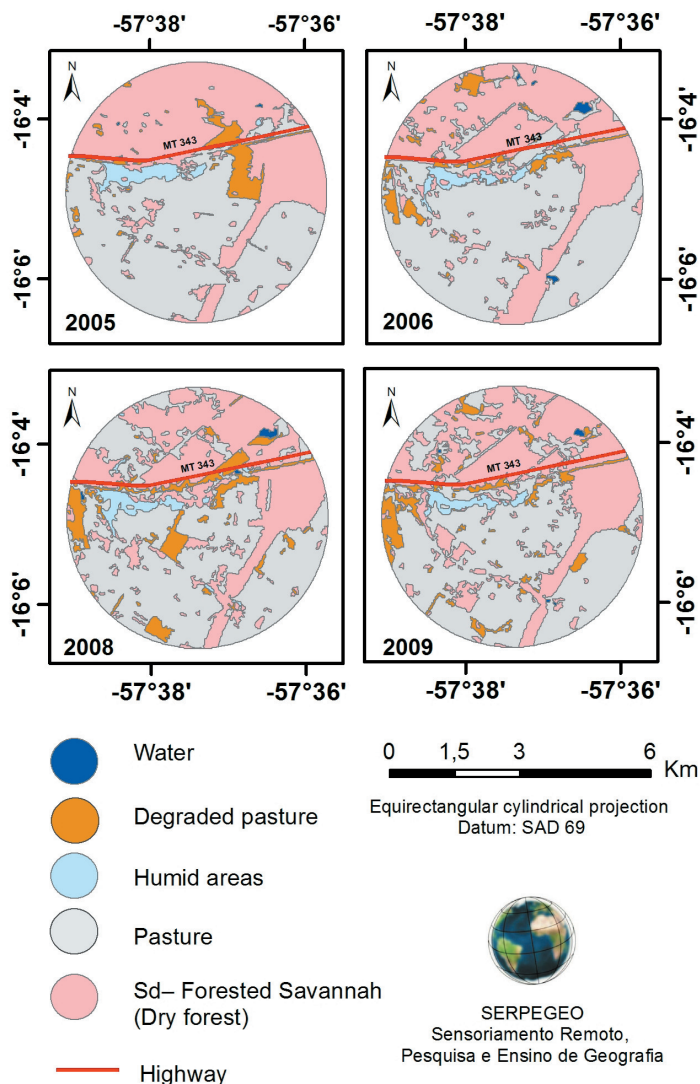


Figure 2 - Dynamics of the use and vegetal covering around the commercial apiary in Cáceres, Mato Grosso, Brazil during the years 2005, 2006, 2008 and 2009

Areas with human activities represented seven spots in 2005, which changed the following year (2006) with an increase in the number and size (Figure 2). In 2008, they increased to fifteen. In 2009, the number of the spots with human activities remained similar to 2008. The increase of the spots with human activities showed a decrease of those areas with native vegetation around the apiary under investigation.

Similarly to this study, the substitution of native areas by human ones was verified in several Brazilian regions as found by Barbosa et al. (2006, p. 189) in Uberlândia (Minas Gerais State) and by Cemin et al. (2009, p. 708) in the Taquari valley (Rio Grande do Sul State).

The plant diversity increased from 161 species during four years to 206 (Table 1). This increase can be related with the enlargement of the human used areas, probably due to the substitution of the Savannah native species by pioneer ones, which are characteristics of degraded pastures. The degraded pasture area increased 8.12% in 2008 and 6.38% in 2009, when compared with the previous years. For the definition of areas with degraded pasture, the main characteristic was the bare soil. (KOBAYAMA et al., 2001, p. 10).

In 2006 and 2009, there was a recovery of the degraded pasture areas around the apiary by harrowing and sowing of *Brachiaria brizantha* (Hochst. Ex A. Rich.) Stapf.

According to the Millennium Report (NAÇÕES UNIDAS, 2000, p. 15), the loss of the vegetation cover affects negatively the diversity of vegetal species. Dauber et al. (2003, p. 327) showed in their study that the types land use/land cover can be used as indicators for species richness at landscape scale, but they are limited where the composition of the landscape is narrowly correlated with the environmental conditions and cropping practices.

In this study, the honey pollen analysis identified the following main botanical families: Fabaceae (24), Asteraceae (10), Rubiaceae (9) and Malvaceae (9). The occurrence of these families could be related to the use of the vegetation cover during the years 2005, 2006, 2008 and 2009, as contributing to the presence of pioneer vegetation species such as *M. pudica*.

**Table 1 - Number of flowery vegetative species around apiary
in Cáceres, Mato Grosso, Brazil**

	2005	2006	2008	2009
Species number	161	120	236	206
Native Vegetation (ha)	1227.02	1148.10	1059.62	1112.74
Anthropic use (ha)	1533.02	1620.52	1698.44	1670.87

The important species for honey were *Cecropia pachystachya* (Urticaceae, accessory pollen in the crop and crop cycles), *Mimosa pudica* (Fabaceae, accessory pollen in the crop and dominant in the crop cycles) and *Myracrodruon urundeuva* (Anacardiaceae, accessory pollen in the crop and in crop cycle).

The dynamics of land use/land cover did not affect the occurrence of *M. urundeuva* in honey, although it is a typical species of native vegetation (POTT & POTT, 1994, p. 31). This can be explained by the presence of this species also in areas with human activities, such as pasture. Bastos et al. (2003, p. 599) also found native species of the Anacardiaceae family in savannah fragment in Minas Gerais State, such as in this study. The results of this work show that the land use/land cover did not interfere on the occurrence of *Myracrodruon urundeuva* in the local honey; however the conservation of those areas with Savannah around the apiary is of fundamental importance for the maintenance of this native species along the years.

According to Sande et al. (2009, p. 2706, 2707), the honey production was strongly influenced by the proximity of native vegetation in Kenya, when compared to the areas with

agricultural activities. For Coulson et al. (2005, p. 101) the environmental heterogeneity favors the supply of food resources to communities of bees, which influences positively the honey production. Féon et al. (2010, p. 148) shows that the abundance and wealth of the bee' communities decreases with the intensive management of the landscape.

The species *C. pachystachya* and *M. pudica* are also relevant for the maintenance of the apicultural activity in the area under study, because important pollen was found in the honey. *C. pachystachya* and *M. pudica* are considered as pioneers, as colonizers of clearings presenting a fast growth, which are very important for the regeneration of human-influenced regions (POTT; POTT, 1994, p. 77; EMMONS, 2005, p. 351) such as the degraded pasture areas mentioned.

The similarity among the honeys was divided in three groups. The first similar group was composed by the crop /2005 and the crop cycle/2006 ($S_s = 0.29$) (Figure 3). The second group was composed by the crop cycle and crop 2008 ($S_s=0.35$). The crop/2009 ($S_s=0.44$) was not similar to the two groups formed, because it presented a higher diversity of pollen types (Figure 3). However, the similarity of the pollen types probably occurred due to the proximity of the years under investigation, but it is not related to the periods of crop and crop cycle, which indicates that the flowering of the species can be biannual.

The dynamics of the Forested Savannah and human-influenced areas probably contributed to the similarity of the pollen types in the periods under study, since the land use/land cover presented few variations over this period, with reduction of the native vegetation and an increase of those areas with human activities.

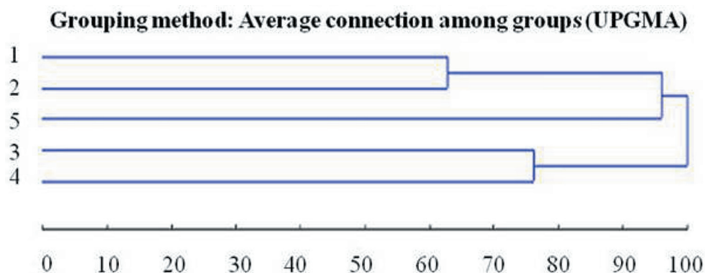


Figure 3 - Similarity dendrogram of the vegetal species between the crop and crop cycle periods. 1 = Crop cycle /2006; 2 = Crop/2005; 3 = Crop cycle /2008; 4 = Crop/2008; 5 = Crop/2009

CONCLUSION

The use of geo-technologies by Geographic Information System (GIS) showed that the native vegetation areas decreased along the years, but it did not endanger the presence of native species in honey.

During the years 2005, 2006, 2008 and 2009, those areas with human activities and the Forested Savannah presented few variations. This did not interfere into similarity of the pollen types found in honey and neither in the important apicultural vegetal species, therefore indicating the compatibility between the economical activities of livestock and beekeeping.

The important species for honey, *Cecropia pachystachya*, *Mimosa pudica* and *Myracrodruon urundeuva* are not related to temporary changes of land use/land cover.

Although the variation of land use/land cover was not sufficiently significant to influence the similarity of the pollen types found in honey, the dynamics of occupation in the next years will probably interfere in the apicultural activity.

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