

Foraging behavior, environmental parameters and nests development of *Melipona colimana* Ayala (Hymenoptera: Meliponini) in temperate climate of Jalisco, México

J. O. Macías-Macías^{a*}, J. M. Tapia-Gonzalez^a and F. Contreras-Escareño^b

^aDepartamento de Desarrollo Regional, Centro de Investigaciones en Abejas, Centro Universitario del Sur, Universidad de Guadalajara, Avenida Enrique Arreola Silva, 883, Cd. Guzmán, Jalisco, México

^bDepartamento de Producción Agrícola, Centro de Investigaciones en Abejas, Centro Universitario de la Costa Sur, Universidad de Guadalajara, Independencia Nacional, 151, Autlán de Navarro, Jalisco, México

*e-mail: joseoc@cusur.udg.mx

Received: October 20, 2015 – Accepted: February 25, 2016 – Distributed: May 31, 2017

(With 5 figures)

Abstract

Melipona colimana Ayala is an endemic species inhabiting temperate forests of pine and oak of south of Jalisco in Mexico. During a year, it was recorded every 15 days foraging activity, environmental parameters and the development of colonies of *M. colimana* in its wild habitat. For five minutes every hour from 7:00 to 21:00, the bees that entered and left the hive and bringing pollen and resin were registered. Every hour the relative humidity, temperature, wind speed and light intensity was recorded and related to foraging activity. Additionally, the weight of the colonies recently transferred to wooden boxes, the number of brood combs, honey pots and pollen were registered. The time of beginning and ending of the foraging activity differs from the reports of stingless bees of tropical weather and the same happens with the pollen collection. The environmental parameters that affect other tropical stingless bees in the foraging activity also affect *M. colimana* in temperate climate. It was determined that the major activity season and the presence of more pollen pots in the colony is from November through February, for what it could be the best time of the year for the division and obtainance of new colonies, while the critical period of minor activity and pollen flow was during rainy season. These data may be useful for the future sustainable use of this species in temperate climate.

Keywords: *Melipona colimana*, foraging behaviour, development, temperate, México.

Comportamento de forragem, parâmetros ambientais e desenvolvimento de ninhos de *Melipona colimana* (Hymenoptera: Meliponini) em clima temperado de Jalisco, México

Resumo

Melipona colimana Ayala é uma espécie endêmica de clima temperado que habita nas florestas de pinho e de azinheira do sul de Jalisco, no México. Registrou-se durante um ano, todos os quinze dias, a atividade de forragem, os parâmetros ambientais e o desenvolvimento de colônias de *M. colimana* no seu habitat silvestre. Registrou-se durante cinco minutos, cada hora das 7:00 às 21:00, as abelhas que entraram e saíram da colmeia e as que traziam pólen e resinas. Registrou-se toda hora, a umidade relativa, temperatura, velocidade do vento e intensidade da luz e relacionaram-se à atividade de forragem. Além do mais, registrou-se o peso de colônias recém transferidas a gavetas de madeira e contabilizou-se o número de panais, potes de mel e pólen. A hora de início e de fim da atividade de forragem difere com os reportes das abelhas sem ferrão de clima tropical e o mesmo acontece com a recollecção de pólen. Os parâmetros ambientais que afetam outros meliponinos de clima tropical na forragem também afetam a *M. colimana* em clima temperado. Determinou-se que a temporada de maior atividade e a presença de mais potes de pólen na colônia é de Novembro a Fevereiro, razão pela qual pode ser a melhor temporada do ano para a divisão e obtenção de novas colônias, enquanto que o período crítico de menor atividade e fluxo de pólen foi durante a temporada de chuvas. Esses dados podem ser úteis para o futuro aproveitamento sustentável de esta espécie em clima temperado.

Palavras-Chave: *Melipona colimana*, comportamento, forragem, desenvolvimento, México.

1. Introduction

Some stingless bees species are endemic of certain regions thereafter they have had to coevolve with their natural habitat adapting to the weather conditions that have influence with their foraging behavior and the development of their nests (Roubik, 1989). In this sense, the factors that have influence in the foraging behavior of the bees can be different depending on the height and the geographic habitat of the different species (Kleinert-Giovannini, 1982; Corbet et al., 1993). The foraging behavior in stingless bees of *Melipona* genus has been studied by several researchers (Kerr, 1996; Kerr et al., 1996; Guibu et al., 1988; Hilario et al., 2000; Souza et al., 2006; Fidalgo and Kleinert, 2007), however, the majority of these works have been done with tropical climate species where the foraging activity starts early and the major activity of resources recollection (the pollen in example) is registered in the morning, before nectar collection: that conduct pattern has been reported for *Melipona* genus because of the fact that in tropical areas the resource availability is higher at first hours of the day (Roubik, 1989). However, for the temperate climate zones this date is unknown and there does not exist any study that indicates how the distribution in resources recollection is, nor which the weather factors are that affect this activity. Likewise, there is not information available about the nests development in geographical transition zones where the climate is predominantly temperate; this is important considering that to achieve an increase in the number of colonies of stingless bees, the main condition is that the colony where another colony will be obtained has the best strength conditions, therefore it is necessary to know what period of the year a colony presents a greater population and food reserves (Guzmán et al., 2004). At the same time, to collaborate in the induced development of the colonies it is also necessary to know the season where a scarcity of floral resources is observed, in order to provide artificial feeding to the bees (González-Acereto and Araujo-Freitas, 2005). *Melipona colimana* Ayala is an endemic species bounded to the mountain zones of the South of the state of Jalisco that was described in the year of 1999 (Ayala, 1999), but its particular biology and its possible commercial use is not known. The aim of this study was to determine the foraging behavior of the workers in their natural habitat, the influence of climatic factors in this activity and register the development of nests recently transferred to wooden boxes to determine the best time of year to obtain new colonies and the critical period where artificial food has to be provide.

2. Material and Methods

2.1. Study site

The observations took place in the village of San Isidro in the Halo mountain range, in the municipality of Tecalitlán, Jalisco. (18° 58' 00" North latitude and 102° 59' 45" West longitude) to a sea level of 1600 m. This is a zone of pine woods (*Pinus spp*) and oak trees

(*Quercus spp*) considered of temperate climate where more than 40 days with inferior temperatures than 7 °C are presented (CONAGUA, 2014).

2.2. Foraging behavior and environmental parameters

To get to know the foraging behavior of *M. colimana*, 10 colonies where used in its wild habitat lodged in their original oak trees trunks "chilillo" (*Quercus laurina* L.). Every 15 days with a manual counter and by direct observation to each of these colonies, every hour for five minutes next data was registered: bees that go out, bees that enter, bees that enter with pollen and bees that enter with resin; the observations started at 7:00 hours and ended at 21:00 hours.

In the same way, each hour of each day of observation next environmental data was registered: relative humidity (%) and temperature in °C (Dataloguer RH520 Extech Instruments), light intensity in luxes (luxometre FR-35, Extech Instruments) and wind velocity in kilometers by hour (Anemometer Sk-23). The data gathering was carried out for a 12 month time. For the analysis, statistic description was made and the foraging activity data of the bees for each hour of the day was obtained and monthly as well. To know the influence of the environmental parameters with the forage activity the data were related trough a Pearson correlation (Zar, 1999).

2.3. Nests development

In the same period of time and to know the population dynamic of nests growth, 10 colonies were used that were transferred to oak tree (*Q. laurina*) wooden boxes to which the food resources were removed (honey and pollen) and brood combs were moved from some colonies to others so all initiated with the same brood combs quantity. Each 15 days the weight combined of the box and nest was registered (Scale AND model FG150 K) and the brood combs number, the honey pots and the pollen pots were registered. At the end of the observation period, descriptive statics was done and the averages of the registered data were obtained.

3. Results

3.1. Foraging behavior and environmental parameters

The foraging activity data of the bees that entered and went out during the day can be appreciated in Figure 1. The activity started at 8:00 hours and ended at 20:00 hours with a period of major activity between 11:00 and 19:00 hours.

The activity in the pollen collection started at 9:00 hours and the resins collection started at 10:00 hours with a major activity in the recollection of both resources at 12:00 hours, both activities ended at 19:00 hours (see Figure 2).

During all year, the maximum activity period is observed during the months of November to February, with a slight rise in the month of April, while fewer activity period is appreciated in the months of June to September (see Figure 3).

The annual foraging registers in pollen collection and resins can be observed in Figure 4. The maximum activity

Foraging behaviour in *Melipona colimana*

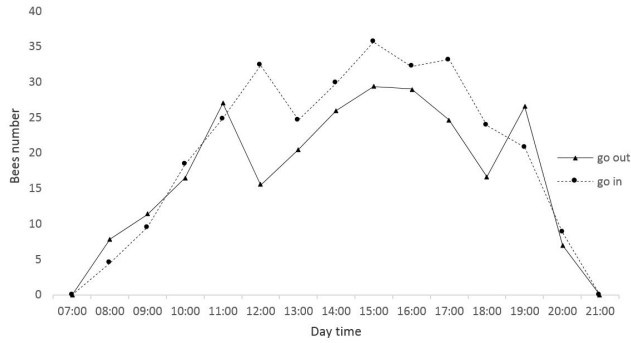


Figure 1. Average number of stingless bees (*M. colimana*) that enter and leave in a five minutes period of each hour during all day.

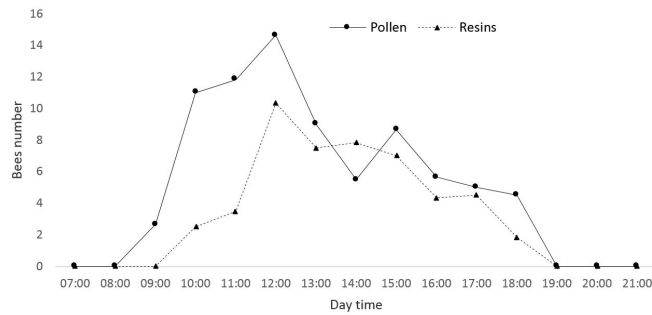


Figure 2. Average number of stingless bees (*M. colimana*) that enter and leave with resins and pollen in a five minutes period of each hour during all day.

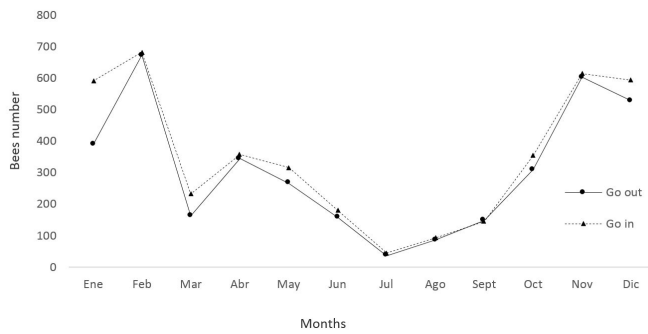


Figure 3. Average number of stingless bees (*M. colimana*) that enter and leave the colonies every month during a whole year.

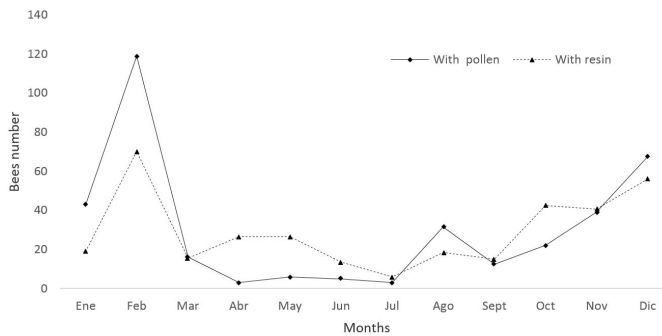


Figure 4. Average number of stingless bees (*M. colimana*) that enter with pollen and resins to the colonies

Table 1. Correlation value (r) of temperature, humidity, wind velocity and luminosity, related with the activity of the bees that leave, that enter, that enter with pollen and resins.

PARAMETER	Bees that leave	Bees that enter	Enter with pollen	Enter with resins
Temperature	0.50 P < 0.05	0.58 P < 0.05	0.51 P < 0.05	0.74 P < 0.05
Humidity	-0.48 P < 0.05	-0.57 P < 0.05	-0.50 P < 0.05	-0.74 P < 0.05
Wind velocity	0.76 P < 0.05	0.85 P < 0.05	0.82 P < 0.05	0.86 P < 0.05

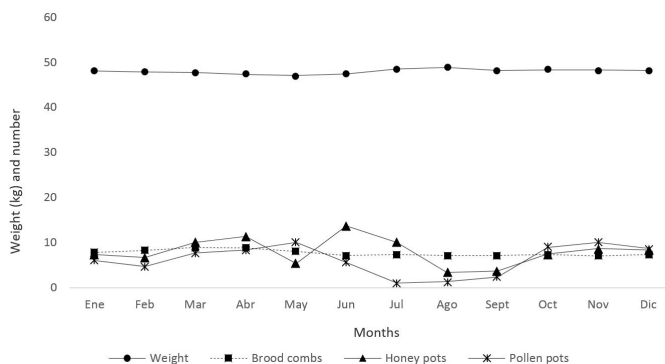


Figure 5. Monthly averages of weight (kg) number of brood combs, honey and pollen pots in colonies of *M. colimana*.

was registered in the months of November to February and fewer activity from April to July.

From the registered environmental factors, the majority had a positive significant correlation; just humidity presented a negative significant correlation in the forage activities of the bees (as shown in Table 1).

3.2. Nests development

Regarding to the recently transferred nests, it was observed that there were not big variations towards weight and brood combs number, whereas in the honey pots and pollen were minimal variations were a light increase in the month of June for the honey pots was appreciated and a noticeable reduction in the months of July to September for the pollen pots. (see Figure 5)

4. Discussion

The start and end hours of forage activity of *M. colimana* differs to what has been reported in other carried out works with stingless bees of the same genus in tropical climates (Monteiro and Schlindwein, 2003; Von and Blochtein, 2005; Fidalgo and Kleinert, 2007; Nates-Parra and Rodriguez, 2011) where the activity starts and ends between two to three hours earlier, however, the total quantity of time that bees forage in tropical and temperate climate is similar (between 11 and 12 hours). In the recollection of pollen and resins behavior a tendency of greater activity towards midday was appreciated, were it was observed the bees making these activities between 9 and 10 hours during the day. Pollen recollection of stingless bees in tropical climate has been mainly reported by early mornings; made works with *M. beecheii* y *M. fasciata* in tropical areas (Roubik and Buchmann 1984; Bruijn and Sommeijer, 1997) report

pollen collect too early in the morning, different situation to behavior of *M. colimana* in the recollection of these resource in temperate climate; an explanation to this fact could be that the release of pollen of the temperate climate plant species can occur later when the environment is warm and less humid (Cuevas et al., 2004). Foraging activity of *M. colimana* had a variation between study seasons; greater activity was observed during Autumn-Winter season with a noticeable decrease in Summer; which is when rainy season presented. The months of major activity of the bees coincide with the season of greater flowering of vegetal species observed, what suggests that these bees, as the same in other species, present a bigger forage activity related with the appearance of blooming (Waddington, 1983). Regarding to environmental parameters, it is observed that all have relation with different foraging activities of bees that indicates that these factors can affect its activities, specially humidity, that presented a negative correlation. Registered temperature ranges that affect worker bees of *M. colimana* coincide with the reported for other species of bees of the same genus (Hilario et al., 2000; Borges and Blochtein, 2005; Souza et al., 2006). In relation to colonies development, the registered growth during 12 months was not so evident, since the weight of the colonies and the number of brood combs maintained practically stable and only some variations could be observed regarding the quantity of honey and pollen pots. This slow growth could have been consequence that all food resources were removed, since the main purpose was to evaluate the potential of the natural nests development. However, this information is relevant to be considered in the future sustainable use of the species and have special attention in the care of colonies being transferred to rational boxes and foresee the new nests will develop slowly. Another situation that should

be considered, is that in the months of July to September the numbers of pollen pots decreased, and the activity of the bees that enter and leave in the colonies was smaller, which indicates that this is the critical season where it is not recommendable to obtain new colonies by induced method division (González-Acereto and Araujo-Freitas, 2005; Gonzalez-Acereto, 2008). According to the obtained results it can be concluded that the environmental factors have influence in the forage activity of *M. colimana*, that the best season for division and the obtainance of new colonies is the season running from November to February and that the critical season for bees is the rainy season (in Summer), where the use of artificial feeding for sustainable development of the colonies is a must. These data can be useful for the future sustainable use of *M. colimana* in the mountain zones of México.

Acknowledgements

To the students of Veterinary Medicine and Husbandry career of the University Centre of the South of Guadalajara University that collaborated with the data gathering. To Bernardo Soto Mejia and Gustavo Alcazar for sharing the knowledge of these bees species location.

References

AYALA, R., 1999. Revisión de las abejas sin aguijón de México (Hymenoptera: Apidae: Meliponini). *Folia Entomologica Mexicana*, vol. 106, pp. 1-123.

BORGES, F. and BLOCHTEIN, B., 2005. Actividades externas de *Melipona marginata obscurior* Moure (Hymenoptera, Apidae) en distintas épocas del año, en San Francisco de Paula, Rio Grande do Sul, Brasil. *Revista Brasileira de Zoologia*, vol. 22, no. 3, pp. 680-686. <http://dx.doi.org/10.1590/S0101-81752005000300025>.

BRUIJN, L.L.M. and SOMMEIJER, M.J., 1997. Colony foraging in different species of stingless bees (Apidae: Meliponinae) and the regulation of individual nectar foraging. *Insectes Sociaux*, vol. 44, no. 1, pp. 1-13. <http://dx.doi.org/10.1007/s000400050028>.

COMISIÓN NACIONAL DEL AGUA – CONAGUA, 2014. *Archivos Zona Sur de Jalisco*. Jalisco: Observatorio Meteorológico Regional, Comisión Nacional del Agua, pp. 64-76.

CORBET, S.A., FUSSELL, M., AKE, R., FRASER, A., GUNSON, C., SAVAGE, A. and SMITH, K., 1993. Temperature and pollination activity of social bees. *Ecological Entomology*, vol. 18, no. 1, pp. 17-30. <http://dx.doi.org/10.1111/j.1365-2311.1993.tb01075.x>.

CUEVAS, G.R., KOCH, S., GARCIA, M.E., NUÑEZ, L.N.M. and JARDEL, P.E.J., 2004. Flora vascular de la estación científica las Joyas. In: G.R. CUEVAS and P.E.J. JARDEL. *Flora y vegetación de la Estación Científica las Joyas*. Guadalajara: Universidad de Guadalajara, pp. 119-176.

FIDALGO, A.O. and KLEINERT, A.M.P., 2007. Foraging behaviour of *Melipona rufiventris* Lepetier (Apinae: Meliponini) in Ubatuba, SP, Brazil. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 67, no. 1, pp. 133-140. <http://dx.doi.org/10.1590/S1519-69842007000100018>. PMID:17505760.

GONZÁLEZ-ACERETO, J.A. and ARAUJO-FREITAS, C.H., 2005. *Manual de meliponicultura Mexicana*. Mérida:

Universidad Autónoma de Yucatán, Fundación Produce Yucatán. A.C. 123 p.

GONZALEZ-ACERETO, J.A., 2008. *Cría y manejo de abejas nativas sin aguijón en México*. Mérida: Universidad Autónoma de Yucatán, Secretaria de Fomento Agropecuario y Pesquero, Fundación Produce Yucatán. A.C. 177 p.

GUIBU, L.S., RAMALHO, M., KLEINERT-GIOVANNINI, A. and IMPERATRIZ-FONSECA, V.L., 1988. Exploração dos recursos florais por colônias de *Melipona quadrifasciata* (Apidae, Meliponinae). *Revista Brasileira de Biologia*, vol. 48, pp. 299-305.

GUZMAN, D.M.A., RINCÓN, R.M. and VANDAME, R., 2004. *Manejo y conservación de abejas nativas sin aguijón (Apidae: Meliponini): manual técnico*. Chiapas: Ecosur. 56 p.

HILARIO, S.D., IMPERATRIZ-FONSECA, V.L. and KLEINERT, A.M.P., 2000. Flight activity and colony strength in the stingless bee *Melipona bicolor bicolor* (Apidae, Meliponinae). *Revista Brasileira de Biologia*, vol. 60, no. 2, pp. 299-306. <http://dx.doi.org/10.1590/S0034-7108200000200014>. PMID:10959114.

KERR, W.E., 1996. *Biologia e manejo da tubia: a abelha do Maranhão*. São Luis: EDUFMA. 156 p.

KERR, W.E., CARVALHO, G.A. and NASCIMENTO, V.A., 1996. *Abelha urucu: biología, manejo e conservação*. Belo Horizonte: Acangaú. 144 p.

KLEINERT-GIOVANNINI, A., 1982. The influence of climatic factors on flight activity of *Plebeia emerina* Friese (Hymenoptera: Apidae: Meliponinae) in winter. *Revista Brasileira de Entomologia*, vol. 26, no. 1, pp. 1-13.

MONTEIRO, P.L. and SCHLINDWEIN, C., 2003. Variation in daily flight activity and foraging patterns in colonies of *urucu-Melipona scutellaris* Latreille (Apidae: Meliponini). *Revista Brasileira de Zoologia*, vol. 20, no. 4, pp. 565-571. <http://dx.doi.org/10.1590/S0101-81752003000400001>.

NATES-PARRA, G. and RODRIGUEZ, A., 2011. Forrajeo en colonias de *Melipona eburnea* (Hymenoptera: Apidae) en el piedemonte llanero (Meta, Colombia). *Revista Colombiana de Entomologia*, vol. 37, no. 1, pp. 121-127.

ROUBIK, D.W. and BUCHMANN, S.L., 1984. Nectar selection by *Melipona* and *Apis mellifera* (Hymenoptera: Apidae) and the ecology of nectar intake by bee colonies in a tropical forest. *Oecologia*, vol. 61, no. 1, pp. 1-10. <http://dx.doi.org/10.1007/BF00379082>.

ROUBIK, D.W., 1989. *Ecology and natural history of tropical bees*. Cambridge: Cambridge University Press.

SOUZA, B.A., CARVALHO, C.A.L. and ALVES, R.M.O., 2006. Flight activity of *Melipona asilvai* Moure (Hymenoptera: Apidae). *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 66, no. 2B, pp. 731-737. <http://dx.doi.org/10.1590/S1519-69842006000400017>. PMID:16906305.

VON, B.B.F. and BLOCHTEIN, B., 2005. Actividades externas de *Melipona marginata obscurior* Moure (Hymenoptera, Apidae) em distintas épocas do ano, em Sao Francisco de Paula, Rio Grande do Sul, Brasil. *Revista Brasileira de Zoologia*, vol. 22, pp. 680-686. <http://dx.doi.org/10.1590/S0101-81752005000300025>.

WADDINGTON, D.K., 1983. Foraging behaviour of pollinators. In: L.A. REAL. *Pollination biology*. Orlando: Academic Press, pp. 213-239.

ZAR, J., 1999. *Biostatistic analysis*. New York: Prentice Hall. 944 p.