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Diversity of Ant Species (Hymenoptera: Formiciidae) in Flower Plants Combination on Ratoon Sugarcane

Rabbiana Mawaddah, Bambang Tri Rahardjo, Gatot Mudjiono

Department of Plant Pests and Diseases, Faculty of Agriculture, University of Brawijaya

Email Address : rabbianamw@student.ub.ac.id

KEYWORDS

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Abstract This research aims to examine the effects of several refugia plant treatments on the diversity and number of ants in the ratoon sugarcane system. The diversity and abundance of ants in the plantation's surrounding habitats can fluctuate. Three combinations of flowering plants were used in the study: *Turnera subulata* Sm (Malpighiales: Passifloraceae), *Cosmos sulphureus* (Asteraceae: Asteraceae), and *Zinnia elegans* Jaqc (Asterales: Asteraceae). Ant samples were collected using yellow sticky traps and traps and yellow pan traps. R. software was used to examine all of the data. 4 subfamilies, 14 genera, and 25 species: *Diacamma* sp., *Technomyrmex* sp., *Camponotus* sp.1., *Iridiomyrmex* sp., *Delichoderus* sp., *Leptogenys* sp.; *Odontomachus* sp., *Polyrachis* sp., *Pheidole* sp., *Tetramorium* sp., *Monomorium* sp., *Crematogaster* sp., *Oecophylla smaragdina* was identified from the report's results, this included 1-86 individuals. *Tetramorium* sp. and *Odonthomachus* sp. were the most common ants found at the study site. Even before compared to the other treatments, the combination of refugia and *Z. elegans, C. sulphureus, T. subulata* treatment used to have a significant impact on the presence of ants, increasing the population by 21%. This study discovered that combining refugia could increase ant diversity in ratoon sugarcane. The diversity index value for all treatments was almost the same, in the range of 2.-9-2.82, indicating that the main composition of refugia was moderately diverse.

Introduction

Ants are actively used for pest control, with a more significant impact on plants with a high crop complexity. Sugarcane monocultures, for instance, do not supply sufficient food, shelter, or breeding grounds for animals that can operate as natural enemies. Furthermore, the potential for predatory species diversity spillover from remnant vegetation into sugarcane-dominated environments has not been examined. Understanding the relationship between agricultural intensification, biodiversity, and natural pest enemies is essential for improving biological control and other ecosystem services in agricultural landscapes (Crowder & Jabbour, 2014; Bengtsson, 2015; Rivera-Pedroza *et al.*, 2019).

According to a study, ants can swallow up to 7% of *Diatraea saccharalis* eggs in sugarcane fields, significantly reducing population density. *Solenopsis* sp. was the dominant ant genus Rossi & Fowler, 2004; Wauters et al., 2014; Triyogo *et al.*, 2020. Even non-herbivorous ant species can harm agricultural plants if they coexist with hemipteran insect pests that feed on melon (Javal *et al.*, 2018; Wang *et al.*, 2021). However, most ant-hemipteran interactions favour food crops since ants prey on more dangerous pests (Del-Claro, 2004; Eubanks & Finke, 2014; Xu *et al.*, 2020; Wang *et al.*, 2021). Ant colonies in

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sugarcane fields are significantly reduced by agricultural practices such as tillage, and consequently, re-colonization from outside the areas is required to rebuild populations after sugarcane plantations (Thurman *et al*., 2019; Lazarova *et al*., 2021). Ant species have been observed to use semi-natural constructions to provide resources and other habitat services (Holland *et al*., 2017; Muhammad *et al.*, 2022). According to De Oliveira *et al*. (2012); Dinardo-Miranda & Fracasso, (2013); Pérez *et al*. (2021) research, the sugarcane borer *D. saccharalis* is a major pest of sugarcane, and ants are one of its primary predators. *Solenopsis saevissima*, as well as the morphotypes *Crematogaster* sp. and *Pheidole* sp., have the potential to be key borer predators on sugarcane plants whose straw is not burned. As a result, forest fragments in sugarcane-dominated landscapes are supposed means having played an important effect in the re-colonization process.

Ants' purpose is to defend plants from herbivores. Furthermore, ants often enhance soil conditions, promoting increased plant diversity. Ants can also play important roles in a variety of ecosystem processes, assisting in the maintenance of more resilient ecosystems in the face of large disturbances and habitat loss (Hagen *et al*., 2012; Wills & Landis, 2018). by preserving landscape diversity and hence increasing ecosystem services Higher quality resources encourage ant foraging behavior on plants and provide more protection from other herbivores (Gray & Lewis, 2014; Henry *et al*., 2018). Ants looking for honey or other resources can be a nuisance to blossoming plants (Sinu *et al*., 2017; Maharani *et al.*, 2020). Ants play an important part in crop pollination, soil bioturbation, bioindication, and the regulation of plant-destroying insects in agrosystems (Diamé *et al*., 2018; Saunders *et al*., 2016).

The ratoon system of sugarcane is not only planted in monoculture but is also harvested by burning the land, causing ecological damage and the death of natural enemies such as ants. Therefore, the research was carried out using different combinations of refugia to restore habitat complexity and the presence of ants in sugarcane plants. The flower plants used in this study were *Cosmos sulphureus* Cav. (Asterales: Asteraceae), *Zinnia elegans* Jaqc (Asterales: Asteraceae), and *Turnera subulata* J.E.Sm. (Malpighiales: Passifloraceae). It is reported that complex habitats can support greater species richness as they provide more ecological niches including available resources. This information is needed to determine the level of ant presence in a combination of various flower plants so that it can suppress pests in the sugarcane area.

Materials and methods

Study site and sampling method

The research was carried out from March to June 2021 at the Indonesian Sweetener and Fiber Crops Research Institute (ISFCRI) of Kapuharjo, Karangploso Sub-District, Malang Regency, Indonesia. The plant used is ratoon system sugarcane with PS 862. Insect identification and clarification were carried out at the Entomology and Phytopathology Laboratory, Sweetener and Fiber Research Institute (ISCFRI), and Plant Pest Laboratory, Faculty of Agriculture, Brawijaya University. The ants were obtained from three different types of flowers: *Cosmos sulphureus* (Asterales: Asteraceae), *Zinnia elegans* Jaqc (Asterales: Asteraceae), and *Turnera subulata* Sm (Malpighiales: Passifloraceae) (Figure 1). The cropping pattern of refugia plants in each treatment block of the study amounted to 24 refugia plants.

Ant Identification

Sampling was carried out every week as many as 10 times sample. The ants obtained were preserved using 70% alcohol in an eppendorf tube. The identification stage is

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carried out to the morphospecies level based on the identification book *Hymenoptera of the world* (Goulet, 1993), *A Guide to the Ants of Jambi Identification Key to Ant Genera* (Nazaretta, 2021). The variables observed were population, diversity, abundance, and dominance of ants in each treatment.

Analisis Data

Data on the abundance of ants were analyzed for variance (ANOVA). Ant diversity for each treatment was assessed using the Shannon-Weiner index (*H'*), species dominance using the Simpson index (1-D), and species uniformity using the Evenness index (e') (Magurran, 2004). All statistical analyzes are performed using the R version 4.1.0 software (R Core Team, 2022).

Results and Discussion

The diversity of ants found in eight treatments has a total of 473 individual ants consisting of 25 species in 14 genera, which belong to 4 subfamilies, which have been collected including: *Camponotus* sp..1, *Camponotus* sp.2., *Camponotus* sp.3., *Diacamma* sp., *Technomyrmex* sp.1, *Technomyrmex* sp.2, *Iridiomyrmex* sp., *Delichoderus* sp., *Leptogenys* sp.1., *Leptogenys* sp.2., *Odontomachus* sp.1., *Odontomachus* sp.2., *Polyrachis* sp.1 ., *Polyrachis* sp.2., *Polyrachis* sp.3., *Polyrachis* sp.4., *Polyrachis* sp.5., *Polyrachis* sp.6., *Pheidole* sp.1, *Pheidole* sp.2., *Tetramorium* sp., *Tetramorium bicarinatum*, *Monomorium* sp., *Crematogaster* sp., *Oecophylla smaragdina* (Figure 2).

The ant morphospecies found in high abundance were *Tetramorium* sp. (104 individuals), with 21.89% of the total abundance. The second most abundant morphospecies was *Odontomachus* sp.1 followed by *Pheidole* sp.2. This is supported by research by Roldán et al. (2021) that the ant species *Tetramorium* sp. can compete with other ants foraging in sugarcane fields, because ants of this species tend to compete for nest sites with other ant species. *Tetramorium* sp. is the most dominant species involved in the interspecific competition, affecting the abundance and diversity of other ant species (Perfecto & Vandermeer, 2013; Derren, 2017) (Figure 2). This species is omnivorous, eating live or dead insects, melons, or any food source in disturbed areas (Smith 1965; Butler *et al*., 2018). However, when the population of *T. bicarinatum* is large, this ant species can be an effective predator against insect pests in the cropping system (Wetterer 2009; Suenaga, 2017). The role of ants is to protect plants from herbivores (Byk & Del-Claro, 2010; Wills & Landis, 2018) and possibly prey on *D. saccharalis* on sugarcane plant. A previous study showed that ants could consume up to 70% of *D. saccharalis* eggs in sugarcane fields, significantly reducing pest population densities (Wilson *et al.*, 2020; Santos, unpublished data).

The combination treatment refugia combination of *Z. elegans, T. subulata,* and *C. sulphureu* had the highest population abundance with an average number of individuals (2.23-0.61). Refugia plants combined *Z. elegans, T. subulata,* and *C. sulphureus* flowers had a significant effect. Against the presence of ants in the area of ratoon sugar cane. (F = 2.388, P > -.--1) (Table 1). Yuniasari *et al*. (2021), stated that the diversity of ant species in the field could be influenced by habitat conditions, such as the density of canopy cover and undergrowth (weeds) in cocoa plantations. In addition, ants can be predators in ratoon cane plantations. Rossi & Fowler (2000), found that generalist ants contribute to reducing sugarcane attacks by sugarcane borers in the state of So Paulo, Brazil (Rossi & Fowler, 2004). Ants provide ecosystem services in agrosystems by playing a major role in crop pollination, soil bioturbation, bioindication, and regulation of plant-destroying insects (Diamé *et al*., 2018; Saunders et al., 2016).

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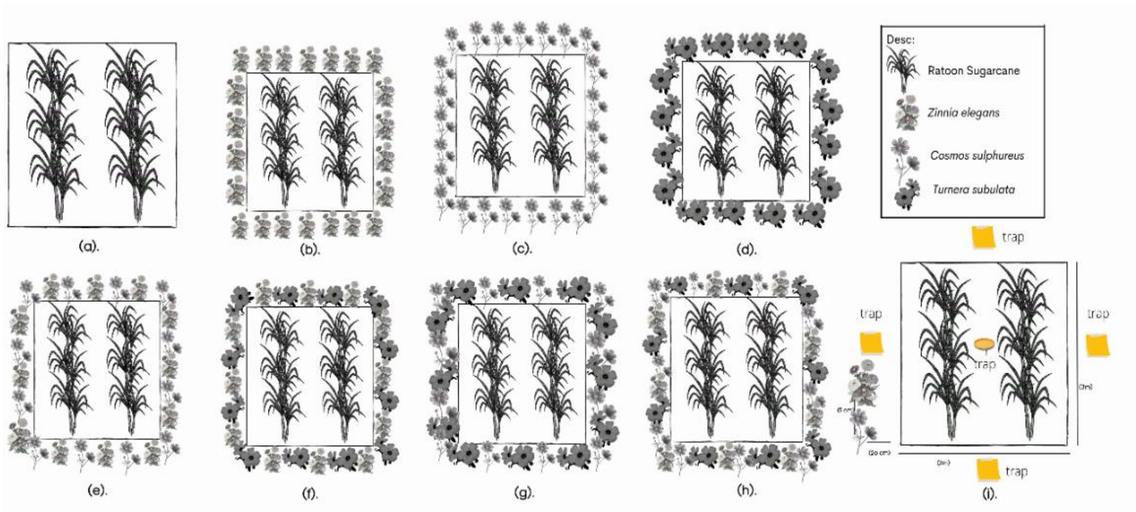

Figure 1. Treatment of the refugia plant composition (a).R0 = Control (without refugia), (b).R1=*Z. elegans,* (c).R2=*C. sulphureus,* (d).R3=*T. subulata,* (e). R1R2=*(Z. elegans+C. sulphureus)*, (f).R1R3=(*Z. elegans+ T. subulata*), (g).R2R3=(*C. sulphureus+T. subulata*), (h).R1R2R3=(*Z. elegans+C. sulphureus+T. subulata*). (i). Trap placement, refugia spacing, and planting area

Figure 2. List of ant species recorded from all treatments plots in refugia plants in ratoon sugarcane (a). *Diacamma* sp.;(b).*Technomyrmex* sp.1; (c).*Technomyrmex* sp.2; (d).*Camponotus* sp.1; (e).*Camponotus* sp.2; (f).*Camponotus* sp.3; (g).*Iridiomyrmex* sp.; (h).*Delichoderus* sp.; (i).*Leptogenys* sp.1; (j).*Leptogenys* sp.2; (k).*Odontomachus* sp.1; (l).*Odontomachus* sp.2; (m).*Polyrachis* sp.1; (n).*Polyrachis* sp.2; (o).*Polyrachis* sp.3; (p).*Polyrachis* sp.4; (q).*Polyrachis* sp.5; (r).*Polyrachis* sp.6; (s).*Pheidole* sp.1; (t).*Pheidole* sp.2; (u).*Tetramorium* sp.1; (v).*Tetramorium* sp.2; (w).*Monomorium* sp.; (x).*Crematogaster* sp.; (y).*Oecophylla smaragdina.*

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Table 1. Species richness (S) and abundance (N) of of ant in various compositions of refugia plants

Refugia	**Population of Ants**	
	Species ± SD	**Individu ± SD**
Control	2.11 ± 1.26 b	0.99 ± 0.37 c
Z. elegans	3.80 ± 1.03 ab	1.75 ± 0.36 abc
C. Sulphureus	2.90 ± 1.96 ab	1.29 ± 0.69 bc
T. subulata	3.11 ± 1.53 ab	1.70 ± 0.67 abc
Z. elegans+C. Sulphureus	3.00 ± 1.33 ab	1.29 ± 0.66 bc
Z. elegans+ T. subulata	4.10 ± 1.96 ab	1.91 ± 0.49 ab
C. Sulphureus+ T. subulata	3.60 ± 1.34 ab	1.67 ± 0.37 abc
Z. elegans+C. Sulphureus+T. subulata	4.60 ± 1.77 a	2.23 ± 0.61 a

Remarks: The numbers followed by the same letter in the same column show differences that are not significantly different based on the Tukey test level 5%.

Table 2. Values of ant indices for different compositions of refugia plants

Refugia	**Diversity Index**		**Evenness Index**		**Dominance index**	
	Score	Category	Score	Category	Score	Category
Control	2.09	Medium	0.84	Medium	0.87	High
Z. elegans	2.62	Medium	0.89	Medium	0.86	High
C. Sulphureus	2.58	Medium	0.90	Medium	0.91	High
T. subulata	2.44	Medium	0.88	Medium	0.90	High
Z. elegans+C. Sulphureus	2.53	Medium	0.90	Medium	0.91	High
Z. elegans+ T. subulata	2.82	Medium	0.92	Medium	0.92	High
C. Sulphureus+ T. subulata	2.47	Medium	0.88	Medium	0.87	High
Z. elegans+C. Sulphureus+T. subulata	2.46	Medium	0.88	Medium	0.85	High

The highest Shannon-Wiener diversity index value of all combinations in this study was found in the *Z.elegans* and *T. subulata* combination (2.82) and the lowest in the control treatment (2.09). The Evenness evenness index was highest in the *Z.elegans* and *T. subulata* treatment (0.92) and the lowest in the control treatment (0.84). The value of the Simpsons dominance index was highest in the *Z.elegans* and *T. subulata* treatment (0.92) and the lowest in the control treatment (0.87) (Table 2). It was indicated by the presence of refugia plants that can attract ants, one of which was reported by (Cruz *et al*., 2018; Leksono *et al*., 2019; Asmoro *et al.*, 2021) reported that extrafloral nectar at the base of the leaves of *T. subulata* can attract various ants in the planting area.

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Conclusions and Suggestion

In this study. 25 ant morphospecies were obtained with a total of 473 individuals—the combination between *Z. elegans.* The composition *of T. subulata* and *C. sulphureus* plants attracted ants significantly because of the complete flower composition. In contrast. Combining *Z. elegans* and *T. subulata* provided the highest diversity. Abundance. and dominance index values. It explains that ants are attracted to *T. subulata* and *Z. elegans* because these plants provide the nectar that ants need.

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References

Asmoro, P. P., Dadang, Pudjianto, & Winasa, I. W. (2021). Olfactory Response of Plutella xylostella (Lepidoptera: Yponomeutidae) Adults to Refugia Plant. *IOP Conference Series: Earth and Environmental Science*, *752*(1), 0–7. https://doi.org/10.1088/1755-1315/752/1/012039

Bengtsson, J. (2015). Biological control as an ecosystem service: Partitioning contributions of nature and human inputs to yield. *Ecological Entomology*, *40*(S1), 45–55. https://doi.org/10.1111/een.12247

Butler, J. R. A., Brown, W. Y., & du Toit, J. T. (2018). Anthropogenic food subsidy to a commensal carnivore: The value and supply of human faeces in the diet of free-ranging dogs. *Animals*, *8*(5). https://doi.org/10.3390/ani8050067

Byk, J., & Del-Claro, K. (2010). Nectar- and pollen-gathering Cephalotes ants provide no protection against herbivory: A new manipulative experiment to test ant protective capabilities. *Acta Ethologica*, *13*(1), 33–38. https://doi.org/10.1007/s10211-010-0071-8

Chin, Darren W. M. (2017). Pavement Ant (*Tetramorium* sp. E) Territoriality: Dominance, Competition and Implications for Control Methods. Purdue University ProQuest Dissertations Publishing, 10271948.

Crowder, D. W., & Jabbour, R. (2014). Relationships between biodiversity and biological control in agroecosystems: Current status and future challenges. *Biological Control*, *75,* 8–17. https://doi.org/10.1016/j.biocontrol.2013.10.010

Cruz, N. G., Cristaldo, P. F., Bacci, L., Almeida, C. S., Camacho, G. P., Santana, A. S., Ribeiro, E. J. M., Oliveira, A. P., Santos, A. A., & Araújo, A. P. A. (2018). Variation in the composition and activity of ants on defense of host plant Turnera subulata (Turneraceae): strong response to simulated herbivore attacks and to herbivore's baits. *Arthropod-Plant Interactions*, *12*(1), 113–121. https://doi.org/10.1007/s11829-017-9559-8

de Oliveira, R. de F., de Almeida, L. C., de Souza, D. R., Munhae, C. B., Bueno, O. C., & Morini, M. S. de C. (2012). Ant diversity (Hymenoptera: Formicidae) and predation by ants on the different stages of the sugarcane borer life cycle Diatraea saccharalis (Lepidoptera: Crambidae).

E-ISSN 2355-9926

European Journal of Entomology, *109*(3), 381–387. https://doi.org/10.14411/eje.2012.049

Del-Claro, K. (2004). Multitrophic relationships, conditional mutualisms, and the study of interaction biodiversity in tropical savannas. *Neotropical Entomology*, *33*(6), 665–672. https://doi.org/10.1590/s1519-566x2004000600002

Diamé, L., Rey, J. Y., Vayssières, J. F., Grechi, I., Chailleux, A., & Diarra, K. (2018). Ants: Major functional elements in fruit agro-ecosystems and biological control agents. In *Sustainability (Switzerland), 10*(1), 1–18. https://doi.org/10.3390/su10010023

Dinardo-Miranda, L. L., & Fracasso, J. V. (2013). Sugarcane straw and the populations of pests and nematodes. In *Scientia Agricola, 70*(5), 369–374. https://doi.org/10.1590/s0103-90162013000500012

Eubanks, M. D., & Finke, D. L. (2014). Interaction webs in agroecosystems: Beyond who eats whom. In *Current Opinion in Insect Science, 2,* 1–6. https://doi.org/10.1016/j.cois.2014.06.005

Koch, F. (2008). Goulet, H. & Hubert, J. F. (1993): Hymenoptera of the world. An identification guide to families. - Research Branch, Agricultural Canada Publication. Canada Communication Group-Publishing, Ottawa. 668 Seiten. Preis: FF 412,-. ISBN 0-660-14933-8. *Deutsche Entomologische Zeitschrift*, *42*(2). https://doi.org/10.1002/mmnd.19950420212

Gray, C. L., & Lewis, O. T. (2014). Do riparian forest fragments provide ecosystem services or disservices in surrounding oil palm plantations? *Basic and Applied Ecology*, *15*(8), 693–700. https://doi.org/10.1016/j.baae.2014.09.009

Hagen, M., Kissling, W. D., Rasmussen, C., de Aguiar, M. A. M., Brown, L. E., Carstensen, D. W., Alves-Dos-Santos, I., Dupont, Y. L., Edwards, F. K., Genini, J., Guimarães, P. R., Jenkins, G. B., Jordano, P., Kaiser-Bunbury, C. N., Ledger, M. E., Maia, K. P., Marquitti, F. M. D., Mclaughlin, Ó., Morellato, L. P. C., … Olesen, J. M. (2012). Biodiversity, Species Interactions and Ecological Networks in a Fragmented World. In *Advances in Ecological Research* (Vol. 46). https://doi.org/10.1016/B978-0-12-396992-7.00002-2

Henry, L. P., Tokita, C. K., Misra, M., Forrow, A. B., & Rubenstein, D. I. (2018). Mutualistic acacia ants exhibit reduced aggression and more frequent off-tree movements near termite mounds. *Biotropica*, *50*(4), 559–562. https://doi.org/10.1111/btp.12572

Holland, J. M., Douma, J. C., Crowley, L., James, L., Kor, L., Stevenson, D. R. W., & Smith, B. M. (2017). Semi-natural habitats support biological control, pollination and soil conservation in Europe. A review. *Agronomy for Sustainable Development*, *37*(4). https://doi.org/10.1007/s13593-017-0434-x

Javal, M., Roques, A., Roux, G., & Laparie, M. (2018). Respiration-based monitoring of metabolic rate following cold-exposure in two invasive Anoplophora species

E-ISSN 2355-9926

depending on acclimation regime. *Comparative Biochemistry and Physiology -Part A : Molecular and Integrative Physiology*, *216,* 20–27. https://doi.org/10.1016/j.cbpa.2017.10.031

Lazarova, S., Coyne, D., Rodríguez, M. G., Peteira, B., & Ciancio, A. (2021). Functional diversity of soil nematodes in relation to the impact of agriculture—a review. In *Diversity*, *13*(2), 1–22. https://doi.org/10.3390/d13020064

Leksono, A. S, Mustafa, I., Afandhi, A., & Zairina, A. (2019). Habitat Modification with Refugia Blocks for Improving Arthropod Richness and Diversity in Paddy Field. *International Journal of Civil Engineering and Technology (IJCIET)*, *10*(8), 256–263.

Magurran, A. (2004). Measuring Biological Diversity - Chapter 2. In *Measuring biological diversity,* 18–215.

Maharani, Y., Maryana, N., Rauf, A., & Hidayat, P. (2020). Insect parasitoid and ant of associated on aphids (Aphididae) colonies on plants in West Java. *CROPSAVER - Journal of Plant Protection*, *3*(2), 59. https://doi.org/10.24198/cropsaver.v3i2.30645

Muhammad, F. N., Rizali, A., & Rahardjo, B. T. (2022). Diversity and species composition of ants at coffee agroforestry systems in East Java, Indonesia: Effect of habitat condition and landscape composition. *Biodiversitas*, *23*(7). https://doi.org/10.13057/biodiv/d230701

Nazarreta, R., Buchori, D., & Hashimoto, Y., Hidayat, P., Scheu, S. & Drescher, J. (2021). A Guide to the Ants of Jambi (Sumatra, Indonesia): Identification Key to Ant Genera and Images of the EFForTS collection. 10.14203/press.273.

Pérez, M. L. D. P., Isas, M. G., Goebel, F. R., Ayup, M. M., Padilla, A. E., Salvatore, A. R., & Gastaminza, G. (2021). Effect of crop residue management on damage by Diatraea saccharalis (Lepidoptera: Crambidae), its egg parasitoids and the ants associated with sugarcane. *Bulletin of Entomological Research*, *111*(1), 91–99. https://doi.org/10.1017/S0007485320000346

Perfecto, I., & Vandermeer, J. (2013). Ant assemblage on a coffee farm: Spatial mosaic versus shifting patchwork. *Environmental Entomology*, *42*(1), 38–48. https://doi.org/10.1603/EN12107

R Core Team. (2022). R: A language and environment for statistical computing. R: Foundation for Statistical Computing, Vienna, Austria. Available at: https://www.R-project.org/

Rivera-Pedroza, L. F., Escobar, F., Philpott, S. M., & Armbrecht, I. (2019). The role of natural vegetation strips in sugarcane monocultures: Ant and bird functional diversity responses. *Agriculture, Ecosystems and Environment*, *284*(December 2018), 106603. https://doi.org/10.1016/j.agee.2019.106603

Roldán, E. L., Beuzelin, J. M., VanWeelden, M. T., & Cherry, R. H. (2021). Abundance of the sugarcane borer (Lepidoptera: Crambidae) and foraging ants

E-ISSN 2355-9926

(Hymenoptera: Formicidae) in sugarcane grown on organic and mineral soils in Florida. *Environmental Entomology*, *49*(2), 473–481. https://doi.org/10.1093/EE/NVAA015

Rossi, M. N., & Fowler, H. G. (2004). Predaceous ant fauna in new sugarcane fields in the state of São Paulo, Brazil. *Brazilian Archives of Biology and Technology*, *47*(5), 805–811. https://doi.org/10.1590/S1516-89132004000500017

Saunders, M. E., Peisley, R. K., Rader, R., & Luck, G. W. (2016). Pollinators, pests, and predators: Recognizing ecological trade-offs in agroecosystems. *Ambio*, *45*(1), 4–14. https://doi.org/10.1007/s13280-015-0696-y

Sinu, P. A., Sibisha, V. C., Nikhila Reshmi, M. v., Reshmi, K. S., Jasna, T. v., Aswathi, K., & Megha, P. P. (2017). Invasive ant (Anoplolepis gracilipes) disrupts pollination in pumpkin. *Biological Invasions*, *19*(9), 2599–2607. https://doi.org/10.1007/s10530-017-1470-9

Suenaga, H. (2017). Ants (Hymenoptera: Formicidae) as potential egg predators of lepidopteran pests of sweet potato, Ipomoea batatas (Solanales: Convolvulaceae), in Japan. *Applied Entomology and Zoology*, *52*(2), 197–207. https://doi.org/10.1007/s13355-016-0468-6

Thurman, J. H., Northfield, T. D., & Snyder, W. E. (2019). Weaver Ants Provide Ecosystem Services to Tropical Tree Crops. *Frontiers in Ecology and Evolution*, *7,* 1–9. https://doi.org/10.3389/fevo.2019.00120

Triyogo, A., Budiadi, Widyastuti, S. M., Subrata, S. A., & Budi, S. S. (2020). Abundance of ants (Hymenoptera: Formicidae) and the functional groups in two different habitats. *Biodiversitas*, *21*(5), 2079–2087. https://doi.org/10.13057/biodiv/d210535

Wang, B., Lu, M., Peng, Y. Q., & Segar, S. T. (2021). Direct and indirect effects of invasive vs. Native ant-hemipteran mutualism: A meta-analysis that supports the mutualism intensity hypothesis. In *Agronomy*, 11(11). https://doi.org/10.3390/agronomy11112323

Wauters, N., Dekoninck, W., Herrera, H. W., & Fournier, D. (2014). Distribution, behavioral dominance and potential impacts on endemic fauna of tropical fire ant Solenopsis geminata (Fabricius, 1804) (Hymenoptera: Formicidae: Myrmicinae) in the Galápagos archipelago. *Pan-Pacific Entomologist*, *90*(4), 205–220. https://doi.org/10.3956/2014-90.4.205

Wills, B. D., & Landis, D. A. (2018). The role of ants in north temperate grasslands: a review. In *Oecologia, 186*(2), 323–338. https://doi.org/10.1007/s00442-017-4007-0

Wilson, B. E., White, W. H., Richard, R. T., & Johnson, R. M. (2020). PopulationTrends of the sugarcane borer (Lepidoptera: Crambidae) in Louisiana sugarcane. *Environmental Entomology*, *49*(6), 1455–1461. https://doi.org/10.1093/ee/nvaa127

E-ISSN 2355-9926

Xu, C., Li, Q., Qu, X., Chen, J., & Zhou, A. (2020). Ant–hemipteran association decreases parasitism of Phenacoccus solenopsis by endoparasitoid Aenasius bambawalei. *Ecological Entomology*, *45*(2), 290–299. https://doi.org/10.1111/een.12797

Yuniasari, N.-, Yuliastanti, N.-, Himawan, T.-, & Rizali, A.-. (2021). Keanekaragaman dan kelimpahan semut pada perkebunan kakao di Jawa Timur: pengaruh kondisi habitat dan keberadaan tropobion. *Jurnal Entomologi Indonesia*, *18*(1), 1. https://doi.org/10.5994/jei.18.1.1

E-ISSN 2355-9926