



# The agroecology power: how the environmental representation and management of leaf-cutting ants by peasants from Assentamento Dênis Gonçalves can be transformed

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## ABSTRACT

The relationship between human beings and leaf-cutting ants is secular and emerged along with the agricultural practices for food production. The environmental representation of peasants about leaf-cutting ants may be related to their country life background, implying directly on the control method used by them to reduce agricultural losses. In this context, it was investigated the relationship between the peasants' socioeconomic profile with their environmental representations about leaf-cutting ants and used control methods. Eighty families from Assentamento Dênis Gonçalves (Brazilian Landless Workers' Movement) were interviewed, in order to socioeconomically characterize them and ask if they know the term agroecology, what are leaf-cutting ants, their ecological function and used control method. Two profiles were identified, one composed by older peasants who had never studied, did not know the term agroecology, had a negative conception about leaf-cutting ants and used commercial formicides. The second profile was constituted by peasants with the opposite characteristics of the first. Agroecology concepts and practices seem to have a high potential to change environmental representations about leaf-cutting ants and used control methods in the studied area. By comprehending the leaf-cutting ants' role in the ecosystem a gradative transition to alternative control methods rather than the commercial ones was observed. This gradual transition enables a better relationship between ADG peasants and leaf-cutting ants. The organic compounds commonly used are clues to the urgent search for a sustainable leaf-cutting ant control method.

**Keywords:** Ethnobiology; Ethnoentomology; Social Movements; Socioeconomic Factors.

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## SIGNIFICANCE STATEMENT

We investigated the influence of socioeconomic factors and agroecological knowledge on the environmental representation of peasants in one settlement belonging in the Brazilian Landless Workers' Movement (MST) regarding leaf-cutting ants and the types of control methods used. These insects are one of the main limiting factors for family agricultural production in Brazil. It was possible to identify an interesting reality within the settlement, in which we found that knowledge about the term agroecology, the age and level of education are factors that shape the environmental representations and actions of peasants regarding these insects. The richness and complexity of the popular knowledge portrayed in this paper reinforce how Agroecology can be a powerful ally in promoting environmentally sustainable agriculture, which is concerned with the development of alternative methodologies in order to allow coexistence between leaf-cutting ants and peasants, besides to help food sovereignty and safety in MST.

## INTRODUCTION

The relationship between humans and leaf-cutting ants is secular and has become more expressive concomitantly with the emergence and modernization of agricultural practices (Altieri et al. 1987; Altieri 2004; Costa Neto and Rodrigues 2005; Cabral 2015; Branstetter et al. 2017). Leaf-cutting ants cause economic damage due to their foraging activity, which consists of cutting fresh leaves of various plant species to grow *Leucoagaricus gongylophorus* Möller (Singer), a symbiotic fungus, which is the food source for the colonies (Schjøtt et al. 2010; Della Lucia et al. 2014).

In Brazil, where agriculture is the main productive chain generating income, the loss caused by these ants is huge and can reach billions of dollars. As consequence, contemporary knowledge of these insects is mostly restricted to their elimination from planting sites, therefore being perceived as pest species, regardless of their ecosystem functions (Montoya-Lerma et al. 2012).

Conventionally, the control of leaf-cutting ants is based on the use of toxic-attractive chemical baits or dry powder applied directly to anthills (Zanetti et al. 2014; de Britto et al. 2016). These chemical control methods are

the most widespread in agriculture due to their high efficiency, accessibility and low financial cost (Della Lucia et al. 2014; de Britto et al. 2016). The active ingredient mainly used in pelletized fornicides is sulfluramid and Brazil has been the leader in its global production and consumption (Zabaleta et al. 2018). When degraded in soil, sulfluramid transforms into perfluorooctane sulfonate (PFOS), which is bioaccumulative, being incorporated by plants produced for human consumption and persisting in the environment for hundreds of years (Gilljam et al. 2015; Gilljam et al 2016; Nascimento et al. 2018; Zabaleta et al. 2018).

In conjunction with residues of other pesticides and agrochemicals, there is a contamination of rivers and groundwater, enabling the emergence of "super pests" and mortality of non-target species, which therefore pose risks to ecosystem biodiversity and environmental health (Devine and Furlong 2007; Cordeiro et al. 2010; Reemtsma et al. 2013; Lourençato et al. 2014; Antwi et al. 2015; Gibbons et al. 2015; Schäfer 2019). It has been also pointed out that direct or indirect exposure of farmers and peasants to pesticides increases the propensity to cancer, low birth

weight, intoxication, liver and kidney disfunction and higher cholesterol levels (Alavanja and Bonner 2012; Hernández et al. 2013; Tofolo et al. 2014; Fang et al. 2018; Nascimento et al. 2018; Hendges et al. 2019; Wang et al. 2019).

In contrast to the use of pesticide and their various impacts, Agroecology as a society project advocates a transition in the management and maintenance of agroecosystems through the application of principles that recognize the importance of popular practices and integrate perspectives of Ethnobiology (Wezel et al. 2009; Anderson 2011; Saylor et al. 2017; Ollivier et al. 2018). The vast majority of peasants who integrate social movements incorporate values beyond the use of natural resources, respecting the conditioning factors of the ecosystem and setting limits on the exploitation of natural resources (Borsatto 2013).

In this sense, when peasants have an agroecological background, it is expected that the environmental representation about leaf cutting ants includes their ecological role in the maintenance of biosystems. Environmental representation is defined as the interviewee's verbalization about their senses and stimuli concerning a set element of biodiversity, that address psychological, cultural and physiological factors (Silva et al. 2010; Silva et al. 2014a). It is a recurrent term adopted as substitute for "perception" which refers to sensorial aspects and not to the speech of the interviewee (Gumuchian and Marois, 2000).

Some studies reporting crop management by traditional peasants who practice agroecology can be considered as hints that their environmental representation about insects is not restricted to being pests. In Honduras arthropod biodiversity in maize crops is maintained to promote the biological control of *Spodoptera frugiperda* (Smith,

1797) (Wyckhuys and O'Neil 2007). In India, the traditional knowledge about seasonality and life cycle of aphids is a benchmark to choose cultivated species between dry and rainy seasons, to guarantee a higher food production for family subsistence (Singh and Sureja 2006). In Mexico, traditional indigenous knowledge about Meliponinae bees pollination is a local representation used by many tribes to improve fruit production (Ayala et al. 2012). Agroecological knowhow allows the farmers to recognise that excess of pests in the crop fields reflects physicochemical imbalances in the soil, encouraging crop rotation (Kremen et al. 2012; Rusch et al. 2013; Wezel et al. 2014).

Also it must be considered that the knowledge and environmental representation of peasants can be influenced by complex socioeconomic profiles that allow understanding the degree of association and integration with biodiversity elements (Abreu et al. 2015; Campos et al. 2015; Liere et al. 2017; Sūmane et al. 2018; Campos et al. 2019).

Thus, the environmental representations of peasants who constitute social movements, based on the agroecological model as the Movimento dos Trabalhadores Rurais Sem Terra (MST) may directly imply on the adopted control methods. The present study proposes verifying the relationship between the socioeconomic profile of peasants in the Assentamento Dênis Gonçalves (MST's settlement) and their agroecological comprehension, with their environmental representation about leaf-cutting ants and used control method.

## MATERIAL AND METHODS

### Study area

The study was conducted with peasants living in the Assentamento Dênis Gonçalves (ADG) (-21.574363 S, -43.209851 W), covering four municipalities of Minas Gerais, in the Zona da Mata region. The consolidation of the settlement began in 2013, due to occupations of the MST, the largest and most known social movement in defense of Agrarian Reform in Latin America (Veltmeyer and Petras 2008; Carter 2010). The site has an area of 4213 hectares and houses about 120 families living on family agricultural production in lots with 15 hectares on average.

The region is under the influence of the subtropical climate, defined by hot, rainy summers and dry winters, with an average temperature of 21°C (Taveira 2010). Seasonal Semideciduous Forest characterizes the vegetation type in early and advanced stages of restoration (Carvalho 2018).

Chronologically, from the second quarter of the nineteenth century, the site, which was a large private farm (Fazenda Fortaleza de Sant'Anna), was divided between crop fields and pastures for agricultural activities, where coffee production stood out followed by cattle breeding (Colombo 2007; Guimarães 2009). The history of intensive land use associated with other factors led to the progressive collapse of the production in the region (Vittoretto 2010), resulting in the degradation of the area. This sequence led the old farm to be considered an unproductive land property by the National Institute of Colonization and Agrarian Reform (INCRA), a criterion considered to meet the demand for appropriation of the area by the MST, that began in 2010. In this context, the trajectory

of anthropic activities at the site favored the constant and massive presence of leaf-cutting ants, considered the most successful and adapted insects in altered neotropical landscapes (Leal et al. 2014).

### Ethnobiological data collection

The sample universe consisted of the set of all 120 lots in the Assentamento Dênis Gonçalves, having as reference the responsible person aged eighteen years or older. After presenting the proposed research, it was possible to conduct 80 interviews with local peasants. For each lot visited, one person was interviewed, totaling approximately 70% of the houses. To ensure that key informants participate in the survey and enrich qualitative information, the snowball methodology (Espinosa et al. 2014) was employed. Thus, at the end of each interview, the participant was asked to indicate other residents recognized for having expertise about ants. Fifteen peasants were indicated through this method and thus included in the survey.

The peasants were asked about their relationship with ants, agriculture, environment, employed control practices and agroecological knowledge. Some personal questions were made to define their socioeconomic profile. Data was collected from September to December 2018 using two semi-structured interviews (Silva et al. 2014b), which were both recorded with a digital voice recorder. Also, for the enrichment and filing of information a field diary was employed (Campos et al. 2019).

The first aimed to socioeconomically characterize the peasants, surveying about: (i) age; (ii) gender; (iii) number of residents in each lot; (iv) local of origin; (v) agricultural or non-agricultural activities that guarantee the family's economy; (vi) formal educational

level; (vii) government public policy; (viii) declared to know the term agroecology or to have heard of it. When positive, a personal definition of agroecology was asked. It is important to highlight that even when the interviewee declared to not know the term agroecology, this did not imply that they do not use this practice. Per capita income was not included as most peasants have no fixed income. The second interview was designed to investigate the environmental representation about leaf-cutting ants. To enrich and to detail local knowledge, a free-listing was used (Cassino et al. 2019) which surveyed about the following topics: (i) ant diversity in the property; (ii) personal opinion about the ants mentioned; (iii) ants' function in the environment; (iv) period of higher ant occurrence in crops; (v) crops most affected by the foraging behavior of leaf-cutting ants; (vi) used control methods.

### **Socioeconomic Characterization of the Peasants**

The lots' production combines diverse activities for self-consumption, such as planting beans (*Phaseolus vulgaris* L.; *Cajanus cajan* L. Millsp.), corn (*Zea mays* L.), pumpkin (*Cucurbita* sp.) and cassava (*Manihot esculenta* Crantz), besides raising pigs and chickens. In addition, there are other income-enhancing practices, such as horticulture, honey production, and beef and dairy cattle raising. The latter is the most widespread, following the history of the region that demands large pasture areas. The historical origin of the peasants is varied and composed by (i) earlier peasants of the Fazenda Fortaleza de Sant' Anna, mostly descendants of enslaved africans; (ii) residents of surrounding cities with rural backgrounds; (iii) migrant families from distant regions with another social and

environmental context.

The gender of the 80 interviewees corresponds to 40 men and 40 women, with the majority of respondents (82%) falling under middle age (40 to 60 years) and elderly (60 to 89 years) categories. About 33% of the peasants participate in the Bolsa Familia Program while 75% received at least one National Institute of Colonization and Agrarian Reform (INCRA) grant as a government public policy. Regarding formal education, 72% of peasants declared incomplete or complete Elementary and High School which was categorized here as Basic Education. About 16% have never frequented a school, while 12% of the peasants have College or Technical formation. Inside the settlement there are two schools for children and teenagers up to sixth grade of Elementary School. At these schools, it is also offered the Education for Teenagers and Adults (EJA) educational program, which encompasses Basic, Elementary and High School levels for students with age over 18 who have never studied or had to interrupt their studies at some point in their lives. Professional activities directly related to agricultural practices were declared by most peasants (62%), who complement their family income with handicrafts, production of comfit, bread and sugar cane liquor (cachaça). The peasants also stated having jobs at civil construction, automobile sector and other self-employed and/or unwaged jobs in the cities near the settlement.

Assentamento Dênis Gonçalves has no public basic sanitation. Household sewage is generally destined to evapotranspiration pits built by the peasants themselves. The medical care is provided by the Unified Health System (SUS) in the Municipality of Goianá and Coronel Pacheco, Minas Gerais, Brazil. There are biweekly visits by doctors to



consult hypertensive and diabetic peasants. In addition, transportation is available for people needing assistance in larger cities in the region.

As a political organization, MST endorse not just the Agrarian Reform, but also Agroecology as a productive and society model, in which sustainable practices are structural politics (Altieri and Toledo 2011; Rosset and Martínez-Torres 2012; Meek 2015; Pahnke 2017; Robles 2019). This was decisive in the choosing of the families from Assentamento Dênis Gonçalves as partners of the present study.

### **Data analysis**

All interviews were transcribed and the peasants' answers were categorized and grouped in levels within analytic variables. Expressions used by the interviewees regarding definitions and concepts of agroecology were arranged in a word cloud graph. The font size of the expressions represents the frequency which they appear in the peasants' speeches. The expressions were also differentiated by colors, to represent political, environmental, productive chain and collective health meanings.

To measure how socioeconomic variables and declared agroecological knowledge can influence the environmental representation about leaf-cutting ants control practices, a Multiple Correspondence Analysis (MCA) was performed, which seeks to draw and spatially visualize the correlation between two or more categorical variables (Kassambara 2017).

The categorization of the interviews generated a database containing 20 categorical explanatory variables from which eight were selected for the MCA analysis (Table 1). The first set is composed by variables that define the socioeconomical (1-

4) and socioenvironmental (5) profile of the peasants, as they integrate the processes that determine the knowledge and management of the environment (Campos et al. 2015; Arruda et al. 2019; Campos et al. 2019). The second set of variables (6-8) were related to the environmental representation about leaf-cutting ants and used control methods. For each variable, the already categorized answers were grouped in as few levels as possible in order to avoid low frequencies, which could distort the analysis (Husson et al. 2017) (Table 1). Additionally, to verify the level of dependence between the pairs of variables that most contributed to the interpretation of MCA, a chi-square test was performed.

All analyzes were performed on the R 3.6.0 Statistical Program (R Core Team 2019) using the "FactoMineR" packages (Le et al. 2008), "factoextra" (Kassambara and Mundt 2017), "corrplot" (Wei and Simko 2017), "Ggplot2" (Wickham 2016), "ggrepel" (Slowikowski 2018) and "wordcloud2" (Lang and Chien 2018).

### **Ethical and Legal Aspects**

All procedures necessary to perform the research were approved by the Ethics Committee on Research with Human Beings of the Federal University of Juiz de Fora (CAAE: 92775618.3.0000.5147, Advice Report Number: 2.906.469). In the field, before each interview, all peasants were informed about the Term of Free and Informed Consent (FICT) to authorize the use of the information provided for the research. According to Ordinance number 378/2018 of the Ministry of the Environment, research with access to Traditional Knowledge, in the context of Law 13.123, must be registered as publication of the second version of the National System of

**Table 1.** Theoretical background, reference and levels of the categorical variables used in the Multiple Correspondence Analysis (MCA).

Variable	Justification for inclusion of variable	Reference	Model variable name	Levels within the variable
1. Age Class	Older people are more likely to learn about new ant control techniques.	Abreu et al. (2015)	Age	>54 or <54 (age median)
2. Gender	Men are more involved in agricultural practices and make a greater contribution to environmental representations and management practices than women.	Campos et al. (2015)	Gender	F = Female M = Male
3. Profession	Agricultural practices allow for greater contact with biodiversity elements, increasing the likelihood of knowing a greater variety of ant control methods.	Sũmane et al. (2018)	Profession	Rural = Source of income derives from exclusively rural activity. Services = Source of income derives from non-rural activities.
4. Schooling	Peasants' schooling may determine contact with agroecology.	Rosset et al. (2019)	Schooling	No Formal Study = No schooling. Basic = Elementary and High School completed or not concluded. Superior = Post-Graduate, Graduate or Technical Education.
5. Knowledge in agroecology	Knowledge about agroecology meets the logic of conservation of local sociobiodiversity, realizing the ecological role of leaf-cutting ants that live together with the cultivated areas.	Altieri and Toledo (2011)	Knowledge of the term Agroecological	No = Does not Know the term Agroecology. Yes = Knows the term Agroecology.
6. Opinion about leaf-cutting ants	Positive environmental representation of leaf-cutting ants is expected to be highly correlated with agroecological management.	Liere et al. (2017)	Opinion about Ants	Positive Negative Both
7. Ecological and environmental function of leaf-cutting ants	The agroecological knowledge implies the assimilation of positive role of living organisms in the environment.	Liere et al. (2017)	Ecological Function of Ants	Economical loss = Reports of losses due to the cutting of crops. Soil = Descriptions related to nutrient cycling, soil aeration and organic matter incorporation Food webs = Reports of ants as a food source for other animals. Don't know = Environmental role is unknown.
8. Leaf-Cutting Ants Control Methods Used	The type of method used to pest control is directly related to contact and adherence to agroecological agriculture.	Sũmane et al. (2018)	Control Method	Chemical = Commercial synthetic formicides. Agroecological = Alternative control methods. Both = Both types of control methods. None = Doesn't perform control.

Genetic Heritage Management (Sisgen). In addition to the Brazilian legal aspects, the present study also followed the established ethical precepts that permeate a research in Ethnobiology, synthesized in the Code of Ethics for Ethnobiological Research of the Latin American Society of Ethnobiology (Solae) (Villamar et al. 2018). Also according to Law 13.123 all knowledge systematized and published here are held by the peasants of Assentamento Dênis Gonçalves.

## RESULTS

### Agroecological Knowledge of Peasants of Assentamento Dênis Gonçalves

About 70% of the peasants stated to know the term agroecology, and they addressed it with several personal meanings which included political, environmental, productive chain and collective health aspects (Figure 1). Most definitions (55 citations) portrayed

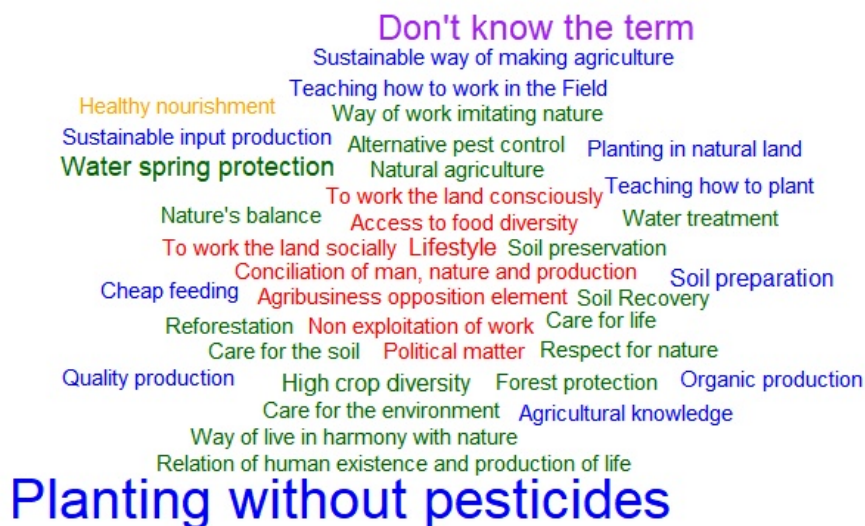
the term Agroecology as an agriculture that does not use pesticides and that worries with the protection of water sources (13 citations).

### Knowledge and environmental representation about leaf-cutting ants

The presence of leaf-cutting ants in the properties was unanimous among the peasants, and only two of the interviewees stated that they had no problems with these herbivores. Peasants identified the leaf-cutting ants considering the ant color, nest's size and architecture, and also by the impact of foraging on crops. For the vast majority, leaf-cutting ants have the nickname of "bigheads" (cabeçuda) due to the marked big size of their head in comparison to the rest of the body and the well-developed jaws when compared with other ant species. They also differentiated the leaf-cutting ants into two groups, which correspond taxonomically to

the genera *Atta* and *Acromyrmex* (Table 2).

Peasants' environmental representations about leaf-cutting ants were often conflicting, since 52% attributed exclusively negative opinions to the insect. In this scenario, the environmental functions attributed to them were limited to crop cutting and economic losses which compromise the family's agricultural production. On the other hand, 35% perceived ants positively and negatively, imputing both productive damage and ecological functions such as (i) soil aeration, fertilization and humidification; (ii) incorporation of organic matter; (iii) nutrient cycling; (iv) element of the food webs (Figure 2). Less widespread but also cited was leaf-cutting ants' usage in entomophagic practices of queens during nuptial-flight periods (five citations) and medicinal procedures for respiratory diseases treatment (two citations). Also, some peasants associated leaf-cutting ants'



**Figure 1.** Answers of ADG peasants about "what is agroecology for you?". The font size represents the frequency of registers. Answers concerning political definitions, environmental meanings and production chain are in red, green and blue respectively. The only definition referring to collective health is in orange. The frequency of answers stating not knowing the term agroecology is in purple.



**Table 2.** Ethnotaxonomic description of leaf-cutting ants genera presented by peasants from Assentamento Dênis Gonçalves, Minas Gerais, Brazil.

<i>Acromyrmex</i>	<i>Atta</i>
<b>Popular names:</b> Quem-Quem, Xenxém, formiga de Cisco, raspa-raspa, campista.	<b>Popular Names:</b> Saúva-limão, batom, cabeça-de-melado, pasteira, cabeça-de-vidro.
<b>Features:</b> Tiny ants. Smaller than the saúva ants ( <i>Atta</i> ). Their color ranges from black to brown.	<b>Features:</b> Big ants, bigger than quem-quem ( <i>Acromyrmex</i> ). Their color ranges from dark red to light red. They have characteristics similar to that of a tanajura (queen).
<b>Nest Architecture:</b> The nests are built with dry branches, leaves and loose grains of soil, not reaching so depth in comparison to the saúva ant ( <i>Atta</i> ).	<b>Nest Architecture:</b> The open nest hole is surrounded by soil. The nests are larger and deeper.
<b>Behavior:</b> These ants mainly cut leaves at night. They cut more leaves than saúva ants ( <i>Atta</i> ).	<b>Behavior:</b> Nocturnal active ants.

foraging activity and nuptial-flight with the most favorable period for plant sowing (six citations). The excavated soil above anthills is used to maintain the integrity of stored seeds and also to build bricks (one citation).

### Leaf-cutting ants Control Methods

The population of the Assentamento Dênis Gonçalves cited 54 different leaf-cutting ant control methods which were grouped in that included commercial toxic baits (synthetic compounds) and alternative methods (physical and natural compounds) (Supplementary material 1). Those who reported using commercial toxic baits said to apply the baits near the nests, while the powdered formicide is applied inside open nest holes using manual pumps. Five physical control methods for foraging restraint or whole ant colony elimination were cited, such as flooding, manual digging of nests and pitfall traps. Natural compound methods included the use of isopathy (13 citations), animal homeopathy (six citations), plant homeopathy (25 citations), natural plant extracts (six citations) and cow urine (19 citations). All of them stood out as potential repellents and/or reducers of ant-foraging

activity. In these cases, the attempt to ensure the coexistence between peasant and these insects was noted (Supplementary material 1). These natural compound methods can be applied over the leaves of the most attacked plants, and/or along the foraging trail and/or directly to the open nest hole. The preparation and application of these products hugely varied, probably according to the personal experience of each peasant. Concomitant planting of repellent species such as rosemary (*Rosmarinus officinalis* L.), clove (*Syzygium aromaticum* (L.) Merr. & LM Perry), sesame (*Sesamum indicum* L.), “guandu bean” (*Cajanus cajan* (L.) Huth) and wax gourd (*Benincasa hispida* (Thunb.)) in crop fields was mentioned by 21% of respondents. The last three species were reported as lethal to ants (Supplementary material 1).

### Influence of socio-economic-environmental factors on leaf-cutting ants environmental representation and control methods used

The sum of the first three axes of the multiple correspondence analysis explained 41.6% of the data variation. The variables

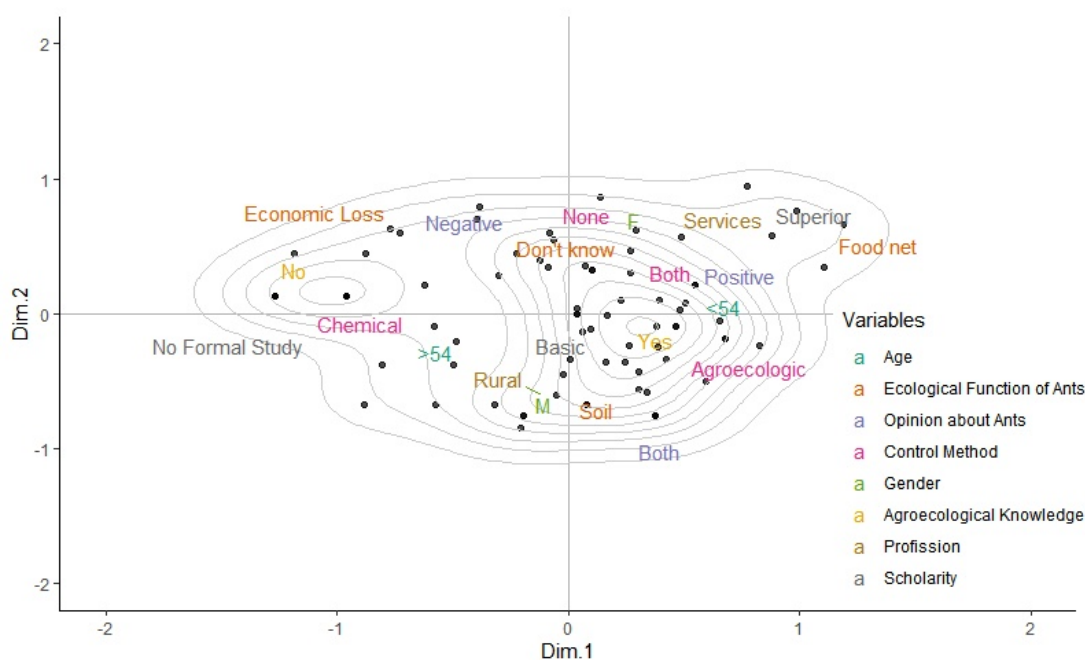


**Figure 2.** Answers of ADG peasants to the question "whats is the function of leaf-cutting ants in nature?" what is the leaf-cutting ant function in the nature? The ecological functions assigned to leaf-cutting ants prefer to Soil Aeration (in brown), Incorporation of Organic Matter (in blue), Nutrient Cycling (in red), Food webs (in green), Economical (in purple), Reforestation (in gray), Weather Forecast (in yellow). In pink it is represented the frequency of statements of not knowing the ecological function of ants and in black of the absence of function.

Agroecological Knowledge, Schooling, Control Method and Age were highly correlated with dimension 1, while the variables Gender, Profession and Opinion about Ants were more closely related to dimension 2. The variable Ecological Function of Ants correlated with both axes. These results indicate that these variables are determining factors in the differentiation of respondent profiles (Figure 3).

In fact, it was verified a profile of peasants over 54 years old, who do not know the term agroecology and have never studied who associated ants with economic loss, to the detriment of their ecological importance in the ecosystem, and also use commercial toxic baits to control leaf-cutting ants (Figure 3). On the other hand, the second profile grouped peasants that were less than 54 years old, with Graduate educational level either completed, in progress or have technical formation, know and adopt agroecological control methods, and recognize the role of ants as elements of food webs, considering their important ecological role in the settlement (Figure 3).

Analyzing the dependence of the variables that were most associated with the axes, that is, those that most contributed to identify the peasants' profile, a significant correlation was observed between Agroecological Knowledge with Ecological Function of Ants ( $X^2=15.80$ ,  $df=3$ ,  $p\text{-value}=0.0012$ ), Schooling ( $X^2=23.55$ ,  $df=2$ ,  $p\text{-value}<0.0001$ ), Age ( $X^2=14.19$ ,  $df=1$ ,  $p\text{-value}<0.0001$ ) and the Control Methods used by the peasants ( $X^2=16.57$ ,  $df=3$ ,  $p\text{-value}<0.0001$ ). Data analysis indicated that the majority of peasants who work in the field are male and older than 54 years old, while women under 54 years old act in non-rural activities, given the dependence between the profession variable with gender ( $X^2=5.29$ ,  $df=1$ ,  $p\text{-value}=0.021$ ) and age ( $X^2=12.45$ ,  $df=1$ ,  $p\text{-value}<0.0001$ ). There were no significant associations involving gender and agroecological knowledge ( $X^2=0.16$ ,  $df=1$ ,  $p\text{-value}=0.686$ ) nor between the occupation of peasants with the types of control methods adopted for leaf-cutting ants ( $X^2=5.13$ ,  $df=3$ ,  $p\text{-value}=0.16$ ).



**Figure 3.** Graphical representation of the Multiple Correspondence Analysis performed with socio-economic-environmental characteristics and environmental representation about leaf-cutting ants. Data corresponds to the 80 interviewed ADG peasants. X -and Y-axes represent the first and second dimension (Dim.1 and Dim.2).The contour lines display areas of similar sample density, with smaller circles representing peaks in such density. Black dots represent individual interviewees. Variable categorical levels are automatically positioned according to their correlations with such dimensional reduction vectors and with each other. In general, the graph can be separated in two profiles, one being distinguished in the left region, the other in the right.

## DISCUSSION

### Agroecological Knowledge as a tool for recovery and conservation of natural resources in Assentamento Dênis Gonçalves

Peasants from ADG have broad and varied definitions of agroecology, which assume political, environmental, economical and health aspects (Figure 1). This variability may be explained by personal experiences, that shape knowledge through idiosyncrasy (Kloppenburg 1991; Folke 2004; Reyes-García et al. 2014) and by current context. Therefore, peasants with a country background greater contact with agriculture, accumulating knowledge about agroecology and thus considering it as an alternative

agriculture. On the other hand, peasants whose background engages territorial struggles and articulation of new settlements define agroecology on a political scope.

Despite this variability, the agroecological knowledge built by the ADG peasants share common points, mainly agriculture without employment of pesticides, and conservation of water resources (Figure 1).The critical view on indiscriminate use of agrochemicals and pesticides is fundamental, considering that Brazil is the second greater consumer of these resources, and eighth per cultivated area (Pahnke 2017; Pignati et al. 2017). Hence alternative methods of herbivore control, crop rotation, traditional prepare of the soil, biofertilization, and preservation of riparian forests are all important measures for a rupture with the conventional agriculture

system that were mentioned during data collection and have been employed as a priority theoretical reference at MST (Rosset and Martínez-Torres 2012; Wezel et al. 2014; Brzozowski and Mazourek 2018).

Specifically in ADG, the conception of agroecology is probably related with MST's political goal, which employs it as a banner of social resistance and agricultural identity in the settlements. The implementation of the "Agroecological Zoning" project is reference throughout MST, in spite of particular characteristics of each settlement and of its participative elaboration (Altieri and Nicholls 2012). The Agroecological Zoning project seeks to promote agroecological practices and concepts in the settlements, encouraging the diversification of food production and gradual reduction of monoculture, breaking with the agribusiness model (Patel et al. 2000; Balestro and Sauer 2013; Caporal 2013).

The agroecological model improves the productivity and quality of ADG's crops, promoting agroecosystems resilient to environmental disturbances. Recognizing the importance of conservation and restoration of natural resources, assure an environmentally sustainable production, and drive the food sovereignty and safety in ADG, guaranteeing the peasants' life quality (Wittman 2010; Chappell and Lavalley 2009; Foley et al. 2011; Letourneau et al. 2011; Tschardt et al. 2011; Ratnadass et al. 2012; Tschardt et al. 2012; Edelman 2014; Sage 2014).

The agroecological knowledge of ADG peasants, when analyzed collectively, revealed a rich and complex discourse that comprehends agroecology as a major political and society project, as defined by Wezel and et al. (2009).

### **Agroecological knowledge is fundamental for the development of new environmental representations about leaf-cutting ants.**

From a utilitarian perspective (Berlin 1992), it is comprehensible why peasants consider leaf-cutting ants highly threatening, reflecting a environmental representation about them. The agricultural damage derived from the herbivorous action of leaf-cutting ants affect the economical income of peasants. Peasants know and differentiate between *Atta* and *Acromyrmex*, probably due to this economical importance, stating their morphological, ecological and behavioral characteristics that correspond to the taxonomic classification of the two genera. The knowledge is linked to the survival and economic factors of human populations, it has a material/utilitarian background and it is therefore more easily disseminated and transmitted across generations (da Silva et al. 2017). This negative environmental representation about leaf-cutting ants agrees with that of other pest insects in different traditional communities around the world (Berlin 1992; Si and Turpin 2015; Ulicsni et al. 2016).

A historical negative relationship between peasants and leaf-cutting ants may have been fostered by economically limited views of the ants importance in the environment, as evidenced by Mariconi's (1970) famous phrase: "either Brazil terminates the ants, or the ants will terminate Brazil" ("ou o Brasil acaba com as formigas, ou as formigas acabarão com o Brasil") and also by the irony of Mario de Andrade (1928): "Poor health and much saúde, Brazil's ills are" ("Pouca saúde e muita saúde, os males do Brasil são"). Such historical relationship probably exerted a great influence in shaping the negative environmental representations



that human groups developed over time about leaf-cutting ants (Serna and Correa 2003; Costa Neto and Rodrigues 2005; Boff et al. 2011), as recorded in the present study.

However, agroecological knowledge may operate by changing these paradigms in ADG. It is noteworthy that one of the peasants associated the high density of nests in their lot with a high environmental degradation level, revealing that they recognize that something is out of natural order. In fact, density of leaf-cutting ant nests and foraging rate are higher in potentially degraded areas (Montoya-Lerma et al. 2012; Leal et al. 2014; Swanson et al. 2019). Also, peasants who declared to know the term agroecology were those with positive environmental representations about leaf-cutting ants, listing their roles in aeration, fertilization, humidification, incorporation of organic matter and nutrient cycling in the soil and also as an important element of food webs.

These positive associations lead to the belief that agroecological knowledge broadens the environmental representation about leaf-cutting ants, allowing the recognition of their role in the ecosystem. Agroecology as a practice and lifestyle should be seen as promising for better crop field management, including the reduction of ant nest density and therefore maintaining homeostasis in the productive systems of the peasants.

Agroecological control practices reduce the herbivorous impact of the leaf-cutting ants, as the cultivated area is closer to a natural environment. Thus, the need for leaf-cutting ants' control is reduced and their density is kept below the baseline for economical loss by using alternative control methods. Indeed, a huge number of non-commercial control methods have been cited to contain the ants' cutting activity without

necessarily eliminating them (Supplementary material 1). The peasants who declared to use alternative control methods also knew the term and presented definitions of agroecology.

### **Use of commercial toxic baits: Contradiction or Need?**

Despite the alternative methods cited by the interviewees, there were frequent reports of the use of commercial toxic formicides in ADG (Supplementary material 1), what might look like a potential contradiction between speech and action. However, one should consider that agricultural practices and values are directly dependent on sociopolitical and socioeconomic aspects (Petersen et al. 2012; McCune et al. 2014; Meek 2015). Such aspects are determinant in the constructive processes of identity, territoriality, life corridors, local economy and maintenance of the biodiversity of a region inhabited by Social Movements (Escobar 1998; Miranda 2013) and explain the obtained results.

According to Barcellos (2009), although the peasants want an agroecological management of natural resources and act in a social and participative way, the socioeconomic and sociopolitical context are barriers that imposes conventional agricultural production similar to the agribusiness model. So, as MST's peasants have low incomes and initially rely on public policies such as "Programa de Fortalecimento da Agricultura Familiar" (PRONAF) as a financial assistance during the agroecological establishment process, some ADG families and other peasants, even if they know about and believe in agroecological values, do not have any option other than to take urgent measures to maintain persevering in their



agricultural production, even if they follow agroecological values. The use of commercial toxic baits to control leaf-cutting ants is currently the only envisioned method, as their effects are immediate and highly efficient (Forti et al. 2003; de Britto et al. 2016). Thus, these herbivores become the major bottleneck of agroecological production.

We also highlight the importance of the establishment of public policies that guarantee the implementation of settlements. In Brazil, the “Instituto Nacional de Colonização e Reforma Agrária” (INCRA), which is the federal agency responsible for land colonization and agrarian reform, has lost strength since 2016 and is practically inoperative (Robles 2019). In consequence, fundamental incentives for peasants, such as the previously mentioned “PRONAF” and also “Fomento Mulher” program (financial credit line made available in recognition of the importance of the productive work of women in the agrarian reform), is not received by the vast majority of the families. Thus, the political articulations between the MST leaders and the Brazilian government managers are extremely compromised, and financing for the land sector is broken. Unfortunately, while these political obstacles, coupled with the current criminalization and harassment of the MST, do not reverse, the purpose of the Movement itself gives rise to a struggling effort for survival and dignity of the peasants (Robles 2019).

It is noteworthy that the practical efforts for the insertion of agroecology in the ADG are being improved and evaluated, as is the MST itself and its organicity (Ferguson and Morales 2010; Meek 2014; Intriago et al. 2017; Rosset et al. 2019). It is observed that ADG is in the Agroecological Transition phase, which aims to increase the productivity of cultivated plants for self-

maintenance and as source of income to the families. It is usual for young settlements to be in this phase, specifically in its first step, called “Efficiency” (Wezel et al. 2014; Gliessman 2016), in which the cautious use of pesticides and chemical fertilizers is accepted in order to assist the primary production in heavily degraded areas. The pesticide usage by peasants helps us to understand that agroecology recognizes that the application of its principles depends on the different realities experienced by those who execute it, and, moreover, it is a process that requires time in both management and redesign of agroecosystems (Martínez-Torres and Rosset 2014; Meek 2015; Duru et al. 2015; Runhaar 2017; Ollivier et al. 2018).

### **Influence of Age, Schooling, Gender and Profession at the choice of leaf-cutting ant control methods**

The verified interdependence between the characteristics higher age, lower schooling and unfamiliarity of the term agroecology with use of commercial toxic formicides could be assigned to their country background. In general, older people commonly had less access to academical or technical education (Timmermann and Félix 2015) and consequently with the formal definition of agroecology, despite having valuable popular knowledge that is recognized and valued in agroecology. Also, they experienced the implementation of the “technological package” of customs and practices of the Green Revolution, turning them more resistant to change their usual agricultural techniques (Meek 2015), which include using commercial formicides.

This same relation may also be a reflex of the Brazilian country background can be characterized by an uneven distribution of land, miserable work conditions for peasants,

low levels of schooling, lack of information, dependence of pesticides, lack of interest of the young for agriculture and consequent migration to urban centers (Guimarães 1977; Brumer 2008; Meek 2015; Duong et al. 2019).

On the other hand, the verified relationship between younger people, higher schooling and familiarity of the term agroecology with the use of alternative leaf-cutting ant control methods may be a reflex of the socioeducational and agroecological precepts of the MST settlement here investigated. In ADG, the settlement leaders provide theoretical and practical courses in agroecology to the community. The formal education of younger peasants is also facilitated by the two schools inside the settlement, that reinforce agroecology along basic education showing the reality and goals of this agricultural lifestyle, which can deconstruct the negative environmental representation about leaf-cutting ants. It is also important to highlight the effect of the “Educação de Jovens e Adultos” (EJA) in the obtained results. This educational program allows a return to formal studies for peasants who are above the appropriate age and wish to share knowledge and strengthen the agroecological ideals defended by MST.

In fact, the educational processes promoted by Social Movements in South America are linked to a great society project (Barbosa 2016; Barbosa and Rosset 2017). In Brazil, the “Educação de Campo” project has gained force inside MST since the 80s decade, as a political pedagogical model with the objective to form critical and politically active peasants, claiming education as a right of the rural population (Molina and Freitas 2011; Tarlau 2015; Barbosa 2016; Barbosa and Rosset 2017). This pedagogical model opposes the model applied at traditional public schools, which

are not fit to a peasant lifestyle (Rosset et al. 2019). This reformulated formal education promotes conducts, behaviors and environmental representations with agroecological basis (Tofolo et al. 2014; Mazon and Souza 2015; McCune et al. 2017).

High schooling level stands out as a variable with high correlation with that of attributing ecological functions to the ants and of adopting alternative leaf-cutting ant control methods. Schools of MST, which are based at Paulo Freire’s assumption that emancipation is an endeavour of education (Caldart 2004), were initially dedicated to revert the peasants’ illiteracy and guarantee the permanence of the youth in rural zones (Tarlau 2013; Thapliyal 2013; Barbosa 2016). Currently MST has 2000 municipal and state educational institutions that add agroecology to the curriculum at theoretical, technical, practical and political levels since Basic Education until Higher Education, being the latter promoted by Federal Public Universities.

In contrast to other studies, that show the male gender as the one with more access to knowledge and use of biodiversity at rural economic practices (Paniagua-Zambrana et al. 2014; Arévalo-Marín et al. 2015; Campos et al. 2019), it was not verified a significant relationship of gender with familiarity about the term agroecology or with the use of alternative leaf-cutting ant control methods. In ADG, social, pedagogical, administrative and agricultural roles were attributed to women, in spite of the high frequency of non-rural activities reported for them. It is suggested that this result is a reflex of MST’s effort on counteracting the historical omission of women’s knowledge about rural practices in the Brazilian agrarian field (Schwendler and Thompson 2016; Schwaab et al. 2019). The transmission of knowledge and equal

rights embraced in feminism are fundamental to breaking rooted paradigms about the division of labor by gender (Lunelli et al. 2016; Schwendler and Thompson 2016; Conway 2018) and is one of the MST struggles.

## CONCLUSIONS

The analysis of the discourse of the ADG peasants revealed two main profiles, one constituted by peasants with more than 54 years old, low schooling level, unfamiliar with the term agroecology who stated a negative environmental representation about leaf-cutting ants and use commercial toxic baits for ant control. The second profile was constituted by peasants with the opposite characteristics of those listed. These different profiles are the reflex of different historical, political and educational backgrounds of the peasants. It is highlighted that as MST is a social movement, sociopolitical aspects cannot be ruled out, as they also directly influence the peasants' socioeconomic status. Clearly, ADG is a young settlement and is still at the technical and structural establishment phase.

Agroecological concepts and practices seem to have a high potential to change environmental representations and control methods of leaf-cutting ants, as agroecology conceives agriculture in harmony with the environment and encourage the reduction of off-farm inputs. By comprehending the leaf-cutting ants' role in the whole ecosystem a gradative transition to alternative control methods rather than the commercial ones was observed in the present study. This gradual transition may enable a better relationship between ADG peasants and leaf-cutting ants.

The presence and reports of agricultural damage caused by leaf-cutting ants was

unanimous within the ADG peasants, and the search for control methods which follow agroecology precepts is urgent. In this context, the evaluation of the peasants' leaf-cutting ant control methods, which are based in natural compounds, is a pathway to find a sustainable crop production, with the maintenance of leaf-cutting ant damage below the economic baseline.

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## DATA AVAILABILITY

The data used to support the findings of this study are available with the first author upon reasonable request.

## CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

## CONTRIBUTION STATEMENT

Conceived of the presented idea: TSN.

Carried out the experiment: TSN.

Carried out the data analysis: JL, TSN.

Wrote the first draft of the manuscript:  
TSN, GTS, JL.

Review and final write of the manuscript:  
TSN, GTS, JL.

Supervision: JL, GTS.

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