frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 23 November 2023
DOI 10.3389/fsufs.2023.1295292

OPEN ACCESS

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RECEIVED 15 September 2023
ACCEPTED 01 November 2023
PUBLISHED 23 November 2023

CITATION
Kolze AL, Philpott SM, Rivera-Pedroza LF and Armbrecht I (2023) Campesino and indigenous women conserve floral species richness for pollinators for esthetic reasons.
Front. Sustain. Food Syst. 7:1295292.
doi: 10.3389/fsufs.2023.1295292

Campesino and indigenous women conserve floral species richness for pollinators for esthetic reasons

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Background: Homegardens in agricultural areas are important refuges for pollinators and other valuable species due to the extensive plant diversity therein. Yet, plant diversity may strongly depend on the identity of the gardeners and their knowledge of plant identification and plant uses.

Objective: In this study, we used botanical surveys and homegardener interviews to explore plant diversity in homegardens in coffee-producing regions of Colombia, and to examine how homegardener identity influences their knowledge of plants, plant uses, and motivations for maintaining a homegarden.

Methods: We collected information in three villages in Cauca, Colombia and interviewed campesino ($n = 30$) and indigenous ($n = 30$) homegardeners. Half of the respondents from each social group were women and half were men.

Results and discussion: Of the 566 plant species that we detected in botanical surveys, the most recognized spontaneous herbs among homegardeners were "papunga" (*Bidens pilosa*, $n = 38$), "lechuguilla" (*Emilia sonchifolia*, $n = 32$), and "escoba" (*Sida acuta*, $n = 31$). Homegardeners identified multiple uses of spontaneous herbs including for food, material, medicine, plants for bees, and other environmental, conservation, or social uses. In addition, three different groups of gardeners emerged from social groupings and interview responses: (1) indigenous men with little knowledge of the uses of spontaneous herbs; (2) indigenous and campesino women who considered it beneficial to have flowers and crops for pollinators; and (3) male farmers who described detailed mutualistic plant-pollinator interactions that benefit crops, and who use spontaneous herbs to maintain soil moisture. In conclusion, homegardeners kept very diverse gardens and identified spontaneous herbs and pollinator functions, but this strongly depended on age, knowledge, and social group. Thus, homegarden presence within agricultural landscapes is of great importance to sustain functional biodiversity and ecosystem services in Colombian agroecosystems.

Conclusion: In conclusion, homegardeners kept very diverse gardens and identified spontaneous herbs and pollinator functions, but this strongly depended on age, knowledge, and social group. Thus, homegarden presence within agricultural landscapes is of great importance to sustain functional biodiversity and ecosystem services in Colombian agroecosystems.

KEYWORDS

plant and pollinator conservation, ethnobotany, women in agriculture, floral visitors, homegarden biodiversity

1 Introduction

Smallholder farmers in tropical agricultural regions often maintain gardens around their homes that provide important resources for biodiversity, including beneficial insects, especially in intensive agricultural landscapes. These family or rural gardens (hereafter "homegardens") are usually near the homes, are typically maintained by women members of farmer households, and provide microhabitats with a large variety of plants. Homegardens provide spaces to cultivate different vegetables, and may also contain tropical fruit or other trees, ornamental and medicinal plants, and other wild plants and spontaneous herbs. Because of this high plant diversity, homegardens can provide resources for visiting floral insects and animals (Eyzaguirre and Watson, 2002; Galluzzi et al., 2010), although the farmers may not be aware of this or of other benefits derived from the diversity of plants (Munyuli, 2011; Arango Gómez, 2019). Homegardens are considered spaces with the potential to become a reservoir for agrobiodiversity (Seid and Kebebew, 2022), especially in agricultural landscapes with predominantly intensive agricultural management. Although there is a tendency in Latin America to employ biodiverse traditional agriculture, especially in coffee producing regions, by using a variety of trees on the plantations (Perfecto and Snelling, 1995; Armbrecht et al., 2005), traditional coffee growing has almost entirely been replaced by intensive systems that require large amounts of chemical supplies (Jha et al., 2014; Harvey et al., 2021). Homegardens may be especially important for biodiversity conservation in tropical regions where coffee production is predominant, and where shade trees and other plants, such as spontaneous herbs, have been eliminated, as these practices limit domesticated and wild plant diversity, reduce floral resource availability for beneficial insects, and may limit the supply of ecosystem services (Potts et al., 2010).

Spontaneous herbs within homegardens guarantee floral diversity, provide resources for beneficial insects (e.g., floral visitors, pollinators, predators, and parasitoids), and may support ecosystem services like pollination and pest control (Blanco and Leyva, 2007; Nicholls and Altieri, 2013). Spontaneous herbs are often better known as weeds, and with that comes a negative connotation as pest plants (Fernández, 1982; Delgado and Romero, 1991). Yet, researchers have recognized that floral weeds fulfill roles of guaranteeing floral diversity in agroecosystems, providing resources and a refuge for insects (visitors, pollinators, among others), supporting pollination services, and some spontaneous herbs protect the soil and support hydrological or cultural services (Blanco and Leyva, 2007; Nicholls and Altieri, 2013; Bretagnolle and Gaba, 2015; Blanco-Valdes, 2016; Rivera-Pedroza et al., 2019). Pollination services, carried out by some flower-visiting insects, is an ecological function and a key economic, ecological, and social ecosystem service that is globally in decline (Daily, 1997; Klein et al., 2007; Potts et al., 2010). It is estimated that 35% of global crop production depends on animal pollination. In addition, the presence of pollinators not only increases crop productivity but also improves crop quality (Bailes et al., 2015), including in coffee plantations (Roubik, 2002; Ricketts, 2004). This ecosystem service is important both for agricultural production and in sustaining natural ecosystems in transformed landscapes. Nevertheless, pollinators not only provide services but also require resources (nectar, pollen, resin) to maintain their populations (Westrich, 1989; Roubik, 1992; Nates Parra, 2005). These resources can be provided by spontaneous herbs, crops, and other plants in homegardens and in natural habitats, such as forests.

Homegardens play an important role in the conservation of biodiversity and contribute to the survival of campesino families with monocultures by providing food products for family consumption or to sell (Eyzaguirre and Watson, 2002; Galluzzi et al., 2010). So, it is reasonable to expect that homegardens can conserve a high biodiversity of traditional ornamental, medicinal, and aromatic plants, both cultivated and wild, and also offer resources for pollinators in the area. In spite of this, traditional knowledge related to homegardens is threatened by a vision that tends toward favoring a homogeneous landscape and the idea that biodiversity in such a space is "dirty," or "weeds" that should be cut down. Moreover, homegardener knowledge may greatly differ depending on the social identities (e.g., based on social group, gender, age, or education, etc.) of people who inhabit agricultural landscapes where homegardens are common.

One axis of social difference that may influence homegarden management and plant diversity is gender (Reyes-García et al., 2010). Women play an important role in agriculture by contributing 43% of farm labor globally, and by providing for food security, care for the family and the home, obtaining income, and occupying themselves with the management of natural resources and biodiversity (García et al., 2006; Doss and Raney, 2011), and they use organic fertilizer (Reyes-García et al., 2010). Gardens and orchards managed by women more often support a variety of ornamental and medicinal plants than those managed by men (Reyes-García et al., 2010; Mahour, 2016), and women may demonstrate a greater awareness and desire to protect and conserve nature and its resources (Hunter et al., 2004). Women can have different perceptions and relations with floral spontaneous herbs than men. In other studies, scientists have documented that management of natural resources, and the use of fertilizer or herbicides is different between women and men in homegardens. These gender differences may translate into differences in homegardens. Traditional gardens are often creative places, a reflection of female identity and a space where sharing, learning, food production, and cultural and family life take place (Eyzaguirre and Watson, 2002). In our observations, we have noted that in rural gardens, the esthetic of the square garden, where biodiversity is submitted to open, monotone, geometrical forms, is broken down. In other words, homegardens usually have a different arrangement, which conforms to distinct feelings, knowledge, or social relations, beauty or artistic concepts, and can be a symbol of enrichment and decoration of the home with ornamental and other plants. Thus, women likely maintain high biodiversity with traditional vertical stratification in their gardens. Although it may seem disorderly to the common observer, women carefully plan each corner of the garden according to the microhabitat and availability of land. Throughout their lives, grandmothers, mothers, and daughters take an interest in maintaining and enriching their gardens and orchards by incorporating fruit, medicinal, aromatic, and ornamental plants. They also exchange seeds, buds and stems, and other offshoots with neighboring women or persons from other distant villages. This protective and loving attitude toward nature unconsciously creates conditions for a constant supply of flowers with pollen and nectar for pollinators. The history of women in the conservation of biodiversity reflects an underestimation of her role, just as of her role in agriculture (Kothari, 2003; García et al., 2006). Thus, studies must be carried out that begin to explore whether women are still continuing with this tradition of conserving biodiversity.

A second axis of social difference that may affect homegarden management is indigenous social identity. In Colombia, there are still various indigenous ethnic groups that manage homegardens in coffee-producing areas as well as campesinos, who are often relatives of the indigenous people, or referred to as mestizo. Social demographic information (e.g., age, education level) and behavior are the main characteristics that explain differences in the use of natural resources (Boster, 1986; Reyes-García et al., 2005). In Colombia, campesino and indigenous people have different lifestyles, languages, traditions, and cosmovisions, they live in nearby communities, and these differences may affect the homegarden management and homegardener knowledge about plant uses, as previously documented (Carr, 2008). In this study, we worked with the indigenous Nasa community, whose territory is in the northern to central-east Cauca department, extending from Caldono up to Popayán and Tierrandentro. They speak their own language, Nasa, as well as Spanish. They still practice their traditional rituals, and their primary economic activities are family agriculture and orchards for household rather than commercial consumption, but many also cultivate coffee. Colombian indigenous communities conserve a high diversity of cultivated plants in their homegardens (here, the Nasa community call it "tull"), which are established for household consumption (Sandoval Sierra and Chavez Servia, 2014).

We saw a great opportunity to interact with the campesino and indigenous communities to document these spontaneous herbs which do not have an economic value, but that may have a potential cultural value with benefits for health, rituals, agriculture, and nature conservation. The tools of ethnobotany may help in this issue to value the spontaneous herbs in homegardens and their potential for biodiversity conservation (Vicente and Sarandón, 2013).

We studied the diversity of floral spontaneous herbs (herbaceous plants) identified by and belonging to homegardeners in coffee production areas of southwestern Colombia. We completed botanical surveys, examined the knowledge of homegardeners from different social identities (e.g., women, men, campesino, and indigenous), and examined the biodiversity conservation potential of homegardens for pollinating insects. We specifically addressed the following research questions: (1) What are the social identities of interview participants? (2) How diverse is the plant composition in the homegardens? (3) Does social identity or demographic background influence plant species richness or knowledge about plants in homegardens? (4) What are the known uses of spontaneous herbs from homegardens?, and (5) Do spontaneous herbs provide a cultural value that promotes pollinator conservation in a Colombian coffee plantation landscape? We hypothesized that women in rural areas, more than men, without retribution or pay, protect and promote the flowers around their homes and, in this way, promote the biodiversity of the insects that visit coffee plantations.

2 Methods

2.1 Study site

This study was carried out in a coffee growing area in southwestern Colombia in the villages of El Rosal, El Pital, and La Isla, municipality of Caldono, Department of Cauca (2°49′44″ - 2°51′32"N y 76°34′8' – 76°33′25"W). Our study sites are located between 1,336 and 1,538 m elevation, and the area has a mean annual temperature of 21.5 C° and an annual rainfall of 2,191 mm. The region has two rainy seasons: April to May and October to November (Urrutia-Escobar and Armbrecht, 2013; Arenas-Clavijo and Armbrecht, 2019). The zone is dominated by mosaics of small coffee farms (with or without shade trees) mixed with corn, beans, plantains, yucca, and red pepper crops, among others. There are also small areas of land for cattle grazing.

Spontaneous herbs are often eliminated by agrochemical herbicides used in sun coffee plantations, although small coffee growers frequently still have spontaneous herbs in their homegardens due to a lack of money or of time to control them. In interviews, homegardeners often mentioned using natural fertilizers (guano, house compost), but some also use synthetic fertilizers (e.g., DAP, Triple 15, 20/24 or 24/25, or Cal Dolomita) and chemical herbicides (e.g., glyphosate). In contrast, the use of agrochemicals is less on shade coffee plantations and these crops are frequently associated with guamo trees, *Inga edulis* Martius, as well as the fruit and timber trees (Arenas-Clavijo and Armbrecht, 2019, obs. Pers. ALK and IA). The landscape is composed of small landholdings (*minifundios*) of up to 10 hectares each, usually with a house. The campesino and indigenous people establish their vegetable and flower gardens near the coffee crop. The women usually have a garden with flowers arranged in different densities and variety according to their taste or preferences.

2.2 Homegardener survey

We designed our surveys as semi-structured interviews (Parfitt, 2013) in order to discover the knowledge and perception of the homegardeners regarding the importance of spontaneous herbs, pollinator biodiversity, and their daily activities on the farms, as well as to determine their role in this context (Appendix 1). The survey was divided in three sections: (1) a social demographic section with questions about the background of the participants (education, age etc.), (2) a section with questions about management of the farm (with focus on coffee plantations for further studies), and (3) a section with questions about homegardener knowledge on the function and importance of spontaneous herbs, bees, and other pollinators as well as their motivations for gardening. We were primarily interested in assessing knowledge among women homegardeners, but men were interviewed as well so that we could compare plant knowledge and uses between genders. We conducted interviews with 60 people who were grouped in 4 groups: campesino women ($n = 15$), indigenous women from the Nasa community ($n = 15$), campesino men ($n = 15$), and indigenous men ($n = 15$). In some cases, we conducted surveys with more than one member of a household, but at different times, to avoid household members from influencing the answers of others. We later categorized all interview participants into three age groups: (youth 20–30 years, middle age 31–50 years, and adults over 51) as an additional possible axis of social difference among homegardeners.

2.3 Botanical survey of homegarden plants

While the interviews were being carried out, we collected information on the plant composition and species richness in the homegardens and other habitats (e.g., coffee plot, grazing area, other crops) within a 20 m radius surrounding the homes of the survey participants (Appendix 2). We took 1–2 h walkabouts with each survey participant, and during these walkabouts recorded the names of each of the plants (e.g., spontaneous herbs, flowers, herbs, grasses, crops, medicinal plants, others) that they recognized. Plants that survey participants recognized but did not have a name for were also recorded. The common names given were reviewed using a biovirtual platform (Bernal et al., 2017) to avoid species duplication, because the participants sometimes have different names for the same plant species. We took photographs of each plant seen during walks, and then used guides and keys (e.g., Pl@ntNet™ Copyright, 2014–2022; CENICAÑA, 2017; Salazar-Gutiérrez, 2020) to identify the scientific names of each plant seen.

2.4 Cultural valuation of spontaneous herbs and other plants in homegardens

The participants evaluated both the spontaneous herbs and the other plants used and recognized during the walkabout. We later categorized the plant uses provided into 11 use categories outlined by Cook (1995): (1) food, (2) spices/herbs, (3) animal food, (4) plants for bees, (5) building materials, (6) fuel, (7) social uses, (8) medicines, (9) conservation, (10) ornamental, and we added the category (11) spontaneous herbs (Supplementary Table S1). The sum of the values was used to compare the knowledge of campesino and indigenous women, and also to compare by gender. To calculate the cultural value of each ethnospecies (an ethnobotanical term for all plant species that the community in question related to use) recorded, we used the following formula (Reyes-García et al., 2006):

$$CV_e = Uc_e * Ic_e * \sum IUc_e \quad (1)$$

where CV_e corresponds to the cultural value of an ethnospecies e and is calculated by multiplying the total number of uses reported divided by the potential uses for ethnospecies e (Uc_e), multiplied by the number of ethnospecies recorded from all of the participants (Ic_e), and the sum of the number of participants who mentioned each use of the ethnospecies e divided by the total number of participants ($n = 60$; $\sum IUc_e$). The higher the calculated value of an ethnospecies, the higher the cultural value. This calculation was carried out using the "ethnobotany R" package (Whitney, 2021), and the tables were exported. We used the first 10 ethnospecies in the list of cultural values for all groups of the participants to generate an alluvial diagram by using the "etno_alluvial" function. This diagram helps to identify and visualize the knowledge and assigned importance of these 10 plants in the lives of the participants.

2.5 Data analysis

We categorized the answers about perceptions and knowledge of plants and pollinators, and we ran a cluster analysis with two packages in the R environment and language (R Core Team, 2022), "FactoMineR" (Le et al., 2008) and "factoextra" (Kassambara and Mundt, 2020). These analyses allowed us to combine demographic data (e.g., social group, gender, age, education), with the quantitative plant data from the botanical records, and with qualitative information from the interviews. Specifically, we chose five interview questions relating to uses of spontaneous herbs, pollinator function, and motivations for keeping a garden to characterize this information. We present the relative contribution of all quantitative and qualitative variables in dimension 1 and 2 in the multifactorial analysis in Supplementary Figures S1–S4. Further, the analyses allowed us to compare perceptions and knowledge about homegarden plants among the mentioned genders, social groups, and other demographic factors (e.g., age, education, working place).

We fitted eight GLMs, one for each of the following response variables: (1) richness of total reported plant species, (2) proportion of spontaneous herbs from total species richness, (3) proportion of ornamental plants from total species richness (4) proportion of other reported plant species from total species richness, (5) proportion of known reported plants, (6) proportion of known reported spontaneous herbs, (7) proportion of known reported ornamental plants, and (8) proportion of other known reported plants. For each model, we included the following factors: gender, social group, age range, education level, work location, hours per week spent in the garden, and homegarden manager gender. We list the information about factor levels in Supplementary Table S2. We did not include any interactions between factors. All statistical analyses were done using the R version 4.2.1. environment (R Core Team, 2022). Over-dispersion and values were calculated and transformed for error distribution from Poisson to negative binomial distribution with the "MASS" package (Venables and Ripley, 2002) for variable 1. For model 1 we used a Poisson distribution for the error but, because of certain over-dispersion, we changed to the negative binomial distribution. For models 2–7, which had a proportion as response variable, we used the quasibinomial distribution, and for model 8 the binomial distribution. For all models we conducted a stepwise elimination of not-significant factors starting with a complete model (all 6 factors included in the model). We chose the model with the best predictor variables using the information theoretic criterion, using the R function "stepAIC." To examine differences between mean values of the factor levels investigated, we run pairwise multiple comparisons of means using the "emmeans" function of the "emmeans" package (Lenth, 2022).

3 Results

3.1 Demographic distribution of participants

Our first study objective was to describe the social identities of the survey participants. The 60 participants represented two social groups: (1) indigenous members of the Nasa community ($n = 30$), and (2) campesinos ($n = 30$); half of each social group were women ($n = 15$). The average age of campesinos was 56.9 and average age of indigenous participants was 46.2. Coffee growing was the main economic activity for both social groups. The indigenous families cultivated coffee as well as homegardens (or "tull") for home consumption. The entire family supported the work in the gardens and in the coffee areas, including time during the harvest. Indigenous women worked in the field and the "tull" and tended to the home and the children. Several generations live on the same farm and families have from two to four children. In contrast, there are few children on campesino farms, but sometimes grandchildren are present. Campesino children are usually already adults and work in neighboring cities, very few remaining with their parents to work on the farm. Campesino men generally worked in fields alone, sometimes with the support of the women or paid labor, both generally and at harvest time. Thus, campesinos work on their own farms and also on other farms to improve their economic situation. Campesino women generally were occupied with housekeeping, helping their husbands with the crops, and keeping their gardens. The women, in general, have no personal income, and may only have temporary work at harvest time. Some women work in the fields or take on other jobs (including cleaning other people's houses) in order to support themselves. There is also a small difference in education level. Most participants had not attended high school or had only studied a few years of elementary school. In general, the few young participants had already finished high school, but this was more common for campesino than for indigenous participants. Defined roles were noted in the two social groups and between genders. Both the indigenous and campesino women are dedicated to work near the home, but the indigenous woman dedicates more time to her vegetable garden (foods, spices, and medicinal plants) than to her flower garden (ornamental plants). The campesino men seem to see women's work as something pretty but unimportant since it produces no income for the home. Likewise, the indigenous men viewed women's work in maintaining ornamental flowers to be less important, but more highly valued women's work in the "tull" (pers. Obs. ALK). The women also answered questions about their work shyly, giving the sensation that they undervalued the time and hours spent working in the homegardens.

3.2 Participant knowledge of plants and pollinators

The multivariate analysis revealed relationships between demographic characteristics of homegardeners, botanical records, and plant functions (Figures 1, 2; Tables 1, 2; also compare with Supplementary Figures S1–S4). The variable that contributed the most to separate the cluster groups was knowledge of the function of pollinators in gardens. Campesino men more often identified the importance of pollinators in the gardens compared with indigenous men or both groups of women ($p < 0.0001$; Tables 1, 2). Another main variable was education. The low education level among the indigenous people was reflected in their very basic answers about the functions of spontaneous herbs and pollinators (Tables 1, 2). More women, in general, and campesino men recognized the functions of spontaneous herbs (Tables 1, 2).

The cluster analysis identified three groups (Figure 1). Group 1 was primarily characterized by indigenous men who had not attended school. This group of people recognized fewer ornamental plants and reported lower species richness in their homegardens. Those interviewed indicated not knowing the answers to questions regarding the function of pollinators in the garden and in the crop. The answer "medicinal" was most frequent when asking about spontaneous herbs uses or functions. Finally, this group had the fewest recorded ornamental plants. Group 2 was composed of indigenous women who had not attended school. In answer to questions about functions of pollinators in the garden as well as in the crop, these women said that these spaces represented a benefit to the crop and a resource for pollinators. These women also recognized that spontaneous herbs function as a fertilizer (improving soil quality). Group 3 was primarily characterized by campesino men with a middle to high education level and who worked both on their own farm and on those of others, but some campesino women ($n = 9$) also were included in this group. Members of this group had higher recorded richness of ornamental plants and total species richness. The most common answer regarding pollinators was that they were of benefit to both plants and pollinators due to mutual interaction. The campesino men interviewed demonstrated knowledge of the benefits of pollination by bees in their fields. Members of this group also reported that spontaneous herbs have a function in soil conservation against erosion and in keeping humidity in the soil.

Multifactor analysis (Figure 2) discriminated between campesino and indigenous people in terms of all selected social demographic data and questions and gender (Table 1). Both campesino and indigenous homegardeners had some overlaps between genders but were distinct from one another. Although there were answers in common for all groups, the analysis showed that there were social factors and life circumstances (gender, social group, age, and education level) that differentiate and identify each group as a whole (Table 2).

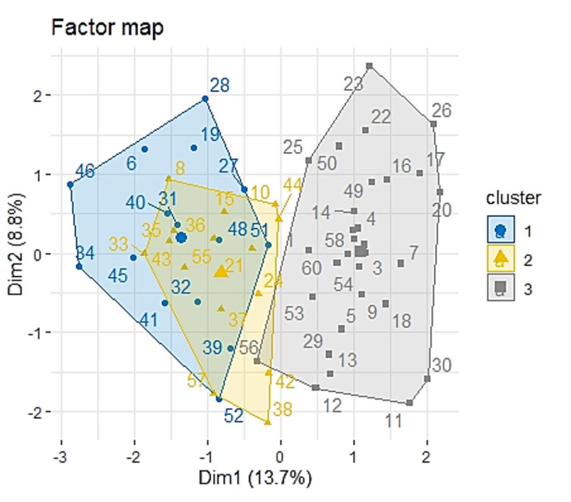

FIGURE 1
Two-dimensional factor map to illustrate pattern and distribution of cluster groups of homegardeners. The blue circles and their outlined area represent group 1 (lower educational level and less knowledge); the yellow triangles and their area represent group 2 (fewer ornamental plants); the gray squares represent group 3 (greater species richness and number of ornamental plants).

3.3 Plant species richness in homegardens

We recorded 2,936 individual plants and 566 different species of plants on the 38 homegardens and surrounding areas (23 homegardens in El Rosal, 12 homegardens in La Isla, and 3 homegardens in El Pital). We documented 166 species of spontaneous herbs (Supplementary Table S3). The homegardeners planted 264 ornamental plant species (Supplementary Table S4) and 136 species of other categories (e.g., crop or tree; Supplementary Table S5). The principal cultivated plants in homegardens were plantain (*Musa* sp.; several varieties; found in 44 homegardens), coffee (*Coffea arabica*; 33), yucca (*Manihot esculenta*in 33 homegardens), and other fruit trees. The main ornamental plants were *corona de cristo* (*Euphorbia milii*), *aloe vera* (*Aloe vera*), and geraniums (*Pelargonium peltatum*). The most recognized spontaneous herbs species were *papunga* (*Bidens pilosa*; found in 38 homegardens), *lechuguilla* (*Emilia sonchifolia* in 32 homegardens), and *escoba* (*Sida acuta* 31 in homegardens).

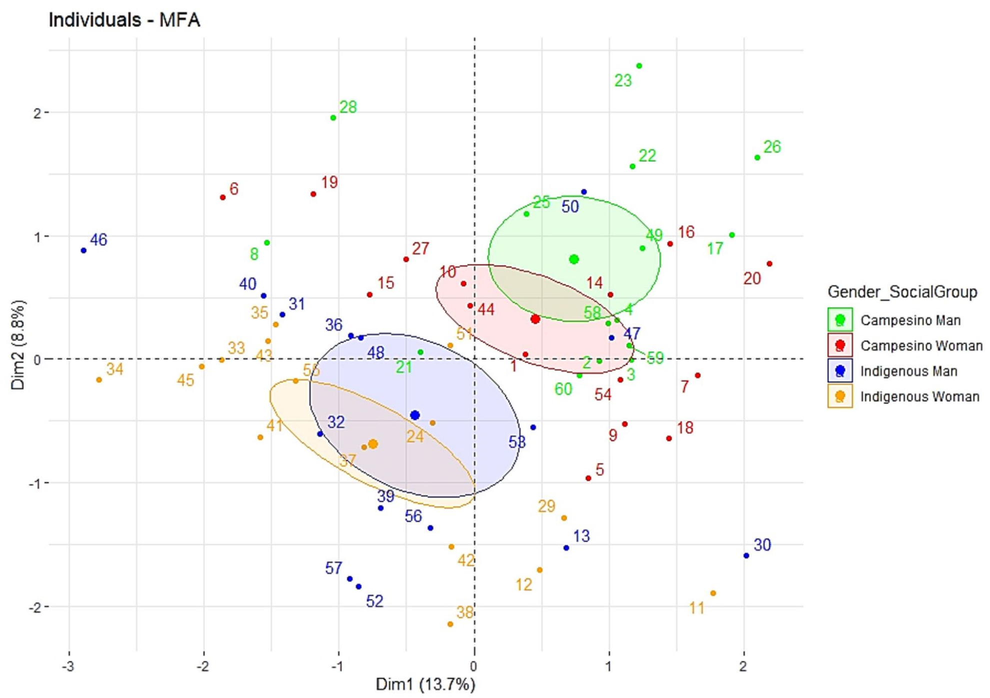

FIGURE 2
Multifactor analysis of the gender group variable and its contributions to the questions chosen to characterize the groups.

TABLE 1 Main variables obtained from multifactor analysis to produce cluster groups.

Main variable	*p* value	*df*
Pollinator function (garden)	<0.0001	4
Pollinator function (crop)	<0.0001	4
Pollinator function (general)	<0.0001	6
Educational level	<0.0001	4
Spontaneous herb functions	<0.0001	8
Gender – social group	<0.0001	6

We observed hundreds of plant species, including ornamental plants, crops, trees, and spontaneous herbs (Supplementary Tables S3–S5). Nevertheless, recorded plant species richness (Model 1) did not differ among participants and the best model for predicting plant richness did not include any predictor variables. Registered spontaneous herb species richness (Model 2) on the farms was best explained by education level and by who managed the homegarden. Unmarried men (where women were absent, $n = 6$) did not have homegardens or had homegardens with very low ornamental plant richness (pers. Obs. ALK), but a higher proportion of spontaneous herbs. People without formal education had a larger proportion of spontaneous herbs plants in their homegardens compared with those with high school education. In Model 3, reported ornamental plant species richness was explained by homegardener gender, social group, and educational level. Homegardens managed by women had more ornamental plant richness, and people with some formal education tended to maintain more ornamental plant species compared to those without formal education. Campesino women had more ornamental plants than indigenous men or women on their homegardens. Additionally, the factors kept in the model explained 28% of Model 4. The plants in the "others" category (crops and trees) showed more diversity on indigenous homegardens. More information about the coefficients and statistics of all models are in Supplementary Table S6.

3.4 Homegardener knowledge of plant species

Knowledge of plant names (total species) on the farms differed with social group and age (Model 5). Although the difference was only marginally significant, indigenous homegardeners tended to know more names of the plants on their homegardens than campesino homegardeners. Elderly homegardeners knew more plant names than middle-age homegardeners. Educational level and homegarden manager gender were important predictors of knowledge of spontaneous herbs (Model 6). These factors explained 29% of the variation of the proportion of recognized spontaneous herbs. Homegardeners with elementary school education knew the names of the spontaneous herbs more than homegardeners without formal education and women homegardeners knew more names than men. The knowledge of the names of ornamental plans in the garden (Model 7) was determined by age and gender. Women tended to have more knowledge of the ornamental plants than men, and elderly gardeners had more knowledge than middle age and young homegardeners. In Model 8, the "other plants" category did not indicate over dispersion and the best model was selected by AIC and BIC. In this case, the model with social group and educational level with the least AIC = 115.044 and BIC = 127.46 and a p value of chi squared 0.02 was chosen (Table 3). Indigenous men and women knew more names of the crops and plants on their farms as did the elderly.

TABLE 2 Characterization of three groups of homegardeners based on survey responses about pollinator and spontaneous herb functions as well as gender and education.

	Pollinator function (garden)	Pollinator function (crop)	Pollinator function (general)	Spontaneous herb functions	Gender-social group	Education level
Group 1	Does not know/ have	Does not know/ have	Does not know/ have	Medicine	Indigenous Men	Does not have
v value	4.666	4.262	2.978	3.619	2.067	3.854
p value	<0.0001	<0.0001	0.0029	<0.0001	0.0387	<0.0001
Group 2	Benefit for pollinators	Benefit for pollinators	Benefit for pollinators	Fertilizer	Indigenous Women	Does not have
v value	5.728	4.707	4.322	2.046	2.689	2.052
p value	<0.0001	<0.0001	<0.0001	0.0408	0.0072	0.0402
Group 3	Benefits by mutualistic interaction flower-pollinator	Benefits from pollinators for crop	Benefits from pollinators for crop	Benefits for soil and its humidity	Campesino Men	Primary / High School
v value	5.892	5.118	4.111	4.705	2.622	3.105 / 2.375
p value	<0.0001	<0.0001	<0.0001	<0.0001	0.0087	0.0019 / 0.0176

TABLE 3 GLM results showing which homegardener factors were the best predictors of different plant groups in homegardens.

Model	Variation explained	Factor	Difference between factor levels	Estimate	SE	Z-Ratio	*p* value
2 (proportion of spontaneous herbs)	44%	Homegarden manager gender	women-men	−0.82	0.208	−3.951	0.0001
		Education level	without -primary	0.194	0.116	1.672	0.2161
			without-graduated	0.435	0.151	2.873	0.0113
			primary-graduated	0.241	0.15	1.608	0.2423
3 (proportion of ornamental plants)	52%	Social group	Campesino-Indigenous	0.445	0.14	3.191	0.0014
		Education level	without -primary	−0.311	0.142	−2.191	0.0727
			without-graduated	−0.416	0.178	−2.335	0.0511
			primary-graduated	−0.105	0.168	−0.622	0.8081
		Homegarden manager gender	women-men	0.93	0.273	3.402	0.0007
4 (proportion of other reported plant species)	28%	Social group	Campesino-Indigenous	−0.405	0.15	−2.7	0.0069
5 (proportion of known reported plants)	27%	Age	young-middle	0.148	0.306	0.483	0.8795
			young-elderly	−0.371	0.284	−1.307	0.3913
			middle-elderly	−0.519	0.175	−2.964	0.0085
		Social group	Campesino-Indigenous	−0.303	0.169	−1.798	0.0722
6 (proportion of known reported spontaneous herbs)	29%	Education level	without -primary	−0.527	0.18	−2.933	0.0094
			without-graduated	0.0245	0.271	0.09	0.9955
			primary-graduated	0.5515	0.27	2.039	0.103
		Homegarden manager gender	women-men	0.77	0.332	2.318	0.0204
7 (proportion of known reported ornamental plants)	35%	Age	young-middle	−0.193	0.425	−0.455	0.8923
			young-elderly	−0.871	0.401	−2.172	0.0761
			middle-elderly	−0.678	0.256	−2.646	0.0222
8 (proportion of other known reported plants)	–	Social group	Campesino-Indigenous	−1.12	0.39	−2.884	0.0039
		Age	young-middle	0.24	0.586	0.409	0.9119
			young-elderly	−0.649	0.584	−1.111	0.5074
			middle-elderly	−0.889	0.395	−2.252	0.0628

Recorded plant species richness was discarded (Model 1) because it did not differ between participants and therefore did not include any predictive variables.

On calculating the average of plants recorded and recognized by group, some tendencies were observed. For example, campesino women recognized more species of ornamental plants while indigenous women and campesino men recognized more spontaneous herbs plants. Indigenous men centered their knowledge on the names of crops and trees (Table 4), those species that provide income for the family.

3.5 Gendered perceptions of spontaneous herbs, pollinators, and the garden

There were no significant differences in the way men and women discussed spontaneous herbs, pollinators, and garden motivations. We nevertheless summarize observed differences by gender. Of the 60 persons interviewed, only 11 knew the term "*arvense*" – a Spanish language term equivalent to spontaneous herb – (campesino women = 3, campesino men = 11, indigenous women = 1, indigenous men = 0) while 57 persons recognized the term "*maleza*" – a Spanish language term equivalent to weed. In the interviews, the term "*planta del monte*," or "wild plant," was most often used to describe this group of plants (see Supplementary Figure S5). Women more often reported that spontaneous herbs were beneficial for people and have a biological function (see Supplementary Figures S6, S7). Women mostly related spontaneous herbs to medical uses but also as beneficial to the soil and as feed for animals and pollinators. Men identified spontaneous herbs more as a function in the crop as well as in conserving humidity and protecting the soil (see Supplementary Figure S8). Women expressed pleasure at having a garden. The reasons they gave were that it was good for their physical, mental, and spiritual health. Secondly, it decorated the farm. The men were more inclined toward the decorative aspect of gardens (see Supplementary Figure S9).

As to the questions regarding pollinators, men answered with more knowledge of the pollination process and its importance to the crop. Women, on the other hand, referred more to the benefits that the floral resources on the farm received from the pollinators (see Supplementary Figures S10, S11).

3.6 Plant uses and value index

At least one homegardener mentioned each of the 11 use categories for spontaneous herbs, but the most commonly mentioned uses were as weeds (49%), medicinals (18%), and ornamentals (13%; Figure 3).

The uses mentioned varied among participant groups (Figure 3). Campesino men mainly identified spontaneous herbs as "weeds" and tended to identify them less as ornamental compared to other groups. However, this was the group that most spoke of spontaneous herbs as plants for bees and as useful for the environment, including soil conservation. Campesino women focused more on ornamental and medicinal uses, as did the indigenous women. They were more inclined toward the social uses of some spontaneous herbs including, for example, educating children for bad behavior with a small hit with *Verbena* sp., and other plants are used for incense, and cleansing baths. Indigenous women were the group that most referred to the medicinal use of spontaneous herbs and very little to ornamental uses. They were the only group that used spontaneous herbs as food but did not associate them with conservation, just as the indigenous men (Figure 4).

All types of spontaneous herbs, ornamentals, and other plants were included to calculate the cultural value of the plants and to compare which plants had greater cultural value in this coffee growing region. The plants with the greatest cultural value index were spontaneous herbs: *Bidens pilosa* (CV_e = 0.253), *Verbena littoralis* (CV_e = 0.123), *Emilia sonchifolia* (CV_e = 0.103), and *Cuphea racesoma* (CV_e = 0.094). The spontaneous herbs are followed by *Inga* sp.*1* (CV_e = 0.091), *Aloe vera* (CV_e = 0.061), coffee (CV_e = 0.061), *Pelargonium peltatum* (CV_e = 0.061), *Psidium guajava* (CV_e = 0.059) and different varieties of plantain *Musa* spp. I (CV_e = 0.054). On making this cultural value calculation by community gender and social group, the values changed in between the different community groups and between the gender social groups (see Table 5; Supplementary Table S7). For example, *B. pilosa* showed different high cultural values in each group. The highest value was calculated for campesino man and indigenous woman. The lowest value this plant got was among campesino woman. Campesino woman more highly valued *Inga* sp.*1* (CV_e = 0.162), *C. racesoma* (CV_e = 0.114) or *Aloe vera* (CV_e = 0.108). In contrast, the campesino man more highly valued spontaneous herbs. For all other listed species in Table 5, the indigenous women and men had lower cultural values than the campesino community; this was primarily due to calculating the values for each group separately (see Supplementary Table S8).

Homegardeners listed various uses for *B. pilosa* (food, conservation, for bees, and as 'maleza' or spontaneous herbs), *V. littoralis* (medicinal, material, ornamental, social, and for bees); *E. sonchifolia* (medicinal, feed for animals, ornamental, and conservation) and *C. racemosa* (mainly used as a broom, but also for material, medicinal, ornamental, social uses, and as a bee resource). The alluvial diagram (Figure 5) also included other very important plants such as *Aloe vera*, guamo, coffee to consume as food, and medicinal plants. *Pelagorium peltatum* was the only garden plant used mainly for ornamental purposes that is also as a medicinal plant.

4 Discussion

In our hypothesis we proposed that women in rural areas, more than men, without retribution or pay, protect, and promote the flowers around their homes and, in this way, promote the biodiversity of the insects that visit coffee plantation, and our results support this hypothesis. Even though we found a lack of knowledge, the valuation of spontaneous herbs and sometimes the woman's effort in the homegardens, and the awareness of relation between spontaneous herbs, gardening, and pollinators or other insects, all participants, more woman than men, contributing to plant diversity in homegardens, creating a beautiful home, and promoting biodiversity in this coffee landscape. In the following part we will discuss the results in detail to the questions.

In question 1, we asked about the social identities of interview participants with the aim of describing the socio-demographic characteristics of our study participants. We documented differences between the campesino and indigenous participants in terms of their education level and roles. Although we initially characterized our

TABLE 4 Mean species richness of plants recorded by the researchers and recognized by the indigenous and campesino survey participants.

	Women		Men	
Plant group	Campesino	Indigenous	Campesino	Indigenous
Total plant species richness	52.1	46.7	50.4	42.9
Standard deviation	19.8	22.7	16.51	21.7
Plant species recognized by participants	33.5	32.9	30.2	26.9
Standard deviation	13.7	14.6	11.6	12.4
Total spontaneous herb richness	13.6	16.1	15.5	13.2
Standard deviation	5.8	6.9	5.1	9.3
Spontaneous herb species recognized by participants	6.7	8.3	7.7	5
Standard deviation	3.8	3.5	3.2	3.0
Total ornamental plant richness	24.2	15.1	21.3	13
Standard deviation	12.8	10.0	9.4	10.1
Ornamental plant species recognized by participants	13.3	9.3	9.6	5.9
Standard deviation	6.9	5.5	6.2	4.9
Total species richness of other plants (crops and trees)	14.3	15.5	13.6	16.7
Standard deviation	5.5	8.7	7.0	7.2
Total other plants recognized by participants	13.4	15.5	12.9	16.1
Standard deviation	5.5	8.5	6.4	6.8

For statistics, see Table 3.

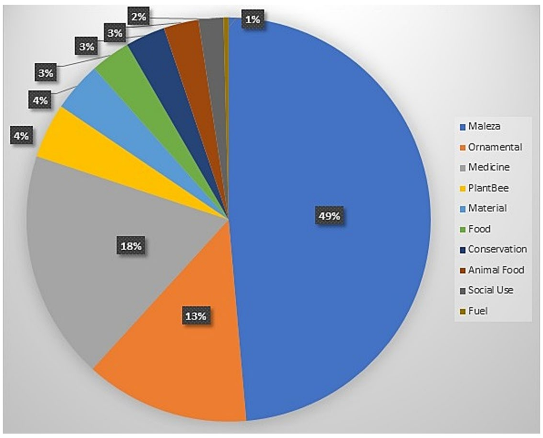

FIGURE 3
Spontaneous herb uses reported by homegardeners. Uses identified include: maleza (or "weed"), plants that grow naturally and are identified as dangerous or that have no function; ornamental, plants that are garden plants; plantbee, plants that represent flora resources for nectar and pollen for the bees; material, plants that are used in construction and furniture, among others; food, edible plants for human beings; conservation, plants that are beneficial to nature, crops and human beings; animal food, food for animals; social use, plants that have a social or spiritual use; and fuel, combustible plants.

participants into four groups, multifactor analysis based on identities, plant diversity, and plant knowledge formed three groups, not four. It turned out that the campesino women varied in their answers on plant species richness in their gardens and were split among multiple groups, although most of them were included in a group with campesino men that had a large number of ornamental plants in their gardens and more knowledge of plant functions and fertilizers. Indigenous participants, in contrast, did not always keep homegardens, and if they did, they were small. In a lifestyle aimed toward cultivating crops for household use, farm area is mostly used for commercial crops and vegetable gardens. Several plants for human consumption were found in homegardens and indigenous women indicated that planting ornamentals and having flower gardens was a luxury. They shared desires for floral diversity, if time and resources allowed, but their energies were concentrated on food and medicine. Single men had little time, had no or only a few ornamental plants, and did not think that having a homegarden was a priority. In contrast, households with women supported a variety of ornamental plants, spontaneous herbs, fruit trees, and spices for the kitchen. The overlap in the Figure 1 in both indigenous gender groups shows that there is not a large difference between them, with a bigger difference between social groups reflective of their education level and daily lifestyle.

The second question addressed the species richness and composition of homegarden plants. Here, we found that campesino women homegardens contained more ornamental plants than those of indigenous women who had very few ornamentals and instead cultivated more plants for food, medicinal, and other uses. Single men also placed more emphasis on food crops and had more grasses and/or spontaneous herbs.

Our third question addressed whether social identity or demographic background influence plant species richness or knowledge about plants in homegardens. We found, generally, that women recognized more plants, and specifically campesino women recognized more ornamental plants; indigenous women and campesino men recognized more spontaneous herbs, and indigenous men were more likely to recognize crops and trees. Importantly, this study emphasizes that farms with women have a greater diversity of

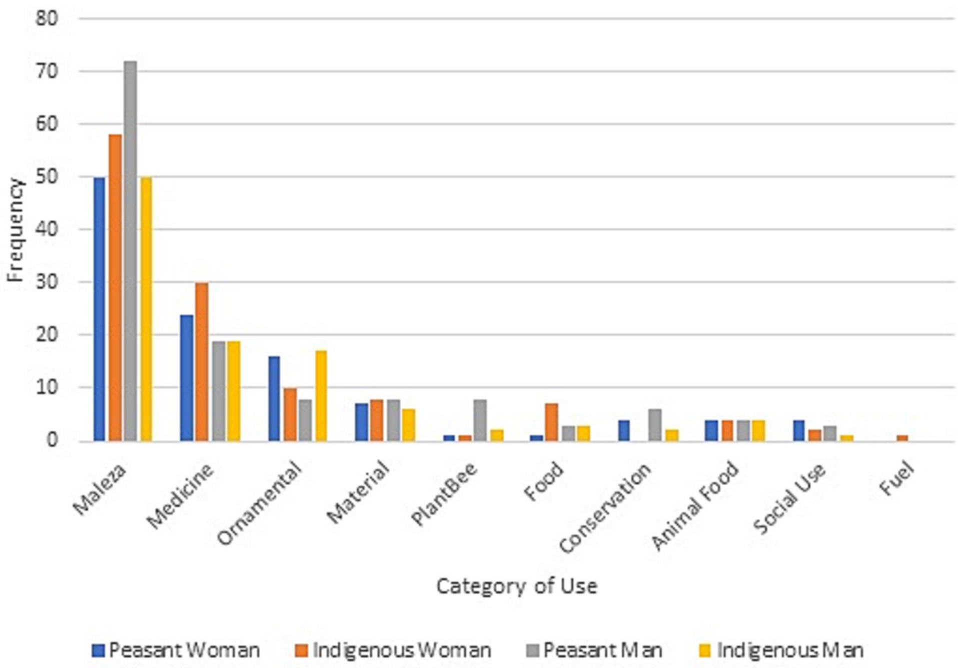

FIGURE 4
Number of species that each group of participants associated with a use. For the conventions of each use category, see Figure 3.

TABLE 5 Cultural values of ethnospecies (CV_e) grouped by ethnic groups of participants community: campesino and indigenous community and grouped by gender-ethnic groups of participants (first 10 ethnospecies).

	Cultural value of ethnospecies (CV_e)						
Scientific name	All	Campesino community	Indigenous community	Campesino woman	Indigenous woman	Campesino man	Indigenous man
Bidens pilosa	0.253	0.23	0.222	0.05	0.256	0.367	0.128
Verbena littoralis	0.123	0.104	0.085	0.05	0.12	0.124	0.037
Emilia sonchifolia	0.103	0.168	0.04	0.16	0.037	0.132	0.018
Cuphea racemosa	0.094	0.161	0.009	0.114	0.011	0.072	0.007
Inga sp. 1	0.091	0.103	0.04	0.162	0.044	0.028	0.036
Aloe vera	0.061	0.089	0.019	0.108	0.022	0.036	0.016
Coffea arabica	0.061	0.08	0.022	0.089	0.022	0.072	0.022
Pelargonium peltatum	0.061	0.08	0.022	0.028	0.036	0.108	0.011
Psidium guajava	0.059	0.04	0.038	0.011	0.044	0.064	0.016
Musa x paradisiaca	0.054	0.049	0.059	0.064	0.044	0.036	0.075

The species are ordered depending on the relative importance of each one in the first column (to be continued in Supplementary Table S7).

ornamental plants as well as more knowledge of plants and their cultural uses. As far as motivation, occupation, and knowledge, similar results were found by Philpott et al. (2020) in the United States where it was found that women produced a greater variety of plant species in gardens, including ornamental and medicinal plants. Elderly people were also found to have more experience and knowledge of plants and their uses (Ladio and Lozada, 2004; Cruz et al., 2013; Bortolotto et al., 2015). Indigenous women knew more about the plant species in their homegarden, but botanical surveys revealed lower species richness of ornamentals and spontaneous herbs in their homegardens compared with campesino men and women. Perhaps, thus, spontaneous herbs, and trees were more useful for family survival due to their self-consumption lifestyle. Since indigenous women work with these plants daily, it was easier for them to recognize more plants. These results (knowledge of plant names, botanical registers, and cultural value of plants) reflected the existence of definite gender roles. Women recognized more plants and men who lived with women knew more about plants and their uses than the single men who usually did not garden or, if they did, had homegardens with low plant species richness. Single men, nevertheless, had more spontaneous herbs on their farms. Several men were able to identify medicinal plants, but women registered a deeper knowledge of medicinal plant uses than men (compared with Camou-Guerrero et al., 2008). On the other hand, since the campesinos were in the field all day, they likely had more contact with spontaneous herbs than the women. This observation was reflected in the cultural value lists. Additionally,

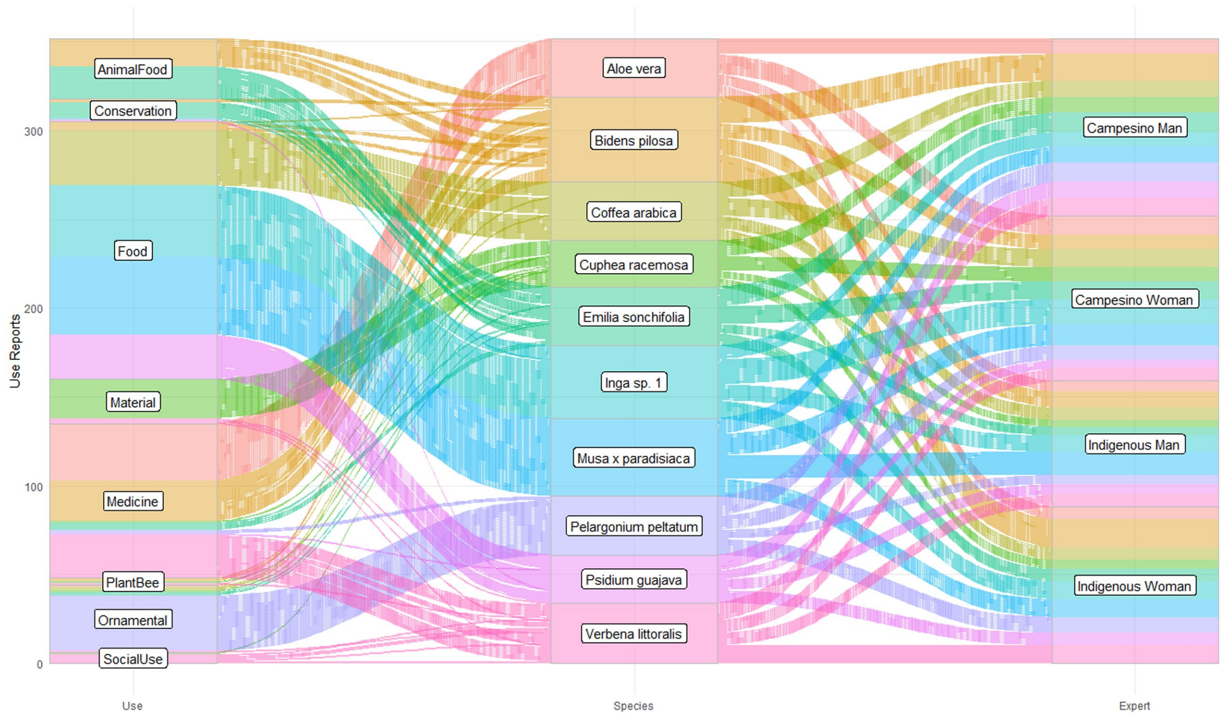

FIGURE 5
Alluvial diagram that relates use categories, plant species, and participant groups. In this diagram, the first 10 plants were selected according to the list of the highest cultural value. Plants are listed alphabetically. The conventions are ornamental, garden plants; food, edible plants for human beings; animal food, plants feeding animals; material, plants in construction, furniture, among others; medicinal plants; plantbee, plants that present floral resources for nectar and pollen for bees, conservation, plants that are beneficial to nature, crops and human beings; and social use, plants with a social or spiritual use.

campesino men and indigenous women registered more knowledge in this last category than campesino women who were busier with domestic chores or who worked in the fields.

Our fourth question aimed to examine the known uses of spontaneous herbs from homegardens. We found that spontaneous herbs were used for several purposes in this campesino and indigenous community. More specifically, 11 use categories were described in more detail. The most reported uses of spontaneous herbs were medicinal, ornamental, and as construction material (Vicente and Sarandón, 2013). *Bidens pilosa, Emilia sonchifolia, Sida acuta, Cuphea racesoma,* and *Verbena littoralis* were the spontaneous herbs with more different uses, as many as five different uses each. These plants were also the most common in botanical records and those most recognized by the campesino and indigenous communities. This resulted in high cultural index values for *B. pilosa, V. littoralis, E. sonchifolia,* and *C. racesoma*, plants that occupied the first places on the list of all of the plants in the study.

On comparing spontaneous herb plant use in other studies focused on edible or medicinal plants, various medicinal plants were found that the campesino and indigenous community identified as "weeds," but that had medicinal properties. For example, the Bussmann (2002) study in Ecuador that investigated the knowledge of healers collected a list of 142 medicinal species corresponding to the illness they cured. Of the list, 25 species appeared in the botanical records of the present study and also corresponded to medicinal uses. However, there are some species that have unrecorded medicinal uses. The same was true for other uses, such as bean plants for soil conservation, among other environmental benefits. These benefits were still not very related to spontaneous herbs. According to *Cenicafe* (Colombian National Center for Coffee Research), an important number of spontaneous herbs in the coffee producing area are classified as "noble arvenses," meaning that they are beneficial. Of these beneficial spontaneous herbs, 21 coincide with plants recorded in the present study (Salazar Gutiérrez and Hincapié Gómez, 2007; Salazar-Gutiérrez, 2020).

By assigning uses to the spontaneous herbs by all groups of participants, we expected to hear more often the uses for being a plant for bees or because it is a flower to be an ornamental plant in the view of the homegardeners. In our results we found that only 6% of spontaneous herbs are reported as plant useful for bees or ornamental. It seems to be that this awareness about the relationship between bees and spontaneous herbs and homegarden beauty are underdeveloped. Only after asking the participants in the walkabouts whether the plant is important for bees, mostly, they have answered with yes, when the spontaneous herb had a flower.

Finally, for our question 5, we examined whether spontaneous herbs provide a cultural value that promotes pollinator conservation in a Colombian coffee plantation landscape. We discuss two major findings related to this study question. First, our study detected a large gap between the knowledge and language used by scientists or agroecologists and rural farmers. The term "arvenses" (or Spanish term for spontaneous herbs) was still not well-known nor were their functions and benefits to crops and fauna. Yet the term "maleza" (or Spanish for weeds) preserves the image that wild plants or spontaneous herbs are damaging and of no use. Similar results were also obtained in other studies in Colombia demonstrating that spontaneous herbs were not important to campesinos (Arango Gómez, 2019). In contrast to Munyuli (2011), we found that indigenous people had the lowest knowledge of the benefits of pollinators for crops, with campesino women and men having a more detailed, or even functional understanding. Second, in general, we observed a low valuation of conservation actions for native wild plants. Several times during the walkabouts, women were seen pulling out spontaneous herbs, or weeding to clean their gardens. However, the ethno-botanical appreciation of these communities indicated a great potential for various uses of spontaneous herbs in their daily lives. Finally, a lack of education and awareness was observed with respect to connections between their work, the functions and benefits of pollinators, and their need to survive. The majority of the participants, more men than women, and more campesino men in general, demonstrated more knowledge of pollinators, but used chemicals to improve crop production and eliminate pests, an action that could negatively affect pollinators. Thus, it is necessary to improve information flow and education in these rural communities in order to conserve flora and fauna biodiversity and create more sensitivity regarding the role of conservation. According to the botanical records, this area seems to be very diverse in plant and floral resources thanks to the men and women who live and work there. Our study used ethnobotanical tools to provide a novel insight to the cultural value of spontaneous herbs. Although there is little literature on this topic, Arango Gómez (2019) is an important reference for Colombia and also indicates that very little attention has been given to the possible services of spontaneous herbs. Our study gives hope for changing the campesino community image of spontaneous herbs, an underestimated class of plants. But they have demonstrated great cultural potential with various uses in the daily life of the participants: medicinal uses, benefits to the soil and crops, and the very important conservation of bees and other beneficial insects.

5 Conclusion

This study documented high floral diversity in a coffee growing region that has been strongly modified by human beings. Homegardens supported an average of 48 species, including cultivated plants for commerce and self-consumption, ornamental plants, and native plants, such as spontaneous herbs, that represent a great potential for the conservation for pollinators. Garden installation, composition, and diversity varied depending on social demographic factors. Both social groups demonstrated a high degree of knowledge of plants and their uses, although knowledge of plants varied by occupation and according to social group and gender. Keeping a garden is still a symbol of luxury, especially for the indigenous community who cultivated medicinal and food plants, but few ornamental plants, and who were also busy with domestic and agricultural labors. Both indigenous and campesino farms, in general, were mostly family farms that shared the home with several generations and cultivated for self-consumption. An important number of campesino women belonged to the elderly group and were mainly housewives with more available time. They may have also had more economic resources to dedicate to their gardens. The campesino man tended to his crop alone or with the aid of workers. In reference to pollinators, men knew very little about insects, despite that campesino men knew more than other groups. The majority accepted the importance of pollinators once it was explained to them, but a large educational gap as well as the small amount of information flow from science to the rural population was observed.

Little recognition of the term "spontaneous herbs" confirmed this observation. The term was considered very technical and the native plants in this landscape were usually referred to as weeds or wild plants. Several potential uses were recorded for spontaneous herbs and the species with the highest cultural values were all spontaneous herbs. Thus, spontaneous herbs have been underestimated as to their presence, uses, and benefits to human beings, crops, and conservation of fauna and pollinators. Taking all this into account, it is clear that all participants contributed to conservation of plant diversity, but that women had a special role because of their diligence and dedication, using their imagination to create a space to beautify the home. Campesino and indigenous women pass their knowledge on to families, neighbors, and friends. There was not only a spoken exchange but an exchange of seeds or plants as well. Women brought flowers, beauty, and life to the home from a motivation that produces no income, but from a natural appreciation of doing. "Where there is a woman, there are flowers" was often heard during the interviews and is also reflected in the records. In conclusion, this study connected ethnobotany and the social aspect for a better understanding of the biological uses and benefits of spontaneous herbs and pollinators in order to increase awareness and make better decisions in favor of biological conservation.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Author contributions

AK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. SP: Supervision, Validation, Writing – original draft, Writing – review & editing. LR-P: Supervision, Validation, Writing – original draft, Writing – review & editing. IA: Conceptualization, Funding acquisition, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was funded by the WWB Research Fund Colombia, Announcement V 2020.

Acknowledgments

We would like to thank the *Universidad del Valle* for logistic support and extend our sincere thanks to Ashly Lisset Arevalo Rodríguez, Juan Carlos Tafur, María Alejandra Bautista Giraldo, Gerardo Peñaranda, Manuel Antonio Velasco, and Miriam Velasco for their field work and identification of plants. We wish to thank the campesino and indigenous communities in the rural areas of El Rosal, El Pital and la Isla in the municipality of Caldono for their support and participation in this study. Special thanks to Wilmar Alexander Torres López for his guidance and his advise in the statistical analysis.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1295292/full#supplementary-material

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