Plant Species and Their Uses In Homegardens of Migrant Maya and Mestizo Smallholder Farmers In Calakmul, Campeche, Mexico

Authors: Neulinger, Korinna, Vogl, Christian R., and Alayón-Gamboa, José A.

Source: Journal of Ethnobiology, 33(1) : 105-124

Published By: Society of Ethnobiology

URL: https://doi.org/10.2993/0278-0771-33.1.105

Journal of Ethnobiology 33(1): 105–124 Spring/Summer 2013

PLANT SPECIES AND THEIR USES IN HOMEGARDENS OF MIGRANT MAYA AND *MESTIZO* SMALLHOLDER FARMERS IN CALAKMUL, CAMPECHE, MEXICO

Korinna Neulinger, Christian R. Vogl and José A. Alayón-Gamboa

This paper examines the relationship between botanical composition of homegardens and the cultural background of their owners, as well as the multiple functions of tropical homegardens and the high diversity of plant species found there. In 2008, an ethnobotanical research study was conducted in 20 Maya and Mestizo *homegardens in Calakmul, Campeche, Mexico, a zone of outstanding biocultural diversity. Interviews, inventories and a ranking system were used to identify the botanical composition, structure and infrastructure of the homegardens as well as the knowledge and behavior of Maya and* Mestizo *farmers related to the management and product processing of the homegardens. A total of 310 plant species from 94 families were identified, with a varied number of species within the sampled homegardens (32–141 plant species) and the villages (111–203 plant species). The most frequent use of plants was ornamental (41%), followed by food (35%) and medicinal use (30%). The floristic composition of the homegardens is strongly related to the socioeconomic conditions and cultural background of the farmer, and ornamental plants show the greatest difference between cultures. But neither gender nor culture has an impact on the farmers' evaluation of the different functions of homegardens.*

Key words: *tropical agroforestry systems, ethnobotany, biodiversity, sustainable livelihood, Calakmul*

En este trabajo se analiza la relación entre la composición botánica de los huertos familiares con el origen cultural de los campesinos, las funciones múltiples que tienen para las familias campesinas y la alta diversidad florística encontrada. La investigación etnobotánica se realizo en el año 2008 en 20 huertos de familias Mayas y Mestizas del municipio de Calakmul, Campeche; una zona de alta diversidad biocultural. Se realizaron entrevistas, inventarios y un sistema de evaluación por rangos para identificar la composición botánica, la estructura e infraestructura de los huertos familiares; y el conocimiento de los campesinos relacionados al manejo y proceso de los recursos vegetales del huerto familiar. Se identificaron 310 especies vegetales pertenecientes a 94 familias botánicas; y la riqueza de las especies de plantas varió entre huertos familiares (32–141 especies) y comunidades (111–203 especies). El mayor uso de las plantas fue para ornato (41%), alimentación (35%) y medicina (30%). La composición florística de los huertos familiares se relacionó estrechamente con las condiciones socioeconómicas y el origen cultural de los campesinos, encontrándose diferencias en el uso de plantas ornamentales. Pero no existieron diferencias por sexo o grupo cultural en la evaluación de las diferentes funciones que cubren las plantas del huerto familiar.

Introduction

Rural livelihoods are based on a diversified production strategy (Ellis 1998). In rural Mexico small-scale farmers have adopted different means of diversifi-

Korinna Neulinger, Department for Sustainable Agricultural Systems. University of Natural Resources and Life Sciences Vienna (BOKU Wien), Gregor Mendel Strasse 33, 1180 Vienna, Austria (korinna.neulinger@gmail.com)

Christian R. Vogl, Department for Sustainable Agricultural Systems. University of Natural Resources and Life Sciences Vienna (BOKU Wien), Gregor Mendel Strasse 33, 1180 Vienna, Austria (christian.vogl@boku.ac.at)

José A. Alayón-Gamboa, Departamento: Conservación de la Biodiversidad; El Colegio de la Frontera Sur (ECOSUR), Unidad Campeche, Avenida Rancho Polígono 2-A, Ciudad Industrial Lerma. CP. 24500, Campeche, México (jalayon@ecosur.mx)

cation such as rural self-employment, salaried jobs, manufacturing of handmade crafts, and national or international migration, which combine with other subsistence activities including agriculture, forestry, hunting and homegardens (González-Jácome 2003). Family homegardens in the tropics are socio-ecological production systems that involve a diversified management of plants and animals for farmer subsistence (Kumar and Nair 2004). The management of homegardens contributes to the maintenance of a high biodiversity and acts as a local diversity reservoir (Aguilar-Støen et al. 2009; Castiñeiras et al. 2001; Jarvis et al. 2007). Homegardens supply farmers with essential goods such as food, medicinal herbs and timber, as well as occasional income from selling homegarden products. The homegardens' contribution to the farmers' livelihoods is critical for marginalized communities (Fernandes and Nair 1986; Montagnini 2006). The benefits of tropical homegardens are influenced by biophysical and social factors where the traditional ecological knowledge of different ethnic groups plays a key role in the botanic composition, plant diversity and structure of the homegardens (Caballero 1992; Netting 1993; Vogl et al. 2002). Among these groups, the Maya in the lowlands of the Yucatan Peninsula maintain a high diversity of plant species in their homegardens within a complex vertical and horizontal structure that mimics the natural ecosystem and often contains 300 to 500 species of plants and animals (De Clerck and Negreros-Castillo 2000; Rico-Gray et al. 1990; Toledo et al. 2008). Based on the ecological knowledge of the local environment and the specific needs of plants and animals, farmers combine practices for soil management, nutrient conservation, and water and crop protection (Barrera-Bassols and Toledo 2005; Netting 1993). However, over the last decades due to global socioeconomic changes and migration, the composition and diversity of plants found in Mayan homegardens has changed, resulting in a decrease in species cultivated for food and medicinal purposes and an increase in ornamentals (Hernández 2010). Diversity is lost as migrating families lose interest in maintaining a variety of plant species. Also, families permanently adjust their mode of life in response to social, economic, and ecological changes, which may lead to the decline of the family homegarden (Corzo-Márquez and Schwartz 2008).

Global socioeconomic changes as well as structural reforms in land tenure made by the Mexican government at the end of the 1970s and early 1980s forced the migration of indigenous and non-indigenous (*Mestizo*) farmers to what were then almost uninhabited forests in southeastern Mexico (Kelly 2001; Redclift 1983). *Mestizo* refers to a person of mixed racial ancestry, especially mixed European and Native American ancestry (Larousse 2004). In the present study the term *Mestizo* is used for migrant farmers from the Mexican states of Veracruz and Tabasco. The migratory movements to the southern Yucatan Peninsula led to a concentration of diverse ethnic groups encompassing a wide bio-cultural diversity in the region. In the last decade, immigrants represented 20% to 40% of the total population, with 16% being of Maya, Chol, Kanjobal, Tzeltal, Nahuatl, and Tzotzil background. The *Mestizo* population, representing 26% of immigrants, came mainly from the Mexican states of Tabasco, Chiapas, Veracruz, and Michoacán (López-Villar 2005). With the immigration and settlement in the forest, families adapted to the unfamiliar environment by implementing various

subsistence strategies that relied on the intensive use of natural resources, notably through homegardens (Guerrero-Peñuelas 2007; López-Villar 2005; Wilk 1997). Immigrants tested different strategies, growing native plant species or those brought from their homeland, to guarantee their food supply and economic income. As a result, the homegardens of immigrants were more diverse and productive than those of local people (Guerrero-Peñuelas 2007; Shrivastava and Heinen 2005). Still, in some cases (e.g., Tzotzil Maya in Chiapas, Mexico, and migrant families in Petén, Guatemala), immigration caused the loss of species, abandonment of traditional practices and less use of homegardens (Atran et al. 2002; Corzo-Márquez and Schwartz 2008; Lipton 1980). Similarly, Guerrero-Peñuelas (2007) found that migration in the state of Mexico led to a general decrease of homegarden plant diversity, in particular of food plants. Our research explores and compares the homegardens of Maya and *Mestizo* migrants to the region of Calakmul, Campeche. We propose that because of their different cultural and geographic backgrounds and ethnobotanical knowledge, Maya and *Mestizo* smallholders would show differences in the composition and plant diversity in family homegardens.

Study Area

The research was conducted in the state of Campeche, Mexico, located in the southern Mexican frontier zone (Figure 1). The sparsely populated state (14 inhabitants/km^2) has 174,853 inhabitants; 23.1% of the total population belongs to indigenous groups (Navarrete-Linares 2008). The Calakmul municipality encompasses 13,839 km^2 and has a population of 26,882 (INEGI 2011). The Calakmul Biosphere Reserve (CBR) covers the majority of this municipality (7231.85 km^2) and is divided in two nuclear zones and one buffer zone (CONANP 2008).

The average annual temperature of the humid subtropical climate is 24.6° C and the annual average precipitation in the municipality of Calakmul ranges significantly from 552 mm in the north to 1,634 mm in the south (INEGI 2011; Martínez and Galindo-Leal 2002). The rainy season lasts from June to November followed by the dry season from December to May. Trade winds and hurricanes occur mainly at the end of the rainy season. The karstic parent material of the Yucatan Peninsula allows only few permanent sources of surface water. A high level of evapotranspiration, in addition to ground water levels that reach depths of 150 m to 200 m are factors that influence acute seasonal water scarcity and hence make water a limiting factor for the region (Morales-Rosas 1999). The undulating landscape is part of a central plateau (Meseta de Zoh-Laguna) and reaches elevations of up to 350 m above sea level in the south (Gates et al. 1999; Martínez et al. 2001; Morales-Rosas 1999).

The CBR, together with the neighboring protected zones in Chiapas, the Petén of Guatemala and Belize, make up the second largest adherent tropical forest in the Americas (CONANP 2008). The seasonal tropical forest of Calakmul forms an ecocline between the dry northern Peninsula and the humid Petén of Guatemala in the south, constituting the Mesoamerican Biological Corridor. This forest shows spatial heterogeneity in the vegetation, with no species or vegetation

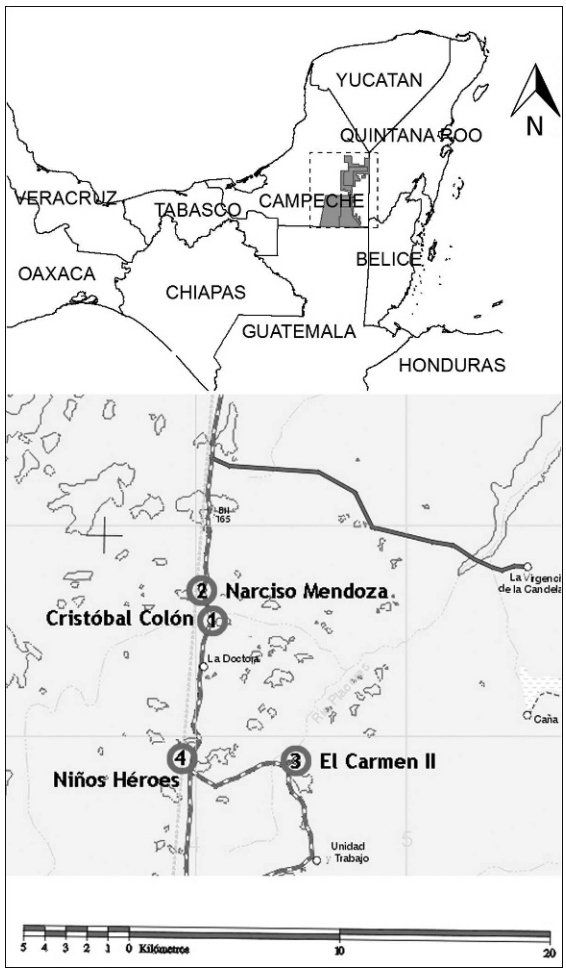

Figure 1. Location of the study villages in the Calakmul Biosphere Reserve (CBR), State of Campeche, Mexico.

type being dominant (Martínez and Galindo-Leal 2002; Turner II 2010; Vester et al. 2007).

In the zone of Calakmul, impressive architectural relics from the Mayan culture remain, dating back to the Late Pre-Classic (200 B.C.) and the Late Classic (A.D. 800) periods when the region was probably densely populated (Gates et al. 1999). Ancient Maya agricultural systems modified the natural landscape of the tropical forest (Zarate Hoyos 1998). The decline of the Mayan culture was followed by centuries of human abandonment of this region, until the end of the 1970s, when a second wave of settlement started in the Calakmul region (García-Gil and Pat-Fernández 2000). People migrated to this region due to scarcity of land, poverty and unemployment as well as social, cultural, political or economic factors that led to conflicts in other regions in Mexico (López-Villar 2005). The settlers emigrated from 23 different Mexican states bringing various languages,

Table 1. Geographic and demographic data for the villages studied in Calakmul, Campeche.

Village	Altitude (m.a.s.l.)	Longitude	Latitude	Population	Culture	Origin
Cristóbal Colón	250	892713	181318	371	*Mestizo*	Veracruz
Narciso Mendoza	240	892713	181350	368	*Mestizo*	Tabasco
Niños Héroes	280	892713	180908	217	Maya Ch'ol	Chiapas
El Carmen II	210	892453	180928	314	Maya Ch'ol	Chiapas

Source: INEGI (2011)

cultural identities and geographic backgrounds to the Calakmul region (Alayón-Gamboa and Gurri 2007). Because of its biological and cultural diversity, this region is considered to be a hot spot of bio-cultural diversity (Stepp et al. 2008). Indigenous languages here include Yucatec Maya (80.9%), Maya Ch'ol (9.4%), Kanjobal (2.0%) and Tzeltal (1.8%), among others (CNDI-PNUD 2000; López-Villar 2005). The last 40 years were also characterized by significant human disturbances to the local ecosystem such as increased settlement, the expansion of livestock farming and the intensification of agriculture, all leading to high rates of deforestation and thus posing a threat to biodiversity (Turner II 2010; Vester et al. 2007).

This study was conducted in four communities that exemplify the region's different cultural backgrounds. Cristóbal Colón (CC) and Narciso Mendoza (NM) are villages with *Mestizo* inhabitants from Acayucan, Xalapa, Puerto de Veracruz and San Andrés Tuxtla, Veracruz (CC), and Comalcalco, Tabasco (NM) (Table 1). Coming from a humid tropical region, these *Mestizos* have a broad knowledge of the biological diversity commonly found in tropical ecosystems. El Carmen II (EC) and Niños Héroes (NH) are Mayan villages whose inhabitants came from Salto de Agua and Tila (EC) and Salto de Agua and Tumbalá (NH) in the state of Chiapas where the climate is temperate and the biological resources different than those found in humid subtropical Calakmul. Maya Ch'ol is the native language used amongst these villagers, and Spanish is primarily used by men in communication with *Mestizos*. For cultural reasons, women communicate little with people from outside and rarely leave their communities. Therefore, their Spanish skills and mobility are more limited than men's.

All four villages are located along a principal road 60 km south of the district capital Xpujil and lie within the buffer zone of the CBR (Figure 1). The settlements are organized as *ejidos*, which are communally managed land units granted by the Mexican government to farmers. This land is allocated for usufruct activities and is distributed individually to families who hold the rights to use these plots to sustain their families' livelihoods (Hinojosa 1983). All families own approximately 40 ha of farmland outside the village, where they practice slash and burn agriculture. The main crops cultivated are maize (*Zea mays* L.), beans (*Phaseolus lunatus* L., *Phaseolus vulgaris* L.), pumpkins (*Cucurbita mixta* Pangalo, *Cucurbita moschata* Duchesne, *Cucurbita pepo* L.) and sweet potatoes (*Ipomoea batatas* (L.) Lam.). The cultivation of *jalapeño* pepper (*Capsicum annum* L.) for commercial sale is also common.

Methodology

The fieldwork was conducted in 2008 from the end of May to the beginning of September. Altogether 20 homegardens, 5 in each village, were selected using

the snowball sampling method (Bernard 2006) and each homegarden was visited at least twice. The area of the homegarden was defined as the parcel of land in the village where farmers established their homestead. All the plants and constructional infrastructure inside the limited plot were considered part of the homegarden area. Structured, semi-structured and unstructured interviews were conducted mainly with women, who claimed to be responsible for the management of the homegardens. Interviews collected information on the socioeconomic background of the families, the characteristics and uses of the homegardens, and the preparation of products from the homegardens. Ethnobotanical information was gathered through structured interviews as well as participant and non-participant observation in the homegardens. Only plants with a specific purpose for the farmers were documented and categorized, and their ethnobotanical uses were determined while walking through each homegarden with the interview partner. On site, each plant species was pointed out and its use was requested with the same set of pre-tested questions (Martin 1995; Vogl et al. 2004). In addition, a ranking method, using a set of cards with images of possible functions of the homegardens was employed, where female and male heads of the household evaluated the importance of different functions of the homegardens. Inventories were conducted to record the size, botanical composition and infrastructure of the homegardens. Four voucher specimens of each plant species that could not be identified on site were collected. These samples were identified in collaboration with botanists from the Autonomous University of Campeche (AUC). Modified from Vogl-Lukasser (1998) and based on local characteristics, the authors defined four layers according to the vertical height of plants and into five different horizontal areas (areas close to the house, for ornamental plants, herbs and vegetables, fruit trees and secondary vegetation, Figure 2). Chi-square-tests, analysis of variance, lineal regression, cluster analysis and ranking correlations were carried out using Statistic Package for Social Sciences (Ver. 13.0, SPSS Inc.; Dytham 2001).

As the research area lies within the buffer zone of the CBR, a permit for plant collection was obtained from the Ministry of Environment and Natural Resources (SEMARNAT) of the Mexican government. Also, prior consent was obtained from the heads of households –male or female– for their participation in interviews and the use of the ranking method, and for the collection of botanical samples.

Results

Layout and Infrastructure

After settling on a plot of land in the village, most families immediately started to establish their homegarden on that plot. All homegardens were rectangular or square and were arranged along lineal grids in the villages. The most common size of sampled homegarden was 2,500 m^2 (75%, n=20), although *Mestizo* homegardens were larger than Maya homegardens. The homegardens were fenced, but farmers also used plants to delineate the boundaries; of the 30 species we recorded for this use, the most common were ornamentals (e.g., *Ixora coccinea* L., *Hibiscus rosa-sinensis* L., *Cassia fistula* L., *Codiaeum variegatum* Blume,

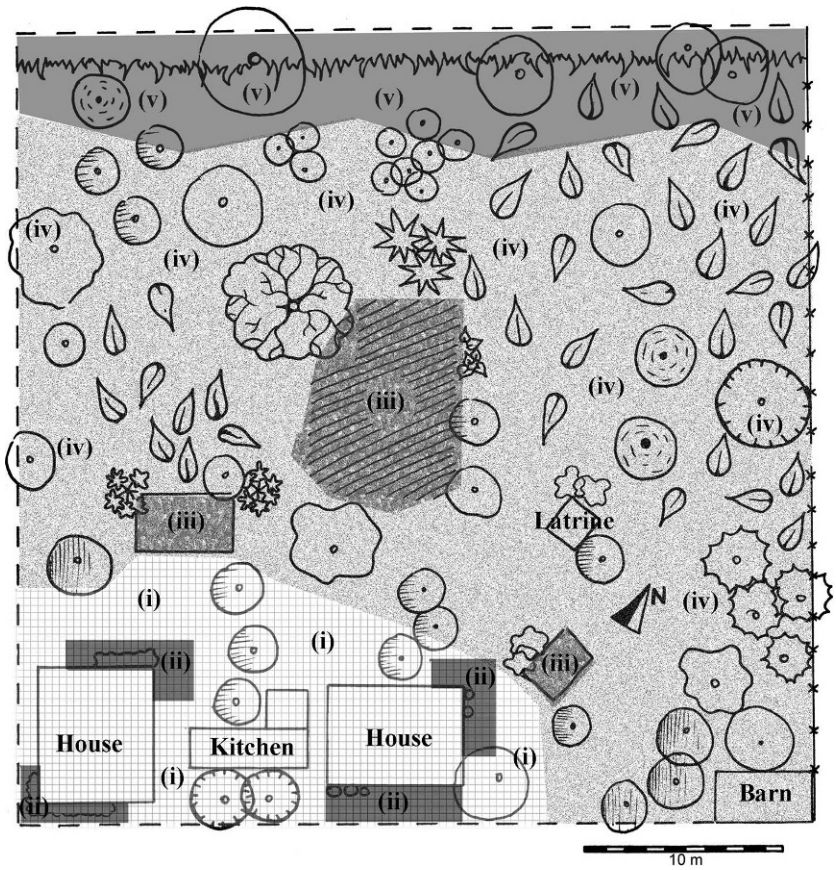

Figure 2. Schematic drawing of horizontal zonal plant distribution in the homegarden: (i) living areas close to the house; (ii) areas for ornamental plants; (iii) areas for herbs and vegetables; (iv) areas for fruit trees; (v) secondary vegetation (Modified from Neulinger 2013).

Spathodea campanulata P. Beauv., *Sansevieria trifasciata* Prain.), although plants for food and medicine were also grown along the borders (e.g., *Sambucus mexicana* Presl., *Yucca elephantipes* Regel, *Graptophyllum pictum* (L.) Griff, *Tithonia diversifolia* (Hemsley) A. Gray). Spiny plants were used as living fences due to their impenetrable qualities (e.g., *Bromelia penguin* L., *Opuntia* sp., *Euphorbia trigona* Haw., *Acanthocereus subinermis* Britton & Rose).

In each homegarden, two or more houses were commonly arranged facing the street. Most families used a combination of traditional and modern building materials. The one-storied houses had a rectangular ground plan and were made of wooden boards of hardwoods such as mahogany (*Swietenia macrophylla* King), ciricote (*Cordia dodecandra* DC.) or cedar (*Cedrela odorata* L.). More recently, houses were made of concrete because of governmental promotion programs. The steep roofs were traditionally made out of palm leaves (*Sabal mexicana* Mart., *Sabal mauritiiformis* (H. Karst.) Griseb. & H. Wendl.), but corrugated metal sheets were also commonly used. For smaller structures, such as chicken coops, farmers used palm leaves (*Orbignya cohune* (Mart.) Dahlgren ex Standl.). Few houses had

divided rooms, and floors were made of compacted soil, boards or concrete. Latrines were constructed within a certain distance of the house and moved to another spot on the plot every 2 to 3 years. Other structures found in the homegardens were sheds for recreational purposes, cars or tools, barns for storing the food harvest or firewood, and stables for chickens and pigs. Potted plants were often arranged in the living area close to the house, and raised wooden frames with soil were constructed to protect certain plants from animals. In these pots farmers raised fruit trees like *Persea Americana* Mill., but mainly grew spices like *Allium schoenoprasum* L. or ornamentals such as *Portulaca umbraticola* Kunth. For the cultivation of chayote (*Sechium edule* (Jacq.) Sw.), farmers constructed a frame of sticks as a climbing aid.

Domestic Animals and Activities in Homegardens

Domestic animals were very common in the homegardens and supplied the family with meat and other products like eggs. Occasionally, animals and their products were sold to generate additional income. Fowl, such as chickens (*Gallus gallus*), turkeys (*Meleagris gallopavo*), ducks (*Cairina moschata*) and geese (*Anser anser*) were kept for meat and eggs, and goats (*Capra hircus*), pigs (*Sus scrofa*) and sheep (*Ovis ovis*) were kept for their meat. Horses (*Equus ferus caballus*) were used for labor and transportation, and wild parrots (*Amazona xantholora*), pigeons (*Columba livia*) and turtles (*Kinosternon leucostomum*) were kept as pets for the children. No obvious difference between Maya and *Mestizo* homegardens with respect to the presence of domestic animals could be detected.

Women and children managed the homegardens, and their responsibilities commonly included weeding, irrigating, harvesting, sowing, clearing branches and caring for domestic animals. Domestic animals were slaughtered and some traditional foods were cooked on open fires in the homegardens (e.g., tamales), especially during holidays and religious festivities. Men completed the physically demanding tasks, such as tree cutting and the construction of buildings and other structures. As the houses were placed inside the plot, the homegarden was an optimal playground for children, and sheds with benches and hammocks served as recreational spaces and were used to receive visitors. Sixty-five percent of the interviewees who managed homegardens learned their gardening skills as children.

Botanical Composition in Maya and *Mestizo* Homegardens

A total of 310 plant species that possessed one or more uses for farmers were recorded in the 20 homegardens, 275 in the *Mestizo* communities and 185 in the Maya communities, representing a significant difference ($P\alpha_{0.0.5} = 0.02$). Of these, 125 plant species appeared exclusively in *Mestizo* homegardens, with 28 of these found in both *Mestizo* communities. In comparison, 35 species were recorded exclusively in Maya homegardens, with 5 of these found in both Maya communities. The highest species diversity was found in the *Mestizo* community of Narciso Mendoza (203 species), and the lowest in the Maya community Niños Héroes (111 species). The variety of species in a single homegarden varied from 32 to 141 species; in Maya homegardens an average of 57.6 species was found whereas in *Mestizo* homegardens an average of 82.7 species was observed.

Of the 310 plant species found in homegardens, 257 were cultivated and managed consciously by the farmers. The rest were spontaneously growing wild species that were protected or tolerated. The most abundant phenotypes were annual herbs and herbaceous perennials (119 species), followed by trees (93 species) and shrubs (57 species). The rest were succulents, palms, bananas and vines. When comparing the 20 most abundant plant species across *Mestizo* and Maya villages, it is notable that in the homegardens of *Mestizo* villages (Table 2) 6 ornamental plants (*Aloe vera* L., *Zephyranthes carinata* Herb., *Rosa* sp., *Hibiscus rosa-sinensis*, *Crinum amabile* Donn, and *Acanthocereus subinermis*) were found, whereas in Maya homegardens (Table 3) 2 ornamental plant species (*Catharanthus roseus* (L.) G. Don and *Yucca elephantipes*) were present.

Hierarchical cluster analysis shows a clear differentiation between *Mestizo* and Maya homegardens (Figure 3). Their plant compositions form two groups identical to their cultural affiliation, with the exception of garden 2, a *Mestizo* homegarden more similar to Maya ones. Figure 3 also shows a greater similarity in species composition among Maya homegardens than *Mestizo* homegardens. However, the functional horizontal zonal division was similar between Maya and *Mestizo* homegardens. In addition, the age of the sampled homegardens ranged between 1 and 35 years (23.3 years on average), but age was not related to the number of different plant species found ($r^2_{\text{Pearson}} = 0.038$).

Uses of Plant Species

Although the number of plant species per homegarden differed between the cultural groups, the functional distribution of plants within Maya and *Mestizo* homegardens was similar (Figure 4, χ^2 $P_{\alpha 0.05} = 0.55$). Also, farmers' personal evaluation of the functions of their homegardens did not show any significant variation between cultures or between women and men. Thus the farmers' personal evaluation of the functions of the homegardens is congruent with the observed functional distribution of plant species.

Most of the 310 plant species cultivated in homegardens were used for family needs, and only 5.2% were occasionally sold in the village or at local events. Ornamental plants were most abundant (123 species), followed by plants grown for food (114 species), and plants grown for medicinal use (94 species) (Table 4). Farmers often used multiple parts of the plants (leaf, fruit, root tuber, root, bark, and trunk), and most plant species had more than one use. For example, medicinal plants such as papaya (*Carica papaya* L.), pitahaya (*Hylocereus undatus* (Haw.) Britton & Rose), and *jobo* (*Spondias mombin*), and ornamental plants such as canna (*Canna indica* L.) and *flor de mayo* (*Plumeria rubra* L.) can also be used for food.

Ornamental plants tended to be placed in similar locations in all homegardens. Farmers often planted patches of ornamentals close to the house and on the side of the homegarden that faced the street, and arranged ornamentals in pots along boundaries. In the *Mestizo* villages, significantly more (χ^2 $P_{\alpha 0.05} = 0.001$) and different species of ornamental plants were recorded than in Maya villages (108 vs. 65 species respectively); 58 ornamental species were found only in *Mestizo* homegardens, whereas 15 species were found exclusively in Maya homegardens (Table 4).

Table 2. Most ubiquitous plant species in *Mestizo* homegardens in Calakmul and their uses.

Scientific name	Spanish name	Ch'ol name	English name	Rate of appearance	Use
Chenopodium ambrosioides	*epazote*	***pazote***	worm-seed, Mexican tea	100%	food (condiment), medicine
Citrus grandis	*naranja dulce/china*	***alaxax***	sweet orange	100%	food, medicine
Aloe vera	*sábila, aloe*	***sabila***	aloe, aloe vera	90%	medicine, ornamental
Cocos nucifera	*coco*	***coco***	coconut	90%	food, medicine
Hylocereus undatus	*pitaya, pitahaya*	***nijin***	night-blooming cereus	90%	food, medicine
Melicoccus bijugatus	*guaya*	***guaya de otiot***	honey-berry, genip	90%	food, medicine, animal fodder, sale
Persea americana	*aguacate*		avocado	90%	food
Rosa sp.	*rosa*	***rosa***	rose	90%	ornamental
Spondias mombin	*ciruela, jobo*	***luluy, poom***	jobo	90%	food, medicine
Tamarindus indica	*tamarindo*	***tamarinto***	tamarind	90%	food
Zephyranthes carinata	*brujita*		rain lily	90%	ornamental
Annona muricata	*guanábana*	***c'Λtsats***	custard apple	80%	food, medicine, utensil, sale
Byrsonima crassifolia	*nance, nanche*	***chi'***	golden spoon, nance	80%	food, medicine, sale
Citrus aurantifolia	*limón, limón indio/injerto*	***pa limon***	key lime	80%	food, medicine
Eryngium foetidum	*perejil*	***perejil, perejin***	long coriander	80%	food (condiment)
Hibiscus rosa-sinensis	*tulipán, hibiscus /canastita/San José*	***tulipan***	Chinese hibiscus	80%	medicine, ornamental
Acanthocereus subinermis	*cruceta*			70%	ornamental, border plant
Carica papaya	*papaya*	***uchunte'***	papaya	70%	food, medicine
Crinum amabile	*lirio jacinto*		giant spider lily	70%	ornamental
Mangifera indica	*mango, mango manila*	***mango, manco***	mango	70%	food, medicine

Table 3. Most ubiquitous plant species in Maya homegardens in Calakmul and their uses.

Scientific name	Spanish name	Ch'ol name	English name	Rate of appearance	Use
Citrus grandis	*naranja dulce/china*	***alaxax***	sweet orange	100%	food, medicine
Cnidoscolus chayamansa	*chaya*	***ec'***	tree spinach	100%	food,medicine
Solanum nigrum	*hierba mora*	***ch'ajuc'***	black nightshade	100%	food
Capsicum annuum	*chile chiltepín/jalapeño*	***ich maxito, colen***	chili	90%	food, ceremonial, sale
Cedrela odorata	*cedro*	***ch'ujte'***	Spanish cedar	90%	timber, border plant
Chenopodium ambrosioides	*epazote*	***epazote, pazote***	worm-seed, Mexican tea	90%	food (condiment), medicine
Hamelia patens	*coralillo, arbusto*	***x'obte'***	firebush, scarlet-bush	90%	medicine
Piper auritum	*momo, acuyo, hierba santa*	***momoy***	Mexican pepperleaf	90%	food
Psidium guajava	*guayaba*	***pʌta***	guava	90%	food, medicine
Allium schoenoprasum	*cebollín*	***werux***	chives	80%	food (condiment)
Annona muricata	*guanábana*	***c'ʌtsats***	custard apple	80%	food, medicine, utensil, sale
Chrysophyllum cainito	*caimito*	***taq'uin ch'ijt, chixt***	star apple, golden leaf tree	80%	food
Citrus reticulata	*mandarina*	***mandarina***	mandarine, tangerine	80%	food, medicine
Manihot esculenta	*yuca*	***ts'ijn***	cassava, manioc	80%	food
Melicoccus bijugatus	*guaya*	***guaya de otiot***	honey-berry, genip	80%	food, medicine, animal fodder, sale
Phaseolus vulgaris	*frijol negro/mulato*	***pech buul***	common bean	80%	food
Saccharum officinarum	*caña*	***si'k'eb***	sugarcane	80%	food, medicine
Spondias mombin	*ciruela, jobo*	***luluy, poom***	jobo	80%	food, medicine
Catharanthus roseus	*balsamina, juanita*	**-**	periwinkle	70%	ornamental
Yucca elephantipes	*flor de izote*	***xc'oc'chij***	yucca	70%	food, ornamental, border plant

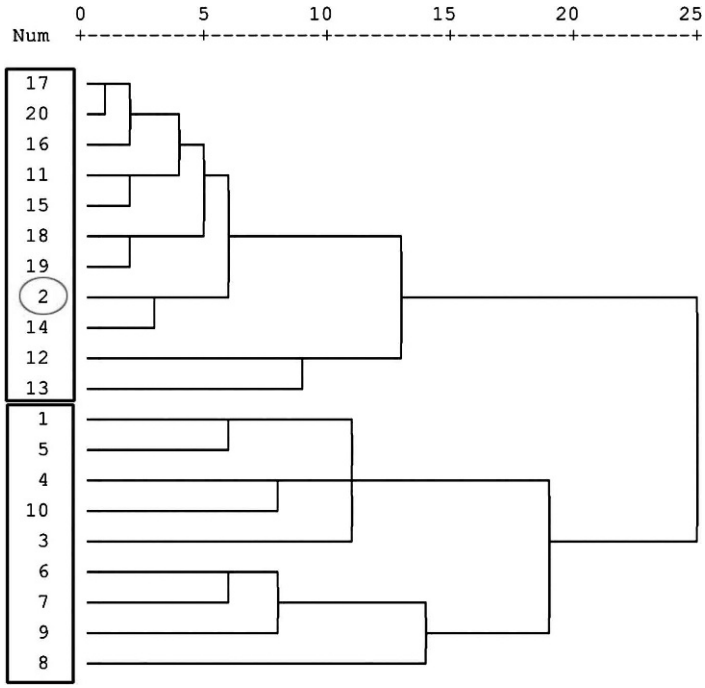

Figure 3. Hierarchical cluster analysis (Ward method) of the floristic composition in the homegardens. The numbers indicate the identity of the homegarden (*Mestizo* 1–10; Maya 11–20).

Maya and *Mestizo* families used 114 plant species for sustenance, and 34 food plants appeared exclusively in *Mestizo* homegardens whereas 8 species were recorded exclusively in Maya homegardens (Table 4). The traditional cuisine of Maya and *Mestizo* farmers of Calakmul consists of a variety of dishes, often using products from the homegardens like cassava (*Manihot esculenta* Crantz), *ñame* (*Manihot aesculifolia* (Kunth) Pohl), sweet potato (*Ipomoea batatas*), *makal* (*Xanthosoma yucatanense* Engl.), and two species of cactus (*Opuntia* sp. and *Acanthocereus subinermis*). Also, spontaneously growing wild plant species, such as *verdolaga* (*Portulaca oleraceae* L.), black nightshade (*Solanum nigrum* L.), and cultivated mustard greens (*Brassica juncea* (L.) Czern.) were fried and eaten with corn tortillas. The seeds of ramon (*Brosimum alicastrum* Sw.) were consumed toasted. Other fruit harvested in homegardens (52 species) was eaten raw (e.g., *Mangifera indica* L., *Tamarindus indica* L., *Citrus grandis*, *Carica papaya*, *Ananas comosus* (L.) Merr.) or prepared as a drink with water or milk (e.g., *Citrus grandis*, *Pouteria sapota* (Jacq.) H.E. Moore & Stearn, *Manilkara zapota* (L.) P. Royen, *Morinda citrifolia* L.). Thirty-eight species of vegetables were grown. Sixteen plant species were used as spices, the most common being achiote (*Bixa orellana* L.), basil (*Ocimum basilicum* L.), peppermint (*Mentha sativa* L.), epazote (*Chenopodium ambrosioides*), Mexican coriander (*Eryngium foetidum* L.), and Chinese parsley (*Coriandrum sativum* L.). The flower petals of eight species were used for food and to prepare drinks (*Yucca elephantipes, Cucurbita moschata*, *Cucurbita mixta*, *Cucurbita pepo*, *Plumeria rubra*, *Hexopetion mexicanum* (Liebm.) Burret, *Hibiscus sabdariffa* L. and *Sambucus mexicana*).

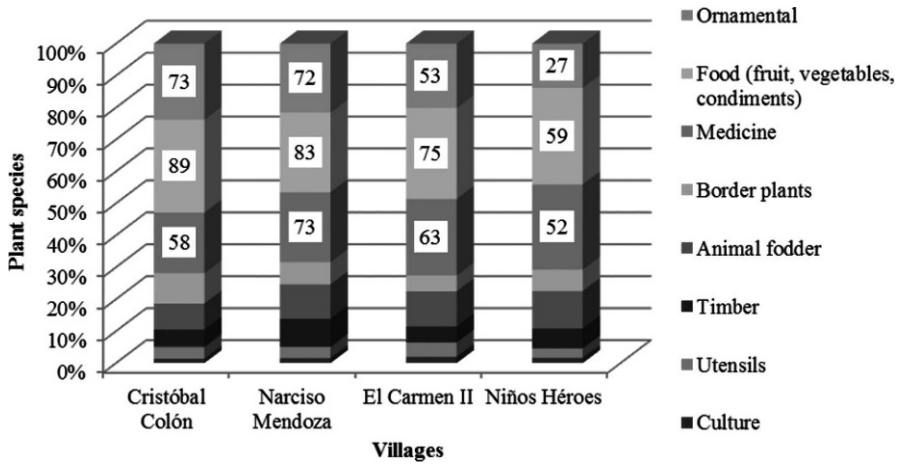

Figure 4. Functional distribution of the richness of plant species in the homegardens of the villages in Calakmul, Campeche.

A total of 94 plant species were used as medicine with *Citrus grandis*, *Chenopodium ambrosioides* and *Spondias mombin* being the most common. Of these, 18 species were found exclusively in *Mestizo* homegardens and 10 species in Maya homegardens (Table 4). Medicinal plants were used to treat 64 physical illnesses and symptoms, as well as spiritual disorders. The most common symptoms and illnesses treated were malaria and dengue fever, gastrointestinal parasites, cough, skin irritations, and insect bites. As malaria and dengue commonly occur in the rainy season, farmers used remedies such as teas and compresses to lower the high body temperatures caused by these illnesses. Also, remedies against spiritual disorders like ''bad air,'' ''bad glance'' or ''fright in the blood'' could be obtained from products of homegardens (e.g., *Nicotiana tabacum* L., *Ocimum basilicum*, *Petiveria alliacea* L.).

To treat symptoms of gastrointestinal parasites, farmers prepared teas, for example from the roots of *Amaranthus spinosus* L., the leaves of *Coccoloba uvifera* (L.) L., *Hibiscus rosa-sinensis*, *Chenopodium ambrosioides*, *Bursera simaruba* (L.) Sarg., and *Tradescantia zebrina* Heynh. ex Bosse and the bark of *Citrus grandis*.

Table 4. Plant species richness by functional category in all sampled homegardens and those found exclusively in *Mestizo* and Maya communities.

Function	Total number of plant species	Exclusively *Mestizo* (n=125 plant species*)	Exclusively Maya (n=35 plant species*)
Ornamental	123	58	15
Edible	114	34	8
Medicinal	94	18	10
Delimitation	39	18	2
Timber	38	19	4
Animal fodder	35	11	0
Utensils	17	4	4
Ceremonial	6	1	0

* Total number of plant species is less than the sum of plants by function due to the overlapping functions of many plants.

For coughs, farmers prepared teas, cold drinks or baths from 12 plants (e.g., *Manilkara zapota*, *Tagetes erecta* L., *Saccharum officinarum* L.). *Morinda citrifolia* leaves and fruits were used for skin burns, diabetes and to improve blood circulation while young *Cecropia peltata* L. leaves were reported to treat diabetes.

Woody plants provided farmers with materials for house construction and tools. In all households, women cooked on an open fire, hence farmers required firewood year round. Timber and firewood were extracted from the surrounding forests, but were also occasionally obtained from the 38 species of trees found in homegardens. For house construction, farmers used hardwoods such as *Metopium browneii* (Jacq.) Urb., *Ehrethia tinifolia* L., *Cordia dodecandra*, *Cedrela odorata*, *Swietenia macrophylla*, *Brosimum alicastrum* and *Guaiacum sanctum* L. Seventeen plant species were used for practical purposes like roofing (*Orbigyna cohune*, *Sabal mauritiiformis*, *Sabal mexicana*) or for the construction of ladders (*Cecropia peltata*, *Bursera simaruba*). The dry leaf of *Cordia dodecandra* has a very coarse surface and was used to polish wood. The hard wood of *Muntingia calabura* L. and *Cordia dodecandra* was used to make axe handles and wooden frames that were harnessed to horses for transporting crops. Leaves of *Heliconia* sp. and *Musa paradisiaca* L. were used in cooking (e.g., tamales) and to wrap goods. Farmers used the dried fruit of *Luffa cylindrica* M. Roem. as a sponge to clean plates or for body care and *Sapindus saponaria* L. seeds as a detergent for the laundry. For handcrafted adornments like necklaces or bracelets, farmers used the seeds of *Erythrina americana* Mill. and *Chamaedorea seifrizii* Burret.

Discussion

The recent migration of groups from diverse cultural and geographic origins characterizes the sociocultural background of the inhabitants of Calakmul. The highly diverse natural environment of this zone combined with its multicultural inhabitants justifies the designation of the region as an area of high biocultural diversity (Stepp et al. 2008). This outstanding biocultural diversity becomes evident through the cultivation and diversified use of the vegetation of homegardens by the different ethnic groups observed in the present work. The high species richness of cultivated and tolerated plants in the homegardens of both cultural groups underlies an ideal structural and spatial arrangement, which allows for the use of the full capacity of both horizontal and vertical zones (Ruonavaara 1996). A complex vertical and horizontal structure allows an optimal exploitation of light and space, augments productivity, and is akin to the structure of the natural forest (De Clerck and Negreros-Castillo 2000; Kumar and Nair 2006; Montagnini 2006). The presence of differentiated zones of plants in the studied homegardens (e.g., zones for ornamental plants, herbs, vegetables, and secondary vegetation), combined with structures (e.g., buildings, pens for chickens or pigs), demonstrate the complex and diversified arrangement in homegardens that has also been reported for Maya and *Mestizo* homegardens in Mexico and Guatemala (Jimenez-Osornio et al. 1999; Ruonavaara 1996; Vogl-Lukasser 1998). Those complex systems involve people, animals, and plants with multiple ecological interactions promoting high diversity (Atran et al. 2002).

The high species richness of plants reported in this study confirms previous findings for homegardens in Veracruz (Lazos-Chavero and Alvarez-Buylla 1988), Yucatán (De Clerck and Negreros-Castillo 2000; Jimenez-Osornio et al. 1999; Osorio-Hernández 1997; Rico-Gray et al. 1990), Campeche (Chi-Quej 2009) and Chiapas (Gasco 2008; Vogl-Lukasser 1998). Most of these studies recorded food and medicinal plants as the most common; however in our study ornamental plants predominated. Chi-Quej's (2009) research on Campeche homegardens and Ruonavaara's (1996) study on household gardens in El Petén, Guatemala found similar results. The large number of plant species found in the homegardens has been associated with family knowledge of the local natural resources (Rico-Gray et al. 1990; Toledo et al. 2008), family preferences, and the age of homegardens (Coomes and Ban 2004). However, in the present study, the age of the homegardens was not related to species richness, which contrasts with other studies in Calakmul (Perea-Mercado 2011). The species richness and composition of the homegardens are influenced by the cultural background of the farmers (Kumar and Nair 2004; Lazos-Chavero and Alvarez-Buylla 1988; Rico-Gray et al 1990). In the present study, a significant difference in plant species richness was detected between Maya and *Mestizo* homegardens. Also, cluster analysis verified the relationship between the floristic composition of the homegardens and the cultural identity. Plant species composition within the Maya homegardens was less diverse, while *Mestizo* homegardens showed greater variation of plant species, suggesting an extensive utilization of the floristic resources of the *Mestizo* homegardens (Ruonavaara 1996).

In addition to differences in floristic diversity, plant species varied between Maya and *Mestizo* homegardens with some found only among one group or the other. Ornamental plants in particular contributed to higher plant species richness in *Mestizo* homegardens, providing aesthetic value and prestige to families (Heckler 2004). Ornamental plants are selected for different reasons, including attractiveness, (e.g., *Allium aflatunense* B. Fedtsch, *Hibiscus rosa-sinensis*), pleasant aromas (e.g., *Murraya paniculata* (L.) Jacq., *Cestrum nocturnum* L.) or leaves with different colors and shapes (e.g., *Begonia rex* Putz, *Sansevieria trifasciata*). Many ornamental plants were obtained from the surrounding forests (e.g., *Chamaedorea seifrizii*, *Aristolochia maxima* Jacq., *Monstera deliciosa* Liebm.); other non-natives were bought (e.g., *Lagerstroemia indica* L., *Rosa* sp., *Datura stramonium* L.). We observed in *Mestizo* homegardens that new ornamental plants are constantly incorporated into homegardens and that families also like to integrate non-ornamental plants with other purposes like food (e.g., *Coffea Arabica* L.) or medicine (*Zingiber officinale* Roscoe).

The lower species richness that appeared in Maya homegardens of Niños Héroes could be influenced, in part, by the economic condition of these households. In contrast to *Mestizo* communities, all houses in Niños Héroes contained modern construction material, as well as commodities like refrigerators and satellite televisions. These reflect higher income, from money sent by male family members who emigrated to the United States (60% of the households interviewed in Niños Héroes had a family member in the U.S.A.). It is possible that having the additional income reduced the need for different plant species in the homegardens, as families had money to buy more products for their basic

needs (Cuanalo de la Cerda and Mukul 2008). Another reason for fewer species in the Niños Héroes homegardens could be a preference for growing plant species that possess market value which changed the aim of the homegardens from subsistence to commercial farming (see Abdoehllah et al. 2006; Shrivastava and Heinen 2005). In Niños Héroes farmers grow much citrus and maize, both of which are sold occasionally. Hence, the plants grown for multiple functions in the homegardens, such as food, medicine, fodder for animals, wood and utensils are replaced by species that are sold for cash, as Alayón-Gamboa and Gurri-García (2008) also found in homegardens of households that practice commercial agriculture. A similar situation has been observed in homegardens under constant process of adaptation as a consequence of modernization (Caballero 1992; Corzo-Márquez and Schwartz 2008; Vogl-Lukasser 1998).

Differences in Maya and *Mestizo* homegardens also probably reflect that these Maya migrants originated from a distinct environment from Calakmul and gaining local ecological knowledge may have been limited by the principal use of their indigenous language. The dominant use of the Ch'ol language could limit their communication and acquisition of local knowledge on plant management and use, especially among women with restricted mobility and Spanish skills. Similar findings were reported for Maya Q'eqchi immigrants in El Petén, Guatemala, who also migrated from a temperate climate to tropical lowlands (Atran et al. 2002).

The cultural differences in plant species richness and exclusive species in Maya or *Mestizo* homegardens were also reflected in how the families used the plants. In both cultural groups, the most numerous use category was ornamental plants. Of the 123 ornamental plants reported from the 20 homegardens, 46.4% appeared exclusively in *Mestizo* homegardens. Apart from the ornamental uses of plants, *Mestizo* homegardens presented more plant species in all functional categories (e.g., food, delimitation, medicine, timber or for animal fodder) than Maya homegardens (Figure 4). The authors observed a constant incorporation of new species, particularly in *Mestizo* homegardens, obtained locally through trade with neighbors, extracted from the surrounding forests, or brought by the migrant farmers from their native land as also reported by Perea-Mercado (2011). Within the sampled families we observed that *Mestizo* women had greater mobility and a more active social life than Maya women, giving *Mestizo* women more opportunities to acquire a diversity of plant material. The higher plant species richness provided a wider array of resources from the *Mestizo* homegardens; these provisions might make these families less vulnerable to the poverty and seasonal food shortages which characterize rural Calakmul and have negative impacts on living conditions and health (Alayón-Gamboa and Gurri-Garcia 2007). The availability of medicinal plants for remedies of common illnesses (e.g., gastrointestinal parasites, malaria and dengue fever) assists families considering the limited government support programs for healthcare in Calakmul. The supply of medicine and additional food from homegrown plants is more limited within the Maya families, making them more dependent on supplemental income from emigrated family members for their families' livelihoods.

Conclusion

The homegardens managed by the farmers of Calakmul present high species richness and structural diversity, generated by an optimal spatial arrangement and a management of multiple layers, which create a complex agroforestry-system analogous to the natural ecosystem. These plant species and their diverse uses fill a broad range of family needs and are strongly related to the socioeconomic conditions and cultural background of the farmers. *Mestizo* families with low income integrate more useful plant species in their homegardens than Maya families, making them less vulnerable to difficult conditions related to the scarcity of food and healthcare that is characteristic of the highly marginalized and impoverished region of Calakmul. Maya families benefit from higher income and manage the natural resources obtained from their homegardens in a very similar way. Nevertheless, with less species richness, Maya families are more dependent on cash incomes and less self-sustainable in terms of providing resources for their livelihoods.

The higher number of species reported in the *Mestizo* homegardens did not correlate with a preference for a particular functional category of plants (e.g. medicinal plants, food plants, or plants used for timber). However, ornamentals contributed considerably to the significantly higher species richness of *Mestizo* homegardens. This use category has received little attention in previous research and could be an important indicator of the culture-related species diversity of homegardens, especially in the context of women's preferences and cultural behavior. In this context, the aesthetic of the homegarden confers prestige among women and, for those with an active social web, provides more opportunities to acquire a diversity of plant species.

Acknowledgments

The authors wish to thank the farmers of Calakmul whose cooperation, knowledge and interest made this work possible. Special thanks to Adelina López for Ch'ol translation and to the families López-Gutierrez and Pantoja-Culebro for their hospitality. The first author is grateful for the grant she received from the University of Natural Resources and Life Sciences, Vienna. Gratitude goes to the Mexican host institution El Colegio de la Frontera Sur, Unidad Campeche, which provided support with the research project CAMP-2008-C01-94360. Many thanks go to Ricardo Góngora Chin and Rodolfo Noriega Trejo for the identification of the collected plant specimens and to Guillermo E. Castillo-Vela for the comments and revision. Finally, thank you to the anonymous reviewers for improving this manuscript.

References Cited

Abdoehllah, O.S., H.Y. Hadikusumah, K. Takeuchi, S. Okubo, and Parikesit
2006 Commercialization of Homegardens in an Indonesian Village: Vegetation Composition and Functional Changes. In *Tropical Homegardens: A Time-tested Example of Sustainable Agroforestry*, eds. B.M. Kumar and P.K.R. Nair, pp. 233–250. Springer, The Netherlands.

Aguilar-Støen, M., R.M. Stein, and S.L. Camargo-Ricalde
2009 Homegardens Sustain Crop Diversity

and Improve Farm Resilience in Candelaria Loxicha, Oaxaca, Mexico. *Human Ecology* 37: 55–77.

Alayón-Gamboa, J.A. and F.D. Gurri-García
2007 Impact of Seasonal Scarcity on Energy Balance and Body Composition in Peasant Adolescents from Calakmul, Campeche, Mexico. *American Journal of Human Biology* 19:751–762.
2008 Homegarden Production and Energetic Sustainability in Calakmul, Campeche, Mexico. *Human Ecology* 36:395–407.

Atran, S., D. Medin, N. Ross, E. Lynch, V. Vapnarsky, E. Ucan-Ek, J. Coley, C. Timura, and M. Baran
2002 Folkecology, Cultural Epidemiology, and the Spirit of the Commons: A Garden Experiment in the Maya Lowlands, 1991–2001. *Current Anthropology* 43:421–450.

Barrera-Bassols, N. and V.M. Toledo
2005 Ethnoecology of the Yucatec Maya: Symbolism, Knowledge and Management of Natural Resources. *Journal of Latin American Geography* 4:9–40.

Bernard, R.H.
2006 *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. Altamira Press, Walnut Creek.

Caballero, J.
1992 Maya Homegardens: Past, Present and Future. *Ethnoecológica* 1:35–54.

Castiñeiras, L., Z. Fundora Mayor, T. Shagarodsky, V. Moreno, O. Barrios, L. Fernández, and R. Cristóbal
2001 Contribution of Homegardens to *in situ* Conservation of Plant Genetic Resources in Farming systems - Cuban Component. In *Homegardens and in situ Conservation of Plant Genetic Resources in Farming System*, eds. J.W. Watson and P.B. Eyzaguirre, pp. 42–55. IPGRI, Rome.

Chi-Quej, J.
2009 Caracterización y Manejo de los Huertos Caseros Familiares en Tres Grupos Étnicos (Mayas Peninsulares, Choles y Mestizos) del estado de Campeche, México. Master's Thesis (Agricultura Ecológica). Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica.

CNDI-PNUD.
2000 Comisión Nacional para el Desarrollo de los Pueblos Indígenas. Programa de las Naciones Unidas para el Desarrollo. Sistema sobre Indicadores sobre la Población Indígena de México, con base en INEGI, XII Censo General de Población y Vivienda, México. Available at: www.cdi.gob.mx/pnud/proyecto.html (verified 15 March 2010).

CONANP
2008 Comisión Nacional de Áreas Naturales Protegidas. Programa de Conservación y Manejo. Reserva de la Biosfera Calakmul. Available at: www.conanp.gob.mx (verified 20 July 2010).

Coomes, O.T. and N. Ban
2004 Cultivated Plant Species Diversity in Home Gardens of an Amazonian Peasant Village in Northeastern Peru. *Economic Botany* 58:420–434.

Corzo-Márquez, A.R. and N.B. Schwartz
2008 Traditional Home Gardens of Petén Guatemala: Resource Management, Food Security and Conservation. *Journal of Ethnobiology* 28:305–317.

Cuanalo de la Cerda, H.E. and R.R. Guerra Mukul
2008 Homegarden Production and Productivity in a Mayan Community of Yucatan. *Human Ecology* 36:423–433.

De Clerck, F.A.J. and P. Negereros-Castillo
2000 Plant Species of Traditional Mayan Homegardens of Mexico as Analogs for Multistrata Agroforests. *Agroforestry Systems* 48:303–317.

Dytham, C.
2001 *Choosing and Using Statistics: A Biologist Guide*. Blackwell Science Ltd, London.

Ellis, F.
1998 Household Strategies and Rural Livelihood Diversification. *The Journal of Development Studies* 35:1–38.

Fernandes, E.C.M. and P.K.R. Nair
1986 An Evaluation of the Structure and Function of Tropical Home Gardens. *Agricultural Systems* 21:279–310.

García-Gil, G. and J.M. Pat-Fernández
2000 Apropiación del Espacio y Colonización en la Reserva de la Biosfera Calakmul, Campeche, México. *Revista Mexicana del Caribe* 10:212–132.

Gasco, J.
2008 'Le Da Alegria Tener Flores' Homegardens in the Soconusco Region of Chiapas, Mexico. *Journal of Ethnobiology* 28: 259–277.

Gates, M., W. Folan, and M.C. Sánchez
1999 Introducción. In *Naturaleza y Cultura en Calakmul, Campeche*, eds. W. Folan Higgins, M.C. Sánchez González and J.M. García Ortega, pp. 13–17. Universidad Autónoma de Campeche, Mexico.

González-Jácome, A.
2003 *Cultura y Agricultura: Transformaciones en el Agro Mexicano*. Universidad Iberoamericana A.C., México D.F.

Guerrero- Peñuelas, A.G.
2007 The Impact of Migration on Housegarden Management in La Purísima Concepción Mayorazgo, San Felipe del Progreso, State of Mexico. *Boletín del Instituto de Geografía, Universidad Nacional Autónoma de México* 63:105–124.

Heckler, S.L.
2004 Cultivating Sociality: Aesthetic Factors in the Composition and Function of Piaroa Homegardens. *Journal of Ethnobiology* 24:203–232.

Hernández, S.M.
2010 Cambios y Continuidades en los Solares Maya Yucatecos: Un Análisis Intergeneracional de su Configuración Espacial en dos Comunidades del Sur de Yucatán. Master's Thesis (Ecología Humana). Centro de Investigaciones y Estudios Avanzados del Instituto Politécnico Nacional, México.

Hinojosa, O.J.
1983 El Concepto de Ejido en la Legislación Mexicana. *Revista Jurídica* 15:173–187.

INEGI
2011 Instituto Nacional de Estadística y Geografía. México en Cifras, Campeche. Available at: www.inegi.org.mx (verified 30 March 2012).

Jarvis D.I., C. Padoch, and H.D. Cooper
2007 La Biodiversidad, la Agricultura y los Servicios Ambientales. In *El Manejo de la Biodiversidad en los Sistemas Agrícolas*, eds. D.I. Jarvis, D. Padoch and H.D. Cooper, pp. 1–12. Bioversity International, Rome.

Jiménez-Osornio, J.J., M.R. Ruenes Morales, and P. Montañez Escalante
1999 Agrodiversidad de los Solares de la Península de Yucatán. *Red, Gestión de Recursos Naturales* 2:30–40.

Kelly, T.J.
2001 Neoliberal Reforms and Rural Poverty. *Latin American Perspectives* 28:84–103.

Kumar, B.M. and P.K.R. Nair
2004 The Enigma of Tropical Homegardens. *Agroforestry Systems* 61:135–152.
2006 *Tropical Homegardens: A time-tested Example of Sustainable Agroforestry*. Springer, The Netherlands.

Larousse
2004 *Diccionario Enciclopédico*. Ediciones Larousse de Colombia, Santafé de Bogotá, Colombia.

Lazos-Chavero, E. and M.E. Alvarez-Buylla Roces
1988 Ethnobotany in a Tropical-humid Region: The Homegardens of Balzapote, Veracruz, Mexico. *Journal of Ethnobiology* 8: 45–79.

Lipton, M.
1980 Migration from Rural Areas of Poor Countries: The Impact on Rural Productivity and Income Distribution. *World Development* 8:1–24.

López-Villar, D.A.
2005 *La Migración de la Población Hablante de Lengua Indígena en el Sureste Mexicano. Población y Salud en Mesoamérica*. Centro Centroamericano de Población, Costa Rica.

Martin, G.J.
1995 *Ethnobotany: A 'People and Plants' Conservation Manual*. Chapman and Hall, London.

Martínez, E. and C. Galindo-Leal
2002 *La Vegetación de Calakmul, Campeche, México: Clasificación, Descripción y Distribución*. Universidad Nacional Autónoma de México D.F., México.

Martínez, E., M.S. Sousa, and C.H. Rámos Álvarez
2001 *XXII. Región de Calakmul, Campeche*. Instituto de Biología, Universidad Nacional Autónoma de México. D.F., México.

Montagnini, F.
2006 Homegardens of Mesoamerica: Biodiversity, Food Security and Nutrient Management. In *Tropical Homegardens: A Time-tested Example of Sustainable Agroforestry*, eds. B.M. Kumar and P.K.R. Nair, pp. 61–84. Springer, The Netherlands.

Morales-Rosas, J.
1999 Suelos. In *Naturaleza y Cultura en Calakmul, Campeche*, eds. W. Folan Higgins, M.C. Sánchez González and J.M. García Ortega, pp. 41–49. Universidad Autónoma de Campeche, México.

Navarrete-Linares, F.
2008 Los Pueblos Indígenas de México. CDI, Mexico. Available at: www.cdi.gob.mx (verified 23 March 2012).

Netting, R.
1993 *Smallholders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture*. Stanford University Press, Stanford.

Osorio-Hernández, C.
1997 El Solar en la Zona Maya de Quintana Roo. Master's Thesis (Biología). Universidad Nacional Autónoma de México, Mexico.

Perea-Mercado, S.L.
2011 Influencia del Empoderamiento de las Mujeres sobe la Diversidad Vegetal en Solares de Campeche, México. Master's Thesis (Antropología). Universidad Autónoma de México, Mexico D.F

Redclift, M.
1983 Production Programs for Small Farmers: Plan Puebla as Myth and Reality. *Economic Development and Cultural Change* 31:551–570.

Rico-Gray, V., J.G. Garcia-Franco, A. Chemas, A. Puch, and P. Sima
1990 Species Composition, Similarity and Structure of Mayan Homegardens in Tixpeual and Tixcacaltuyub, Yucatán, México. *Economic Botany* 44:470–487.

Ruonavaara, D.
1996 Traditional Household Gardens of the Petén, Guatemala. Master's Thesis (Community, Agriculture, Recreation, and Resource Studies). Michigan State University, East Lansing.

Shrivastava, R.J. and J.T. Heinen
2005 Migration and Home Gardens in the Brahmaputra Valley, Assam, India. *Journal of Ecological Anthropology* 9:20–34.

Stepp, J.R., H. Castañeda, J. Reilly-Brown, and C. Russell
2008 *Set of 13 maps of Global and Regional Biocultural Diversity*. Biocultural Diversity Mapping Project, University of Florida, Gainesville.

Toledo, V.M., N. Barrera-Bassols, E. García-Frapolli, and P. Aracón-Chaires
2008 Uso últiple y Biodiversidad entre los Maya Yucatecos (México). *Interciencia* 33: 345–352.

Torquebiau, E.
1992 Are Tropical Agroforestry Home Gardens Sustainable? *Agriculture, Ecosystems & Environment* 4:189–207.

Turner II, B.L.
2010 Sustainability and Forest Transitions in the Southern Yucatán: The Land Architecture Approach. *Land Use Policy* 27: 170–179.

Vester, H.F.M., D. Lawrence, J.R. Eastman, B.L. Turner II, S. Calmé, R. Dickson, C. Pozo, and F. Sangermano
2007 Land Change in the Southern Yucatán and Calakmul Biosphere Reserve: Effects on Habitat and Biodiversity. *Ecological Applications* 17:989–1003.

Vogl-Lukasser, B.
1998 *Hausgärten der Mayas: Zwischen Tradition und Moderne. Investigaciones 1. Forschungen zu Lateinamerika*. Brandes & Apsel/Südwind, Frankfurt am Main, Germany.

Vogl C.R., B. Vogl-Lukasser, and C. Caballero
2002 Homegardens of Maya Migrants in the District of Palenque (Chiapas/Mexico). Implications for Sustainable Rural Development. In *Ethnobiology and Biocultural Diversity*, eds. J.R. Stepp, F.S. Wyndham and R.K. Zarger, pp. 631–647. University of Georgia, Athens.

Vogl C.R., B. Vogl-Lukasser, and R.K. Puri
2004 Tools and Methods for Data Collection in Ethnobotanical Studies of Homegardens. *Field Methods* 16:285–306.

Wilk, R.R.
1997 *Household Ecology: Economic Change and Domestic Life among the Kekchi Maya in Belize*. Northern Illinois University Press, DeKalb.

Zarate-Hoyos, G.A.
1998 Markets and Biodiversity in the Yucatan. Paper presented at the Latin American Studies Association conference, Chicago, Illinois.