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Cymbopogon winterianus, Neurolaena lobata, and *Ruta chalepensis*—Recurring Herbal Remedies in Guatemalan Maya Q'eqchi' Homegardens

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Abstract We report on the top three ethnopharmacological herbs growing among a lowland Guatemalan Q'eqchi' community's homegardens. In a gardening culture characterized by pragmatic species distribution and sharing, these few herbaceous species recur in multiple households' dooryard gardens. Our aim in reporting on the most predominant ethnobotanical herbs gardened in a Maya Q'eqchi' village's dooryards is to valorize the capacities of local pharmacological traditions. Thirty-one walking homegarden interviews and participant-observation inform this research with village residents. *Té de limón* (*Cymbopogon winterianus,* for cough, fever), *Qa'mank/Tres punta* (*Neurolaena lobata,* for diabetes, fever, headache, gastrointestinal ills, evil eye), and *Ruda* (*Ruta chalepensis,* for children's vomiting, weepiness, evil eye) are the prevalent non-woody Q'eqchi' homegarden herbs here. Regional ethnomedical and extant pharmacology research mutually support the efficacy and continued practicality of these Q'eqchi' plant uses. Ethnopharmacological research of Maya Q'eqchi' medicinals documents local knowledge for conservation and calls for their cultural and biomedical respect as prominent, accessible, therapeutic species.

Resumen Reportamos sobre las tres principales hierbas etnofarmacológicas cultivadas en los huertos familiares de una comunidad Q'eqchi' guatemalteca de tierras bajas. En una cultura de jardinería caracterizada por la distribución pragmática de especies y el intercambio, algunas especies herbáceas se repiten en los huertos familiares de múltiples hogares. Nuestro objetivo al reportar sobre las hierbas etnobotánicas más predominantes cultivadas en los patios de una aldea Maya Q'eqchi' es el de valorizar las capacidades de las tradiciones farmacológicas. Treinta y una entrevistas en base a "caminatas botánicas" y la observación participante informan esta investigación con los residentes de la aldea. *Cymbopogon winterianus* (para la tos, fiebre), *Neurolaena lobata* (para la diabetes, fiebre, dolor de cabeza, enfermedades gastrointestinales, mal de ojo) y *Ruta chalepensis* (para el vómito, el llanto y el mal de ojo en niños) son las hierbas medicinales predominantes. Las investigaciones regionales etnomédicas y farmacológicas actuales apoyan mutuamente la eficacia y la factibilidad de estas plantas y sus usos entre los Q'eqchi'. La investigación etnofarmacológica de las medicinas Maya Q'eqchi' documenta el conocimiento local como base para la conservación e invita al respeto cultural y biomédico de estas como especies terapéuticas destacadas y accesibles.

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Introduction

Home remedies with medicinal plants are often the first healthcare choice in financially disadvantaged, rural, areas that lack healthcare services and infrastructure (Vandebroek 2013, Weller et al. 1997). Homegardens provide access to these resources conveniently (Kumar and Nair 2006) and at lower or no cost (Vogl et al. 2002). In Guatemala, herbal

remedies are common home healthcare (Adams and Hawkins 2007, Cosminsky 2016), and many of these plants show pharmacological efficacy (Caceres 1996, Michel et al. 2007). Here, we report the three most common herbaceous homegarden medicinals (*Cymbopogon winterianus, Neurolaena lobata,* and *Ruta chalepensis*) in a Maya Q'eqchi' village and discuss them in regional ethnomedical and pharmacological context.

Indigenous and local knowledge (ILK) uniquely supports local biocultural adaptation and vitality, and yet suppression, misrepresentation, appropriation, assimilation, disconnection, and destruction all threaten ILK through continuing historical legacies of colonization, globalization, and urbanization (Fernández-Llamazares et al. 2021). Our Guatemalan Q'eqchi' research participants' lifeways and knowledge have suffered every one of these threats; in interviews, many reported having fled their homes in other parts of the country in 1980 amidst the Guatemalan civil war, seeking a safe place to live self-sufficiently and in community (see also Maass 2008:127). In the wake of the consequences of relocation, racism, genocide, and violence, villagers report erosion of environmental ILK. Yet many villagers retain some ethnopharmacological knowledge and practice, as evidenced here. Additionally, it is likely that by moving to a lowland region from the highlands, founding villagers and their descendants adapted previous ILK—adjusting former practices and learning new ones—in their new socioecological context. We document the Indigenous ethnopharmacological knowledge herein as one step towards valorizing Guatemalan Q'eqchi' ILK and its continuing transmission into the future.

Methods

Study location

This research assesses medical ethnobotany in a lowland Guatemalan village in Alta Verapaz. Abundant rain falls (2000–3000mm annually) and the average temperature is 26°C. Evergreen rainforest grows from limestone soil (Maass 2008:117,152) containing native palms, orchids, and bromeliads (Standley and Steyermark 1945).

The village, founded in 1980, is home to ~700 people. The village area is mostly flat with palm-thatched, wooden plank homes in a rectangular grid—a typical layout in post-war Guatemala (Wilson 1995). Almost all villagers identify as Maya Q'eqchi'. A few residents have other Maya ethnicities (Kaqchikel, Pokomchi, Mam), and fewer identify as Ladino (Mestizo). Q'eqchi' is the predominant language, even among the few non-Q'eqchi', though Spanish is also widely spoken.

Homegardens are the (30m by 60m) parcels of land where people live. Villagers own or rent additional plots for maize horticultural production. For extensive ethnographic description and local definitions and perceptions of homegardens, see Thiel and Quinlan (2022).

Data collection

Research occurred between June and August 2016, and in July 2018. We conducted participant observation (Musante and DeWalt 2010) throughout this time, inquiring about ethnobotanical and ethnomedical activities from key informants and interested villagers.

Thirty-two adult residents (nine men, 23 women), between the ages of 19 and 70, residing in 26 households, participated in interviews. Availability skewed the sample's sex ratio; men spend daylight hours working outside the home, while women remain near home. We selected participants via stratified convenience sampling according to distance on either side of the main road for a representative spatial distribution of gardens. Our semi-structured interviews were two-part: a life-history questionnaire and walking homegarden tours (Martin 2010). In the homegarden tours, we asked questions to elicit individuals' knowledge of plants' names and uses, and probing for details regarding medicinal applications, plant parts, amounts, and preparations. Most interviews were in Spanish; two were in Q'eqchi' using with the assistance of a local translator.

Voucher specimens

The Guatemalan National Council for Protected Areas (CONAP) granted permission for botanical voucher collection. We collected vouchers with key informants during our 2018 field visit and deposited vouchers in the University of San Carlos Herbarium, Guatemala City.

Analyses

We omit one interview for reliability, as one interviewee was not answering independently. We include 31 interviews (8 men, 23 women) in our analysis.

We analyzed interview responses to assess participants' frequency of mention of cultivation of homegarden medicinal species and the overall

agreement on plant uses and preparation methods. We compared local plant uses with the uses reported in regional ethnomedical and global pharmacological literature.

Results

This Q'eqchi' community's most frequently grown herbaceous medicinal plants are *Cymbopogon winterianus, Neurolaena lobata*, and *Ruta chalepensis* (Table 1; see Thiel and Quinlan [2020] for common homegarden medicinal trees). Inter-household variation in homegarden medicinal content and plant-sharing is the norm in this village (Thiel and Quinlan 2022). Yet, these three species recur in 12–19% (3–5/26) of sampled homegardens. Here, we present their frequency of cultivation and medicinal uses, and review related regional ethnomedical and global pharmacological literature.

Cymbopogon winterianus

Three informants (11.5%) identify *Cymbopogon winterianus* in their homegardens. All report the tea for treating coughs, and one recommends it for fever. While only these three informants grow *C. winterianus*, 24% of households reported using it, calling it by its Spanish name *té de limón*, for coughs and fever in combination with other plants they grow (see Thiel and Quinlan 2022).

A pan-tropical medicinal genera, *Cymbopogon*'s various species, including *C. winterianus* and *C. citratus*, show antibacterial, antifungal, antiamoebic, antidiarrheal, antifilarial, and anti-inflammatory properties interchangeably due to similar chemical compositions (Dutta et al. 2016). Guatemalans drink *C. citratus* infusions for digestive ailments, respiratory illnesses, fever, malaria, menstrual problems, high blood pressure, nervousness, and *susto* (fright) (Caceres 1996; Orellana Ayala 1997). For rheumatism and soreness, they use a poultice (Orellana Ayala 1997), and drink or wash with an infusion (Caceres 1996). Mexicans drink the infusion for gastrointestinal problems (Sharma et al. 2017), as do Belizeans, who also drink it for respiratory congestion, and children's fever; adding the root for adults' fevers (Balick and Arvigo 2015).

Cymbopogon winterianus essential oil is antifungal against *Candida albicans* (Oliveira et al. 2011) and highly antimicrobial against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Salmonella typhimurium*, *Bacillus subtilis*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* (Munda and Lal 2020). *C. winterianus* has anticonvulsant, anti-inflammatory, and pain killing (antinociceptive) properties, and induces vaso-relaxation and hypotension (i.e., lowers hypertension) (Munda and Lal 2020). Additionally, most *Cymbopogon* species have insecticidal, anti-cancer, and anti-HIV properties (Avoseh et al. 2015). Among abundant pharmacological *Cymbopogon* species research, we found none targeted toward pulmonary or respiratory actions indicated in Q'eqchi' and other global ethnomedicines.

Neurolaena lobata

Three village subjects (11.5%) grow ***qa'mank***, or *Neurolaena lobata* (*tres punta,* boneset/jackass bitters), and consider it a weed (they do not plant it purposefully). Villagers decoct the bitter, three-pronged leaf to treat stomachache, gastritis, and diabetes. One informant also uses it for evil eye, fever, and headache. The tea requires gathering a handful of leaves, boiling them in ≈1L water, and drinking this three times daily.

Alta Verapaz Q'eqchi' use *N. lobata* leaves for malaria (*paludismo*), gastrointestinal problems, and diabetes (Maass 2008:165). The Q'eqchi' of Izabal use *N. lobata* leaf for dysmenorrhea and vaginal infections (Michel et al. 2007). Other Guatemalans drink *N. lobata* leaf tea for gonorrhea (Caceres 1996), malaria, fever, diarrhea, stomachache, and diabetes (Caceres 1996; Orellana Ayala 1997). Externally, they apply the leaf juice to repel ticks, a leaf infusion to clean wounds, lesions, and ulcers, and a leaf poultice for bites (Caceres 1996), including snake bites, the most dangerous kind being from the venomous *terciopelo* viper (*Bothrops asper*, fer-de-lance) (Hay 2002), for which Guatemalans also drink *N. lobata* leaf infusions and decoctions (Saravia-Otten et al. 2022). Belizeans use *N. lobata* leaf tea or poultice for fever, pain, muscle soreness, swelling, skin ailments, digestive issues, diabetes, colds, influenza, malaria, and women's reproductive system issues (Balick and Arvigo 2015). West Indian islanders use *N. lobata* leaves and stems to make fish poison and insecticides (Lewis and Elvin-Lewis 1977).

Pharmacology finds *N. lobata* efficacy against inflammation, microbial, and protozoal activity (Berger et al. 2001, Caceres et al. 1998, Walshe-Roussel et al. 2013). It is antiglycemic (blood-sugar levelling) in mice (Gupta et al. 1984). An ethanol extract of *N. lobata* worked against the epimastogote (intestine-occupying form) and trypomastigote (blood-occupying, infective) stages of the Chagas

Table 1 The three most frequently mentioned herbaceous medicinal homegarden plants and their uses.

Latin name and family	*Cymbopogon winterianus,* Poaceae	*Neurolaena lobata,* Asteraceae	*Ruta chalepensis,* Rutaceae
Spanish name	té de limón	tres punta	ruda
Q'eqchi' name	(none reported)	qa'mank	ruda
English common gloss	lemon-grass	bonset, jackass bitters	rue
Cultivation status	Introduced, cultivated	Native, weedy/not cultivated	Introduced, cultivated
Plant part used medicinally	aerial parts	leaves	aerial parts
Illnesses treated locally	cough, fever	evil eye, fever, headache, stomachache, diabetes, gastritis	evil eye, vomiting, weepiness, for children's complaints
Households that reported as medicinal	3 (11.5%)	3 (11.5%)	5 (19%)
Homegardens where present (out of 26)	3 (11.5%)	4 (15.4%)	5 (19%)
Voucher ID	AT044/80934	AT109/81406	AT105/81606

Trypanosoma cruzi protozoa, in vivo and in vitro (Berger et al. 2001, Caceres et al. 1998), and against the *Leishmania* spp. and *Trichomonas vaginalis* parasites, in vitro (Berger et al. 2001).

Ruta chalepensis

Five informants (19%) showed ***ruda***, *Ruta chalepensis* (*ruda*, rue) in their homegardens and agreed completely on medicinal uses and preparation. All indicated its usefulness against children's and babies' evil eye, specifying an infusion with the plant's aerial parts as a bath or external wash. They also drink *R. chalepensis* for vomiting and excessive weepiness, both symptoms of evil eye, itself.

Guatemalans use *R. chalepensis* leaf for menstrual problems (Caceres 1996; Michel et al. 2007; Orellana Ayala 1997), respiratory, digestive, and nervous system problems (Caceres 1996; Orellana Ayala 1997), hemorrhaging (Caceres 1996), and to treat hemorrhoids, varicose veins, rheumatism, animal bites, wounds, worms, colic, pain, and *aire* (air) (Orellana Ayala 1997). Eastern Ladinos and Ch'orti' Maya use *R. chalepensis* for fever, pain, respiratory issues, and illnesses with a "psychological or spiritual component" (Kufer et al. 2015:1130).

Belizians use *R. chalepensis* for indications paralleling evil eye: heat exhaustion, headache, fainting spells, infections, swelling, stomach pain, convulsions, nightmares, and to ward off evil (Balick and Arvigo 2015). Yucatec Maya (Mexico), grow *R. chalepensis* in most gardens and consider it a cure-all, making a tea for stomachache and diarrhea (whether from evil eye or other causes), and use it around the house to prevent "evil winds" [i.e., *aire*] (Anderson 2003:206).

Pharmacologically, *Ruta chalepensis* extract depresses the central nervous system (Gonzalez-Trujano et al. 2006), and shows anti-inflammatory, antipyretic (fever-reducing), and analgesic properties in mice (Al-Said et al. 1990). The extract is active against *T. cruzi*, the Chagas disease parasite (Molina-Garza et al. 2014). Essential oils from the leaves inhibit yeasts and fungi (*Candida albicans* and *Trichophyton rubrum*), but not *Staphylococcus aureus* and *Escherichia coli* bacteria (Khoury et al. 2014). But phenolic compounds in *R. chalepensis* inhibit *Pseudomonas aeruginosa*, *S. aureus* and *E. coli* bacteria, and have strong antioxidant properties (Ouerghemmi et al. 2017).

Discussion

The most frequently mentioned herbaceous medicinal plants grown in homegardens in this Alta Verapaz Q'eqchi' village are *C. winterianus*, *N. lobata*, and *R. chalepensis*. The frequency with which informants cultivate and report them as medicinal indicates cultural agreement about their value and specific indications. Because consensus appears to develop over time (Stepp 2016), informant's agreement on the uses of these three herbs likely indicates long-standing Q'eqchi' and regional traditions of medicinal plant use (traditional ethnobotanical [or ecological] knowledge [TEK]). For example, the complete agreement on the uses and preparation methods of *Ruta chalepensis* as an external wash for symptoms of evil eye mirrors its regional uses (Anderson 2003, Balick and Arvigo 2015, Kufer et al. 2015, Orellana Ayala 1997).

Villagers often report cultivates growing in their homegardens *and* common wild plants or weeds growing close to home, as cross-culturally people often use the latter medicinally (Stepp and Moerman 2001). In this study, villagers report growing *N. lobata* because it volunteered in their gardens, not because they planted it purposefully. It appears that, once established in their gardens, villagers cultivate *N. lobata* for its medicinal uses, as they do not report any other uses for the plant. "Weedy" plants growing in disturbed areas—like *N. lobata* in Q'eqchi' homegardens—frequently provide Maya household remedies (Stepp 2018), as tends to occur cross-culturally (Stepp and Moerman 2001).

Of the three remedies, *N. lobata* is the only native plant to this area, whereas *C. winterianus* and *R. chalepensis* are introduced. Relatedly, *N. lobata* is the only plant of the three with a unique Q'eqchi' name. Villagers report the Spanish name of *R. chalepensis*, *ruda*, as the Q'eqchi' name. They use the borrowed term *té de limón* and do not report a Q'eqchi' name for *C. winterianus*. The status of these plants as native or introduced and their corresponding Spanish or Q'eqchi' local names indicate and affirm the dynamism of ILK in this village. Villagers incorporate new plants and knowledge of their uses into ILK, likely because of their increasing integration into local market economies and globally interconnected agriculture (Maass 2008, Wilson 1995). We found a similar pattern among native and introduced medicinal trees in this village (Thiel and Quinlan 2020). That *R. chalepensis* has a Q'eqchi' name may indicate that villagers have incorporated its use into local ethnomedicine longer or more completely than *C. winterianus*, which lacks a name of Q'eqchi' origin.

This would support the assertion that ethnobotanical consensus (including nomenclature) develops over time (Stepp 2016).

Home remedies remain the first treatment choice in health care practice in Guatemala (pers. obs.; Weller et al. 1997) and local medicinal plants are one of the most common home remedies (Adams and Hawkins 2007, Cosminsky 2016). Of the three plants discussed herein, comparable regional ethnomedical uses and extant pharmacological research indicate the herbs' efficacy for similar ailments. Traditional medicinal plant uses warrant further pharmacological inquiry of these therapeutic resources, particularly respiratory uses of *C. winterianus*, salient here and cross -culturally, yet lacking pharmacological investigation (which we suggest happen in collaboration with local people to ensure equitable benefit sharing). How rural, Indigenous Guatemalans care for their health with accessible local resources (e.g., homegarden medicinals) that they value as pharmacologically active may influence public health in Guatemala and elsewhere (Caceres 1996; Michel et al. 2007).

Understanding the context of Guatemalan Maya cultivation and medicinal plant uses is necessary for cultural revitalization and successful integration of diverse regional health care models as Western biomedicine expands (Adams and Hawkins 2007; Caceres 1996) and local fears of ethnobotanical knowledge erosion increase (Cosminsky 2016). The threats to Indigenous and local knowledge (ILK) require active dismantling so this resilient biocultural knowledge may contribute to local and global flourishing (Fernández-Llamazares et al. 2021). We hope that our documentation of these three recurring remedies helps valorize and preserve this practical knowledge for local and global benefit.

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Declarations

Permissions: Washington State University's Institutional Review Board approved this research. We followed the International Society of Ethnobiology (2006) and the Latin American Society of Ethnobiology (Cano Contreras et al. 2016) Codes of Ethics. We followed local customs (see Medinaceli 2018 for our detailed protocol) for conducting research and returning results to the community. We obtained free, prior, and informed consent for each interview and complied with Guatemalan biodiversity conventions per our agreement with the Guatemalan National Council for Protected Areas.

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Conflicts of Interest: None declared.

References Cited

Adams, W., and J. P. Hawkins. 2007. *Health Care in Maya Guatemala*. University of Oklahoma, Norman.

Al-Said, M. S., M. Tariq, M. A. Al-Yahya, S. Rafatullah, O. T. Ginnawi, and A. M. Ageel. 1990. Studies on *Ruta chalepensis*, an Ancient Medicinal Herb Still Used in Traditional Medicine. *Journal of Ethnopharmacology* 28:305–312. DOI:10.1016/0378-8741(90)90081-4

Anderson, E. N. 2003. *Those who Bring the Flowers*. ECOSUR, San Cristobal de las Casas, Chiapas, Mexico.

Avoseh, O., O. Oyedeji, P. Rungqu, B. Nkeh-Chungag, and A. Oyedeji. 2015. Cymbopogon Species; Ethnopharmacology, Phytochemistry and the Pharmacological Importance. *Molecules* 20 (5):7438–7453. DOI:10.3390/molecules20057438.

Balick, M., and R. Arvigo. 2015. *Messages from the Gods*. Oxford University, Oxford, UK.

Berger, I., C.M. Passreiter, A. Cáceres, and W. Kubelka. 2001. Antiprotozoal Activity of *Neurolaena Lobata*. *Phytotherapy Research* 15:327–330. DOI:10.1002/ptr.782

Cáceres, A. 1996. *Plantas de Uso Medicinal en Guatemala*. Editorial Universitaria, Guatemala.

Cáceres, A., B. López, S. González, I. Berger, I. Tada, and J. Maki. 1998. Plants Used in Guatemala for the Treatment of Protozoal Infections, I. *Journal of Ethnopharmacology* 62:195–202. DOI:10.1016/S0378-8741(98)00140-8

Cano Contreras, E., A. Medinaceli, O. Sanabria, and A. Argueta. 2016. Código de Ética para la Investigación, la Investigación-Acción y la Colaboración Etnocientífica en América Latina. Etnobiología 14 (suplemento 1):22-27. DOI:10.18542/ethnoscientia.v3i2.10239

Cosminsky, S. 2016. Midwives and Mothers. University of Texas, Austin, TX.

Dutta, S., S. Munda, M. Lal, and P. R. Bhattacharyya. 2016. A Short Review on Chemical Composition, Therapeutic Use and Enzyme Inhibition Activities of Cymbopogon Species. *Indian Journal of Science and Technology* 9(46):1–9.

Fernández-Llamazares, Á., D. Lepofsky, K. Lertzman, C. G. Armstrong, E. S. Brondizio, M. C. Gavin, P. O. B. Lyver, G. P. Nicholas, P. Pascua, N. J. Reo, V. Reyes-García, N. J. Turner, J. Yletyinen, E. N. Anderson, W. Balee, J. Cariño, D. M. David-Chavez, C. P. Dunn, S. C. Garnett, S. Greening, S. Jackson, H. Kuhnlein, Z. Molnár, G. Odonne, G. B. Retter, W. J. Ripple, L. Sáfián, A. S. Bahraman, M. Torrents-Ticó, and M. B. Vaughan. 2021. Scientists' Warning to Humanity on Threats to Indigenous and Local Knowledge Systems. *Journal of Ethnobiology 41* (2):144–169. DOI:10.2993/0278-0771-41.2.144

Gonzalez-Trujano, M. E., D. Carrera, R. Ventura-Martinez, E. Cedillo-Portugal, and A. Navarrete. 2006. Neuropharmacological Profile of an Ethanol Extract of *Ruta Chalepensis* L. in Mice. *Journal of Ethnopharmacology* 106:129–135. DOI:10.1016/j.jep.2005.12.014

Gupta, M. P., N. G. Solis, M. E. Avella, and C. Sanchez. 1984. Hypoglycemic Activity of *Neurolaena lobata* (L.) R. Br. *Journal of Ethnopharmacology* 10:323–327. DOI:10.1016/0378-8741(84)90020-5.

Hay, Y. O. 2002. Estudio Etnofarmacológico de Plantas Utilizadas en la Medicina Tradicional para el Tratamiento de Leishmaniasis Cutánea, del Paludismo y de la Mordedura de Serpientes, en Tres Departamentos de Guatemala. Universidad de San Carlos de Guatemala, Service de Coopération au Développement, and Institut de Recherche pour le Développment, Guatemala City.

International Society of Ethnobiology. 2006. ISE Code of Ethics. Available at http://ethnobiology.net/code-of-ethics/. Accessed on October 11, 2021.

Khoury, M., D. Stien, N. Ouaini, V. Eparvier, N. Arnold Apostolides, and M. El Beyrouthy. 2014. Chemical Composition and Antimicrobial Activity of the Essential Oil of *Ruta chalepensis* L. Growing Wild in Lebanon. *Chemistry and Biodiversity* 11:1990–1997. DOI:10.1002/cbdv.201400109.

Kufer J., H. Förther, E. Pöll, and M. Heinrich. 2005. Historical and Modern Medicinal Plant Uses—the Example of the Ch'orti' Maya and Ladinos in Eastern Guatemala. *Journal of Pharmacy and Pharmacology* 57:1127–1152. DOI:10.1211/jpp.57.9.0008

Kumar, B. M., and P. K. R. Nair. 2006. *Tropical Homegardens*. Springer, Dordrecht.

Lewis, W. H., and M. P. F. Elvin-Lewis. 1977. *Medical Botany*. John Wiley & Sons, Hoboken, NJ.

Maass, P. 2008. *The Cultural Context of Biodiversity Conservation: Seen and Unseen Dimensions of Indigenous Knowledge among Q'eqchi' Communities in Guatemala*. Universitätsverlag Göttingen, Göttingen, Germany.

Martin, G. J. 2010. *Ethnobotany*. Routledge, Abingdon, UK.

Medinaceli, A. 2018. Taking an Early Step in Ethnobiological Research. *Ethnobiology Letters 9*: 76–85. DOI:10.14237/ebl.9.1.2018.1054.

Michel, J., R. E. Duarte, J. L. Bolton, Y. Huang, A. Caceres, M. Veliz, and G. B. Mahady. 2007. Medical Potential of Plants Used by the Q'eqchi Maya of Livingston, Guatemala for the Treatment of Women's Health Complaints. *Journal of Ethnopharmacology* 114:92–101. DOI:10.1016/j.jep.2007.07.033.

Molina-Garza, Z. J., A. F. Bazaldúa-Rodríguez, R. Quintanilla-Licea, and L. Galaviz-Silva. 2014. Anti-Trypanosoma Cruzi Activity of 10 Medicinal Plants Used in Northeast Mexico. *Acta tropica* 136:14–18. DOI:10.1016/j.actatropica.2014.04.006.

Munda S., and M. Lal. 2020. *Cymbopogon winterianus* Jowitt ex Bor, a Hub for Various Industrial and Pharmaceutical Applications. In *Botanical Leads for Drug Discovery*, edited by B. Singh. Springer, Singapore. DOI:10.1007/978-981-15-5917-4_19.

Musante, K., and B. R. DeWalt. 2010. *Participant Observation: A Guide for Fieldworkers*. AltaMira Press, Lanham, MD.

Oliveira, W. A. D., F. D. O. Pereira, G. C. D. G. D. Luna, I. O. Lima, P. A. Wanderley, R. B. D. Lima, and E. D. O. Lima. 2011. Antifungal Activity of *Cymbopogon winterianus* Jowitt ex Bor Against Candida Albicans. *Brazilian Journal of Microbiology* 42:433–441. DOI:10.1590/S1517-83822011000200004.

Orellana Ayala, R. 1997. *Salud Familiar y Plantas Medicinales en la Sierra de las Minas*. Fundacion Defensores de la Naturaleza, Guatemala.

Ouerghemmi, I., I. Bettaieb Rebey, F. Z. Rahali, S. Bourgou, L. Pistelli, R. Ksouri, B. Marzouk, and M.

Saidani Tounsi. 2017. Antioxidant and Antimicrobial Phenolic Compounds from Extracts of Cultivated and Wild-grown Tunisian *Ruta chalepensis*. *Journal of Food and Drug Analysis* 25:350–359. DOI:10.1016/j.jfda.2016.04.001.

Saravia-Otten, P., R. Hernández, N. Marroquín, J. A. Pereañez, L. M. Preciado, A. Vásquez, G. García, F. Nave, L. Rochac, V. Genovez, M. Mérida, S. M. Cruz, N. Orozco, A. Cáceres, and J. M. Gutiérrez. 2022. Inhibition of Enzymatic Activities of *Bothrops asper* Snake Venom and Docking Analysis of Compounds from Plants Used in Central America to Treat Snakebite Envenoming. *Journal of Ethnopharmacology* 283:114710. DOI:10.1016/j.jep.2021.114710.

Sharma, A., R. C. Flores-Vallejo, A. Cardoso-Taketa, and M. L. Villarreal. 2017. Antibacterial Activities of Medicinal Plants Used in Mexican Traditional Medicine. *Journal of Ethnopharmacology* 208:264–329. DOI:10.1016/j.jep.2016.04.045.

Standley, P. C., and J. Steyermark. 1945. The Vegetation of Guatemala, a Brief Review. In *Plants and Plant Sciences in Latin America*, edited by F. Verdoorn, pp. 275–278. Waltham, MA: Chronica Botanica.

Stepp, J.R. 2016. Transmission, Sharing, and Variation of Medicinal Plant Knowledge and Implications for Health. In *Plants and Health*, edited by E. A. Olson and J. R. Stepp, pp. 163–170. Springer.

Stepp, J. R. 2018. *Ethnoecology and Medicinal Plants of the Highland Maya*. Springer, Cham, Switzerland.

Stepp, J. R., and D. Moerman. 2001. The Importance of Weeds in Ethnopharmacology. *Journal of Ethnopharmacology* 75:19–23. DOI:10.1016/S0378-8741(00)00385-8.

Thiel, A. M., and M.B. Quinlan. 2020. Maya Medicinal Fruit Trees: Q'eqchi' Homegarden Remedies. *Economic Botany* 74(4):464–470. DOI:10.1007/s12231-020-09506-z.

Thiel, A. M., and M. B. Quinlan. 2022. Homegarden Variation and Medicinal Plant Sharing among the Q'eqchi' Maya of Guatemala. *Economic Botany* 76 (1):16-33. DOI:10.1007/s12231-021-09537-0.

Vandebroek, I. 2013. Intercultural Health and Ethnobotany: How to improve healthcare for underserved and minority communities? *Journal of Ethnopharmacology* 148(3):746–754. DOI:10.1016/j.jep.2013.05.039.

Vogl, C.R., B.N. Vogl-Lukasser, and J. Caballero. 2002. Homegardens of Maya Migrants in the District of Palenque, Chiapas, Mexico. In *Ethnobiology and Biocultural Diversity*, edited by J.R. Stepp et al., pp. 631–647. U. Georgia Press, Athens, Georgia, USA.

Walshe-Roussel, B., C. Choueiri, A. Saleem, M. Asim, F. Caal, V. Cal, and J.T. Arnason. 2013. Potent Anti-inflammatory Activity of Sesquiterpene Lactones from *Neurolaena lobata* (L.) R. Br. ex Cass., a Q'eqchi' Maya Traditional Medicine. *Phytochemistry* 92:122–127. DOI:10.1016/j.phytochem.2013.05.004.

Weller, S. C., T.R. Ruebush, and R.E. Klein. 1997. Predicting Treatment-Seeking Behavior in Guatemala. *Medical Anthropology Quarterly* 11:224–245. DOI: 10.1525/maq.1997.11.2.224.

Wilson, R. 1995. *Maya Resurgence in Guatemala*. Norman, OK, University of Oklahoma.