Ethnobotany of Immunomodulatory Treatments Used by the Q'eqchi' Maya of Belize

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Using a quantitative ethnobotanical methodology, we identified 107 plant species belonging to 49 families used by Q'eqchi' Maya healers in the treatment of symptoms from 14 usage categories related to inflammation. The families with the largest number of medicinal species were Piperaceae, Araceae, Asteraceae, Fabaceae, and Adiantaceae with five or more medicinal species. Healer consensus for plant species was high, with 56 species (52%) being used by all the healers, and consensus for usage categories was also high, as informant consensus factor (FIC) values for each category were greater than 0.4.

Key Words: Quantitative ethnobotany, traditional medicines, medicinal plants, inflammation, Q'eqchi' Maya.

Introduction

Maya traditional medicine practiced today has its roots in the classic Maya civilization (Coe 2002) and various well-developed local traditions survive throughout the Mesoamerican area. Q'eqchi' communities of Belize and adjacent Guatemala maintain their native language and traditions and are less acculturated than nearby Yucatec or Mopan communities. They use medicinal plants collected in highly biodiverse tropical lowland semi-evergreen tropical forest regions of the Mesoamerican corridor identified as a hotspot for conservation (Myers et al. 2000).

In a general ethnobotany of the Q'eqchi', our research group found that 169 species were being used with a high degree of consensus among healers (Treyvaud Amiguet et al. 2005). Balick and Arvigo (2015) provided much broader information on Q'eqchi', Yucatec, and Mopan Maya plant use in Belize. Other authors, including members of our group, have provided more specific ethnobotanies for the Q'eqchi', focused on particular treatments. Bourbonnais–Spear et al. (2005) and Awad et al. (2009) studied plants for mental health. De Gezelle 2014 and Michel et al. (2007) reported plant use for women's health.

Selected anti-inflammatory plants of Belize were studied by Sosa et al. (2002) and Walshe-Roussel et al. (2013) for bioactivity in laboratory assays. These studies documented the potent anti-inflammatory activity of several species and the potential value of these plants in medicinal treatments. However, no broad ethnobotanical survey of anti-inflammatory plants has been published for this area.

In the general ethnobotany by Treyvaud Amiguet et al. (2005), several categories of treatments had a high number of plant species used in treatments including infections (141 species or 83%), digestive system disorders (87 species or 51%), muscular–skeletal system disorders (40 species or 24%), and skin disorders (25 species or

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15%). These disorders were among the top five usage categories, and often had underlying immunological conditions. Traditional concepts, such as the classification of hot and cold plants in Maya medicine and the principle of opposites (Ankli et al. 1999; Arnason et al. 1980), often relate treatments of (hot) inflammatory conditions with cold plants. Since inflammation is now recognized as one of the contributing factors to many debilitating chronic conditions (Haddad et al. 2005), the objective of the present study was to define a more specific ethnobotany of Q'eqchi' medicinal plants used for inflammation. To achieve a quantitative methodology, methods were based on ethnobotanical consensus (Heinrich et al. 2009; Trotter and Logan 1986) and emphasized symptoms readily observed and understood by the healers, as recommended by Leduc et al. (2006). In particular, we identified usage categories similar to western concepts of inflammation, and traditional use categories not similar to western categories. For each category, the healers identified a large number of medicinal species. These results were analyzed by usage categories, Maya concepts of hot and cold plants, healer consensus, vegetation, and habitat type.

Materials and Methods

Ethnobotanical Interviews

Ethnobotanical interviews were conducted with the Q'eqchi' Maya Healers Association (QMHA) of Belize. The QMHA is an association of approximately 10 healers from different villages in Southern Belize (Big Falls, Indian Creek, Punta Gorda, Silver Creek, Jalacte) formed in 2000 in collaboration with the Belize Indigenous Training Institute (BITI), a local non-governmental organization with Canadian indigenous support. The healers are representative of the traditional healers in the Toledo district and are mostly older (60 +) male practitioners that provide primary health care in their village. Some of the objectives of the association are to promote recognition of traditional medicine, to train youth, to document traditional medicine, and to provide support for collecting and growing medicinal plants at the Itzamma ethnobotanical garden (Audet et al. 2013). The Canadian and US research team was recruited to assist in these objectives. This ethnobotanical study received ethical approval from the University of Ottawa Research Ethics Board (file H 03–07–01) and IRB approval from Cleveland State University (30283–PES–HS). Following prior informed consent, preliminary interviews were conducted with five available members of the QMHA to gain insight into the healer's understanding of inflammation and related symptoms recognized and treated with medicinal plants. From these preliminary interviews, a list of 14 immunomodulatory usage categories were developed. These were based on a review of the literature and with the assistance of a general medicine physician, Matthew Moher, MD, Victoria General Hospital, and reclassified according to the Cook (1995) ethnobotanical standards. Emic (i.e., culture-specific) and emic/etic (i.e., views shared with western medical concepts) criteria were addressed in developing the list of Q'eqchi' usage categories, as it has been recognized that including both categories of symptoms is important in conducting comprehensive ethnopharmacological field studies (Heinrich et al. 2009). Open-ended interviews were held with all five members of the QMHA initially in the field while collecting and pressing plants. A major question was which plant is used by the healers in the treatment of any symptom that fell into one of the 14 Q'eqchi' immunomodulatory usage categories. Follow-up questions involved the preparation and dosage used by the healers for each species as well as cultural context. After the first interview, information was confirmed in individual interviews with healers using the collected vouchers. The intellectual property described here belongs to the Q'eqchi' Maya Healers Association and should not be used commercially without their permission.

Plant Material

Plant voucher specimens were collected at three locations in the Toledo district of southern Belize used by the healers: Jalacte, Punta Gorda, and the Itzamma Ethnobotanical Garden, where remnant primary and secondary forest remains. Jalacte (GPS coordinates: 16° 11′ 18 N, 89° 10′ 54 W) is a small Q'eqchi' community of approximately 500 inhabitants in the Maya Mountains along the Guatemala border, at an elevation of approximately 300 m. It is surrounded by milpas (indigenous shifting agriculture fields) and is in close proximity to a large area of 1° and 2° semi-evergreen tropical forest. Classified as lowland broadleaf subtropical moist forest based on "Ecosystem classification" data layers (BBMS 2006), the forests of Jalacte are termed elevated lowland for the purposes of this study to

differentiate them from the much lower elevation forests of the two other collection locations. Punta Gorda (GPS coordinates: 16° 05′ 48 N, 88° 49′ 04 W) is a coastal community, and the largest town in the Toledo district, at approximately 10 m above sea level. The Q'eqchi' community in Punta Gorda lives on the outskirts of Punta Gorda, known locally as Indianville, which backs onto a 2° lowland broadleaf subtropical moist forest. Punta Gorda also hosts a market that sells a small assortment of common medicinal plants that were included in this survey. The Itzamma Ethnobotanical Garden (GPS coordinates: 16° 20′ 11 N, 88° 46′ 59 W) is a medicinal plant garden managed by the QMHA and BITI in Indian Creek, at approximately 50 m above sea level. The garden contains an open yard that grows a host of fruit and medicinal crops, and a large area of managed 2° lowland broadleaf subtropical moist forest where the Q'eqchi' healers cultivate medicinal plants already growing there as well as a wide variety of species transplanted from other areas frequented by the healers (Audet et al. 2013). Collecting and export permits, as well as phytosanitary certificates, were obtained from the Belize Forest Department (Ref. No. CD/60/3/08(33)). Authenticated voucher specimens are deposited at the University of Ottawa herbarium, the Juvenal Valerio Rodriguez herbarium of the Universidad Nacional de Costa Rica, and the Missouri Botanical Garden herbarium. Arrangements have been made to transfer duplicates to the Belize Herbarium, Belmopan.

Healer Consensus

Consensus methodology was used to provide an estimate of the importance of each plant species by quantifying the degree of agreement among healers for each specific treatment, as each healer was interviewed independently. The application of these methods to test falsifiable hypotheses concerning human selection and use of plants has been demonstrated by Johns et al. (1990, 1994), Phillips and Gentry (1993), and Trotter and Logan (1986). In this study, the frequency of the mention of a medicinal plant among the healers was used to quantify the degree of confirmation of knowledge of medicinal plants. The frequency of use (F_{use}) (Treyvaud Amiguet et al. 2005) for each plant was calculated by dividing the number of healers using the plant for any usage category by the total number of healers interviewed (all five members of the QMHA). Because the same plant could be used by each healer to treat different symptoms, we also analyzed the consensus in terms of usage categories using the concept of informants' consensus originally developed by Trotter and Logan (1986) and readapted by Phillips and Gentry (1993) and Heinrich et al. (1998). This indicates how homogenous the ethnobotanical information is. For each usage category, the data were quantified by adding up the individual reports on the uses of each plant. A taxon may be listed in several of the categories of indigenous uses; however, in terms of use reports, each plant could be considered only once per healer in a single category. This means that if one informant used a plant to treat more than one disease in the same category, we considered it as one use report. We compared then the number of use reports (n_{ur}) to the number of species (n_{taxa}) in each category of use. The informant consensus factor (F_{ic}) was then calculated using the following formula: $F_{IC} = (n_{ur} - n_{taxa})/(n_{ur} - 1)$. The consensus method helps identify important and interesting species for future cultural and pharmacological research.

Hot–Cold Score

Each healer was asked to rank the plant as hot, cold, or neutral, which corresponds to their traditional classification system. Hot was scored as + 1, cold as − 1, and neutral as 0. The sum of each healer's individual hot–cold score was divided by the total number of healers interviewed in this study. These values were used to develop a composite hot–cold score as a culture–specific (emic) criterion.

Results

Symptom Categories, Use Reports, and Medicinal Plant Species

Preliminary discussions with the members of the Q'eqchi' Maya Healers Association led to the development of 14 immunomodulatory usage categories that were reclassified into eight categories according to the Cook (1995) ethnobotanical standards (Table 1). The Q'eqchi' immunomodulatory symptom categories include both emic (i.e., culture-specific) and etic/emic (i.e., shared concepts of indigenous and modern medicine) criteria, as the inclusion of both was necessary to capture the complete picture of the healer's understanding of inflammation and the relevant plant species used by them. Symptom categories—such as fevers, headaches, arthritis, and

TABLE 1. IMMUNOMODULATORY USAGE CATEGORIES SURVEYED IN ETHNOBOTANICAL INTERVIEWS. Q'EQCHI' USAGE CATEGORIES, Q'EQCHI' CATEGORY NAMES, CATEGORY DESCRIPTION, HUMORAL CLASSIFICATION, AND COOK (1995) ECONOMIC BOTANY DATA STANDARD CLASSIFICATION ARE PRESENTED. ABBREVIATIONS FOR Q'EQCHI' AND COOK USAGE CATEGORIES ARE PRESENTED IN PARENTHESES.

Q'eqchi' usage category	Q'eqchi' name	Q'eqchi' description	Humoral classification	Cook (1995) usage category
Elevated heart rate, breathing rate (ELE)	Jump'at i musekak	Fast pulse, fast breathing	Hot	Circulatory system disorders (CIR)
Stomach cramps (STO)	Ra muchjej se sa	Cramping in the stomach, intestine, and bowels	Cold	Digestive system disorders (DIG)
Ulcers, heartburn (ULC)	Ra se a'am	Burning in the stomach	Hot	Digestive system disorders (DIG)
Fever (FEV)	Tik	Excess heat and chills	Hot	Infections/infestations (INF)
Arthritis, rheumatism (ART)	No specific name	Stiff, swollen, or painful joints caused by manual work and old age	Cold	Muscular–skeletal system disorders (MUS)
Evil spirit swelling (EVI)	Sipok xban maus	Stiff, swollen, or painful joints caused by evil spirits	Hot	Muscular–skeletal system disorders (MUS)
Hot/cold swelling (HOT)	Kwosol	Stiff, swollen, or painful joints caused by fast temperature change	Cold	Muscular–skeletal system disorders (MUS)
Headache (HEA)	Ra se jolom	Aches and pains in the head	Hot	Pain (PAI)
Insect bites and stings (INS)	Sipok xban kok xul	Insect bites and stings	Hot	Poisonings (POI)
Snake bites (SNA)	Xku xum kanti	Snake bites	Hot	Poisonings (POI)
Allergic rhinitis, hay fever (ALL)		Runny nose, sneezing, itchy eyes	Cold	Respiratory system disorders (RES)
Common cold (COM)	Ra sa jaj'l	Congestion, coughing, sore throat	Hot	Respiratory system disorders (RES)
Boils (BOI)	Saki joj	Boils on skin, caused by infections and impure blood	Hot	Skin/subcutaneous cellular tissue disorders (SKI)
Rash, contact dermatitis (RAS)	Ra sa xtyamp I'bak	Redness, bumps, itchiness on skin	Hot	Skin/subcutaneous cellular tissue disorders (SKI)

rheumatism—are recognized in a similar fashion by both Q'eqchi' healers and modern medical practitioners as being related to inflammation, and are examples of etic/emic criteria. The emic symptom categories by contrast include indigenous criteria such as "swelling caused by evil spirits" or "swelling caused by subjecting the body to a rapid temperature change" (e.g., jumping into a cool river after getting hot from working). While arthritis and rheumatism, evil spirit swelling, and hot/cold swelling may all share similar symptoms, they are recognized by Q'eqchi' healers as having different causes and thus requiring different medicinal plant treatments.

In total, 107 species belonging to 49 families were identified through the ethnobotanical interviews (Table 2). Piperaceae, with 14 medicinal species, was the most used family followed in order by Araceae, Asteraceae, Fabaceae, and Adiantaceae with five or more medicinal species. Many plant families (28) were represented by only one medicinal species.

The members of the QMHA recognized these 107 species as 110 plants, the increase in number being attributable to the healers distinguishing between three phenotypes of *Piper aequale* Vahl., which occur on limestone cliffs, riverbanks, or primary rainforest, and two phenotypes of *Iresine diffusa* Humb. & Bonpl. ex Willd., a green phenotype (Biri tak) and a more red phenotype (Kaki biri tak). Interestingly, five species collected in the wild do not appear in the checklist of vascular plants of Belize (Balick et al. 2001): *Anthurium willdenowii* Kunth. (Araceae), *Philodendron radiatum* Schott

TABLE 2. Q'EQCHI' IMMUNOMODULATORY MEDICINAL FLORA. GENUS SPECIES, Q'EQCHI' COMMON NAME(S), TRANSLATION OF Q'EQCHI' NAME(S), PLANT PART(S) USED (B = BARK, L = LEAF, R = ROOT, S = STEM), HOT–COLD SCORE, FREQUENCY OF UTILIZATION (F_{USE}) VALUES, AND VOUCHER NUMBERS (VN) ARE PRESENTED FOR 107 SPECIES. MEDICINAL SPECIES ARE GROUPED BY PLANT FAMILY (49 FAMILIES TOTAL). VOUCHER NUMBERS REFER TO VOUCHER SPECIMENS DEPOSITED IN EITHER THE HERBARIO JUVENAL VALERIO RODRIGUEZ AT THE UNIVERSIDAD NACIONAL IN COSTA RICA (JVN), OR THE UNIVERSITY OF OTTAWA HERBARIUM (OTT). F_{USE} = 1 USED BY ALL HEALERS.

Family	Genus species	Q'eqchi' name(s)	Translation of Q'eqchi' name(s)	Plant part(s) used	Hot–cold score	F_{use}	CN
Acanthaceae	*Aphelandra aurantiaca* (Scheidw.) Lindl.	Jolom chacmut (no. 1)	Bird's head (Jolom = head; chacmut = a specific bird)	L	– 1.00	1	13,851 (JVR)
	Aphelandra scabra (Vahl) Sm.	Jolom chacmut (no. 2)	See Jolom chacmut (no. 1)	L	– 1.00	1	13,845 (JVR)
	Justicia pectoralis Jacq.	Xucoy'i'kok	Turtle's side (Xucoy = side; i = a; kok = turtle)	L	– 1.00	1	13,844 (JVR)
Adiantaceae	*Adiantum latifolium* Lam.	Roq chit cuan (no. 1)	Black bird's foot (Roq = foot; chit cuan = common black bird)	L	– 0.80	1	13,855 (JVR)
	Adiantum petiolatum Desv.	Roq chit cuan (no. 2)	See Roq chit cuan (no. 1)	L	– 0.80	1	13,931 (JVR)
	Adiantum princeps T. Moore	Roq chit cuan (no. 3)	See Roq chit cuan (no. 1)	L	– 1.00	1	20,307(OTT)
	Adiantum tetraphyllum Humb. & Bonpl. ex Willd.	Roq chit cuan (no. 4)	See Roq chit cuan (no. 1)	L	– 0.80	1	13,939 (JVR)
	Adiantum wilsonii Hook.	Ruj'i'rak'aj'tza	Devil's tongue (Ruj'i'rak = tongue; aj = of; tza = devil)	L	– 1.00	1	13,909 (JVR)
Amaranthaceae	*Iresine diffusa* Humb. & Bonpl. ex Willd.	Biri tak; Kaki biri tak	Go and get a plant that breaks easily (Biri = a plant with nodes that break easily; tak = go and get it); Red Biri tak (Kaki = red)	L	– 0.80	1	13,842 (JVR)
Araceae	*Anthurium willdenowii* Kunth	X'chich maus	Devil's sword (X'chich = sword; maus = devil)	L	– 0.80	1	13,915 (JVR)
	Monstera acuminata K. Koch	Jol jol	Very loose (Jol = loose)	L	– 0.60	1	20,312 (OTT)
	Monstera tuberculata Lundell	Letzeb; Sankil pim	A plant that wraps around something; A plant for rotting sores (Sankil = rotting sores; pim = plant)	L	0.50	0.6	13,853 (JVR)
	Philodendron hederaceum (Jacq.) Schott	Kon chi	Bending down like a snake (Kon = bending down; chi = snake-like)	L	0.00	0.8	20,314 (OTT)
	Philodendron radiatum Schott	Xilix; Xtonal i uxb	Hand-like; where the vine roots (Xtonal = base/bottom; i = of; uxb = vine)	L	0.60	0.8	13,901 (JVR)
	Philodendron schottii K. Koch	Kek'ek ux	Very black vine (Kek = black; ek = black; ux = vine)	L	0.25	0.8	13,930 (JVR)
Araliaceae	*Dendropanax arboreus* (L.) Decne & Planch	Cojl	A big wooden spoon for stirring pots	L, S	1.00	1	13,843 (JVR)

TABLE 2. (CONTINUED).

Family	Genus species	Q'eqchi' name(s)	Translation of Q'eqchi' name(s)	Plant part(s) used	Hot–cold score	F_{use}	CN
Aristolochiaceae	*Aristolochia tonduzii* O.C. Schmidt	Sansara kejen; Santa Maria kejen	Medicinal plant that looks like incense burner (Sansara = clay pot for burning incense; kejen = medicinal plant); Saint Mary's medicinal plant (Santa Maria = Saint Mary; kejen = medicinal plant)	L	1.00	1	13,841 (JVR)
Aspleniaceae	*Bolbitis pergamentacea* (Maxon) Ching	Re'quaxiru	For crazy person (Re = for; quaxiru = crazy person)	L	– 1.00	0.6	13,869 (JVR)
Asteraceae	*Baccharis trinervis* Pers.	Cherek sak	A specific type of grasshopper (Cherek = large square leg grasshopper; sak = grasshopper	L	– 0.60	0.8	13,849 (JVR)
	Matricaria recutita L.	Menseneya (Creole)	Specific name for this plant	L, S	0.25	0.8	13,934 (JVR)
	Mikania leiostachya Benth.	Juruch aj pak	Lizard's back (Jurach = back; aj = of; pak = lizard)	L	– 0.60	1	13,852 (JVR)
	Neurolaena lobata (L.) Cass.	K'a mank	Bitter mango (Ka = bitter; mank = mango)	L	0.00	1	13,927 (JVR)
	Pluchea carolinensis (Jacq.) G. Don	Mai pim (no. 1)	Pain plant (Mai = pain; pim = plant)	L, S	0.60	1	13,907 (JVR)
	Porophyllum ruderale (Jacq.) Cass.	So'sol pim	Vulture plant (So'sol = vulture; pim = plant)	L	– 0.40	0.8	13,848 (JVR)
Begoniaceae	*Begonia glabra* Aubl. Var glabra	Pa'ulul	To make a hole through the brain (Pa = to dig/make a hole through; ulul = brain)	L	– 1.00	1	13,857 (JVR)
	Begonia heracleifolia Schltdl. & Cham.	Rutzaj k'opopo'; Xak pek (no. 1)	Frog cane (Rutzaj = cane plant; k'opopo' = frog); plant growing on rock (Xak = leaf; pek = rock)	L	– 0.40	0.8	13,941 (JVR)
	Begonia nelumbiifolia Schltdl. Cham.	Xak pek (no. 2)	See Xak pek (no. 1)	L	– 0.40	1	13,858 (JVR)
	Begonia sericoneura Liebm	Xak pek (no. 3)	See Xak pek (no. 1)	L	– 0.40	1	13,940 (JVR)
Bignoniaceae	*Macfadyena unguis–cati* (L.) A.H. Gentry	Rixij tzunun	Hummingbird toenails (Rixij = toenails or fingernails; tzunun = hummingbird)	L, R	– 0.67	0.6	13,856 (JVR)
Bromeliaceae	*Pitcairnia punicea* Scheidw.	Kis kim i ha; Mes i ha	Aromatic water plam (Kis = aromatic; kim = plam–like leaf; i = of; ha = water); water broom (Mes = broom; i = of; ha = water)	L	0.20	0.8	13,861 (JVR)

TABLE 2. (CONTINUED).

Family	Genus species	Q'eqchi' name(s)	Translation of Q'eqchi' name(s)	Plant part(s) used	Hot–cold score	F_{use}	CN
Burseraceae	*Bursera simaruba* (L.) Sarg.	Kak kajl; Gumbo limbo (Creole)	Peeling Red (Kak = red; kajl = peeling); specific name for this plant	B	0.50	0.8	13,926 (JVR)
Cactaceae	*Epiphyllum crenatum* (Lindl.) G. Don	Chic'ba'bac (no. 1)	For joining bones (Chic = to join; ba = of; bac = bone)	L	0.60	1	13,864 (JVR)
	Epiphyllum phyllanthus (L.) Haw.	Chic'ba'bac (no. 2)	See Chic'ba'bac (no. 1)	L	0.60	1	13,863 (JVR)
Celastraceae	*Crossopetalum eucymosum* (Loes. & Pittier) Lundell	Se ruj ajaw chan	Boa constrictor's eye (Se = the; ruj = eye; ajaw chan = boa constrictor)	L	– 0.50	0.8	20,335(OTT)
Chenopodiaceae	*Chenopodium ambrosioides* L.	Isqij'i'pur	Spice for shells (Isqij = aromatice plant for cooking; i = for; pur = shells)	L	0.25	0.8	13,865 (JVR)
Commelinaceae	*Tradescantia spathacea* Sw.	Ton kit	Bloody bottom (Ton = base/bottom; kit = blood)	L	– 1.00	0.6	13,902 (JVR)
Convulvulaceae	*Itzaea sericea* (Standl.) Standl. & Steyerm.	Iqbolie pim (no. 1); Saki iqbolie pim	Snake plant (Iqbolie = a specific type of snake; pim = plant); White iqbolie pim (Saki = white)	L	– 1.00	0.8	13,862 (JVR)
Costaceae	*Costus pulverulentus* C. Presl	Kaki chun	Red chun (Kaki = red; chun = this specific plant)	L	– 0.60	0.6	13,859 (JVR)
Crassulaceae	*Kalanchoe pinnata* (Lam.) Pers.	No name		L	– 1.00	0.6	13,935 (JVR)
Cucurbitaceae	*Gurania makoyana* (Lem.) Cogn.	Kum pim	Pumpkin plant (Kum = pumpkin; pim = plant)	L	–1.00	0.4	13,070 (JVR)
	Momordica charantia L.	Sand'ia cho; Sorosi (Spanish)	Rat's watermelon (Sand'ia watermelon; cho = rat); specific name for this plant	L, S	0.60	1	13,866 (JVR)
Davalliaceae	*Nephrolepis biserrata* (Sw.) Schott	Ixqu'oq mo'coch	Cohune palm bending down (Ixqu'oq = bending down; mo'coch = cohune palm)	L	–1.00	1	13,888 (JVR)
Dracaenaceae	*Dracaena americana* Donn. Sw.	Tut	Specific name for this plant	B	0.25	0.6	13,923 (JVR)
Euphorbiaceae	*Croton xalapensis* Kunth	Noq te	Thread tree (Noq = thread; te = tree)	L	0.50	0.8	13,925 (JVR)
Fabaceae	*Acacia cornigera* (L.) Willd.	Subin	Specific name for this plant	L, S	0.25	0.8	20,346 (OTT)
	Desmodium adscendens (Sw.) DC.	Chint pim (no. 1)	Chint plant (Chint = this specific plant; pim = plant)	L, B	0.20	0.8	20,349 (OTT)
	Desmodium axillare var. acutifolium (Kuntze) Urb.	Chint pim (no. 2)	See Chint pim (no. 1)	L	0.20	0.8	13,882 (JVR)

TABLE 2. (CONTINUED).

Family	Genus species	Q'eqchi' name(s)	Translation of Q'eqchi' name(s)	Plant part(s) used	Hot–cold score	F_{use}	CN
	Cojoba graciliflora (S. F. Blake) Britton & Rose	Choql ok te	Cloud bean–pod fruiting tree (Choql = cloud; ok = bean–pod fruit of this tree; te = tree)	L, S	0.67	0.4	13,867 (JVR)
	Mimosa pudica L.	Quare kix	Sleepy kix (Quare = sleepy; kix = this specific plant)	L, S	– 0.60	0.8	13,871 (JVR)
Gesneriaceae	*Besleria laxiflora* Benth.	Jolom masan	Shrimp's head (Jolom = head; masan = shrimp)	L	– 1.00	0.6	20,348 (OTT)
	Codonanthe uleana Fritsch	Cacao pim	Cacao plant (Cacao = *Theobroma cacao*; pim = plant)	L	– 1.00	0.6	13,881 (JVR)
	Drymonia serrulata (Jacq.) Mart.	Baknel pim	Snake plant (Baknel = a specific type of snake; pim = plant)	L, S	– 1.00	1	13,917 (JVR)
Haemodoraceae	*Xiphidium caeruleum* Aubl.	Ixcua'i'kuch	Hawk's food (Ixcua = food; i = of; kuch = hawk)	L, S	– 0.60	1	13,914 (JVR)
Lamiaceae	*Hyptis capitata* Jacq.	Se ruj kaway	Horse's eye (Se = the; ruj = eye; kaway = horse)	L	1.00	1	13,922 (JVR)
	Hyptis verticillata Jacq.	Chu pim	Bad smelling plant (Chu = bad smelling; pim = plant)	L	0.60	1	13,880 (JVR)
	Pectis sp.	Pericón (Spanish)	Specific name for this plant	L, S	0.50	0.4	13,933 (JVR)
Loranthaceae	*Phthirusa pyrifolia* (Kunth) Eichler	Neba pim	Orphan plant (Neba = orphan; pim = plant)	L	– 0.50	0.8	13,878 (JVR)
Malvaceae	*Sida rhombifolia* L.	Mes b'eel	Broom for sweeping (Mes = broom; b'eel = for sweeping)	L	– 0.60	1	13,868 (JVR)
Marcgraviaceae	*Marcgravia gentlei* Lundell	Rubelsa'i'xul	Snake's belly (Rubelsa = belly; i =of; xul = a specific snake)	L	– 1.00	1	13,919 (JVR)
	Souroubea sympetala Gilg.	Hub'ub	Specific name for this plant	L	– 0.75	0.8	13,903 (JVR)
Melastomataceae	*Arthrostemma ciliatum* Pav. ex D. Don	Selek sak	Grasshopper's leg (Selek = leg; sak = grasshopper)	L	– 0.20	0.4	13,873 (JVR)
	Blakea cuneata Standl.	Oxlaho chajom	13-year-old teenage boy (Oxlaho = 13; chajom = teenage boy)	L	– 0.33	0.6	13,874 (JVR)
	Miconia gracilis Triana	Roq muqui	Ground dove's foot (Roq = foot; muqui = ground dove)	L	– 0.60	0.8	13,877 (JVR)
Menispermaceae	*Abuta panamensis* (Standl.) Krukoff & Barneby	Raxi chajom kajam	Green teenage boy vine (Raxi = green or blue; chajom = teenage boy; kajam = vine)	L, B	1.00	0.6	13,906 (JVR)
	Disciphania calocarpa Standl.	Roq maus; Xa'ab maus	Devil's foot (Roq = foot; maus = devil); Devil's shoe (Xa'ab = shoe; maus = devil)	L, S	– 0.60	1	13,876 (JVR)

TABLE 2. (CONTINUED).

Family	Genus species	Q'eqchi' name(s)	Translation of Q'eqchi' name(s)	Plant part(s) used	Hot–cold score	F_{use}	CN
Monimiaceae	*Mollinedia guatemalensis* Perkins	Saki kejen	White medicinal plant (Sake = white; kejen = medicinal plant)	L	– 0.20	1	13,905 (JVR)
Moraceae	*Dorstenia lindeniana* Bureau	Chacbolie kejen	Tommygoff medicinal plant (Chacbolie = yellow–jaw tommygoff snake; kejen = medicinal plant)	L	– 1.00	1	13,875 (JVR)
Orchidaceae	*Oeceoclades maculata* (Lindl.) Lindl.	Iqbolie pim (no. 2); Kurarin re kitche	See Iqbolie pim (no. 1); Kurarin re kitche = this specific plant	L	– 1.00	1	13,900 (JVR)
Passifloraceae	*Passiflora oerstedii* Mast.	Tu kej kejen	Deer breast medicinal plant (Tu = breast; kej = deer; kejen = medicinal plant)	L	0.60	1	13,899 (JVR)
Piperaceae	*Peperomia hirta* C. CD.	Ixcua'i'xul (no. 1)	Snake's food (Ixcua = food; i =of; xul = a specific snake)	L, R, S	– 1.00	1	13,916 (JVR)
	Peperomia macrostachya (Vahl) A. Dietr.	Mai pim (no. 2)	See Mai pim (no. 1)	L, R, S	– 1.00	0.8	13,921 (JVR)
	Peperomia obtusifolia (L.) A. Dietr.	Ixcua ajaw chan	Boa constrictor's food (Ixcua = food; ajaw chan = boa constrictor)	L	– 1.00	0.8	13,533 (JVR)
	Peperomia urocarpa Fisch. & C.A. Mey	Ixcua'i'xul (no. 2)	See Ixcua'i'xul (no. 1)	L, R, S	– 1.00	1	13,541 (JVR)
	Piper aequale Vahl	Kan pom; Pu'chuch remuch kej; Pu'chuch re'tzu'ul	Yellow incense (Kan = yellow; pom = incense); piper plant for cramps (Pu'chuch = piper plant; re= for; much kej = cramps); piper plant for mountain (Pu'chuch = piper plant; re= for; tzu'ul = mountain)	L, S	0.40	1	13,543 (JVR)
	Piper amalago L.	Tziritok	Small and fragile	L	1.00	0.8	20,376 (OTT)
	Piper arboreum Aubl.	Tyut'it pu'chuch (no. 1)	Tied node piper (Tyut = tied; it = node; pu'chuch = piper plant)	L, R, S	1.00	0.6	13,534 (JVR)
	Piper auritum Kunth	Ubel	Specific name for this plant	L	1.00	1	13,536 (JVR)
	Piper glabrescens (Miq.) C. DC.	Pu'chuch rekanil	Piper plant for fear (Pu'chuch = piper plant; re= for; kanil = fear)	L, S	0.60	1	13,538 (JVR)
	Piper hispidum Sw.	Rax pu'chuch	Green piper (Rax = Green or blue; pu'chuch = piper plant)	L, S	1.00	1	13,539 (JVR)
	Piper peltatum L.	Saki tyut it; Tyut it		L, R	– 0.40	0.6	20,381 (OTT)

TABLE 2. (CONTINUED).

Family	Genus species	Q'eqchi' name(s)	Translation of Q'eqchi' name(s)	Plant part(s) used	Hot–cold score	F_{use}	CN
			White tied node (Saki = white; tyut = tied; it = node); Tied node (Tyut = tied; it = node)				
	Piper sanctum (Mig.) Schltl. ex C. CD.	Tyut'it pu'chuch (no. 2)	See Tyut'it pu'chuch (no. 1)	L, S	1.00	0.6	13,535 (JVR)
	Piper tuerckheimii C. CD.	Cux sawi	Specific name for this plant	L	0.20	1	13,540 (JVR)
	Piper yucatanense C.CD.	Che pu'chuch; Pu'chuch rebakel	Piper tree (Pu'chuch = piper plant; che = tree); piper plant for bones (Pu'chuch = piper plant; re= for; bakel = bones)	L, S	1.00	0.8	13,537 (JVR)
Poaceae	*Cymbopogon citratus* (DC.) Stapf	Kis kim	Aromatic plam (Kis = aromatic; kim = plam-like leaf)	L	0.00	1	20,385 (OTT)
Rhamnaceae	*Gouania polygama* (Jacq.) Urban	Kek xeb	Black wax (Kek = black; xeb = wax)	L	– 1.00	1	13,895 (JVR)
Rubiaceae	*Gonzalagunia panamensis* (Cav.) K. Schum.	Tzu'ul che	Mountain tree (Tzu'ul = mountain; che = tree)	L, S	– 0.20	1	13,898 (JVR)
	Hamelia patens Jacq.	Chaj max; Jolom'i'posp	Pine tree spider monkey (Chaj = pine tree; max = spider monkey); matchstick head (Jolom = head, i = of, posp = matchstick)	L	– 0.40	1	13,897 (JVR)
	Hoffmannia ghiesbreghtii (Lem.) Hemsl.	Mai pim (no. 3); Kaki mai pim	See Mai pim (no. 1); Red mai pim (Kaki = red)	L	– 0.60	1	13,908 (JVR)
	Psychotria pleuropoda Donn. Sm.	Kolaras	Beaded Maya necklace	L	– 0.33	0.6	13,896 (JVR)
Rutaceae	*Ruta graveolens* L.	Ruda (Spanish)	Rue	L	– 1.00	0.4	13,932 (JVR)
Sapindaceae	*Paullinia costata* Schltdl. & Cham.	Korona kix	Crown of thorns (Korona = crown; kix = thorns)	L	0.20	1	13,891 (JVR)
	Serjania mexicana (L.) Willd.	Bolon Yok	Specific name for this plant	L	1.00	0.8	13,942 (JVR)
Schizaeaceae	*Lygodium heterodoxum* Kunze	Ruxb'i'kaak (no. 1)	Thunder vine (Ruxb = vine; i = of; kaak = thunder)	L	– 1.00	1	20,394 (OTT)
	Lygodium venustum Sw.	Ruxb'i'kaak (no. 2)	See Ruxb'i'kaak (no. 1)	L	– 1.00	1	13,886 (JVR)

TABLE 2. (CONTINUED).

Family	Genus species	Q'eqchi' name(s)	Translation of Q'eqchi' name(s)	Plant part(s) used	Hot–cold score	F_{use}	CN
Selaginellaceae	*Selaginella* sp.	Xquq'i'pek	Hangs off of rock (Xquq = hangs off; i = of; pek = rock)	L	– 1.00	1	13,889 (JVR)
	Selaginella umbrosa Lem. ex Hieron	Choql pim	Cloud plant (Choql = cloud; pim = plant)	L	– 1.00	1	13,920 (JVR)
Smilacaceae	*Smilax* sp.	Ruchire ak; Sarsafaria (Spanish)	Peccary teeth (Ruchire = teeth; ak = pecarry); specific name for this plant	L	0.00	0.4	13,918 (JVR)
Solanaceae	*Cestrum megalophyllum* Dunal	Ik che	Pepper tree (Ik = pepper; che = tree)	L	– 0.40	1	13,892 (JVR)
	Solanum nudum Dunal	Na'i'pajl	Mother of pajl (Na = mother, i = of; pajl = a specific plant)	L	0.40	0.8	20,400 (OTT)
	Solanum torvum Sw.	Pajl	Specific name for this plant	L	0.00	0.8	13,890 (JVR)
Verbenaceae	*Cornutia grandifolia* (Schltdl. & Cham.) Schauer	Roq xa'an	Old lady's foot (Roq = foot; xa'an = old lady)	L	– 0.20	1	13,910 (JVR)
	Cornutia pyramidata L.	Hob'lob'te	Hollow tree (Hob'lob = hollow; te = tree)	L	0.50	0.8	13,885 (JVR)
	Lantana trifolia L.	Tulush	Dragonfly (Tulush = dragonfly)	L	0.60	1	13,884 (JVR)
	Stachytarpheta frantzii Pol.	Xtye aj pak	Lizard's tail (Xtye = tail; aj = of; pak = lizard)	L, S	– 1.00	0.8	13,883 (JVR)
Vitaceae	*Cissus microcarpa* Vahl.	Roq ab	Specific name for this plant	L, S	– 0.60	1	13,887 (JVR)
Zingiberaceae	*Renealmia aromatica* (Aubl.) Griseb.	Cux tzi	Specific name for this plant	L	0.80	1	13,840 (JVR)
	Zingiber officinale Roscoe	Xan xir	Specific name for this plant	R	1.00	0.8	20,425 (OTT)

(Araceae), *Matricaria recutita* L. (Asteraceae), *Miconia gracilis* Triana (Melastomataceae), and *Peperomia hirta* C. CD. (Piperaceae). Also of note, two species, *Pectis* sp. (Asteraceae) and *Ruta graveolens* L. (Rutaceae), were purchased at local markets and two non-wild species, *Cymbopogon citratus* (DC.) Stapf (Poaceae) and *Zingiber officinale* Roscoe (Zingiberaceae), were cultivated by the members of the QMHA at the Itzamma ethnobotanical garden.

Of the 107 species collected, the Q'eqchi' healers used several species interchangeably resulting in 99 unique species uses, which generated a total of 1359 use reports (Fig. 1). Among the Q'eqchi' symptom classifications, headaches, fevers, and stomach cramps generated the most use reports, at 234, 208, and 128 use reports, respectively. This represents 97 species used to treat headaches, 87 species used to treat fevers, and 73 species used to treat stomach cramps. Musculature–skeletal system disorders, pain, and digestive system disorders represented the most use reports in the Cook (1995) classification system, with 309, 234, and 222 use reports respectively, or 75, 97, and 84 species used. The symptom category of allergies generated the fewest use reports, at six, and the fewest species used, also at six. This symptom category falls into the Cook (1995) classification of respiratory system disorders, which included the fewest use reports, at 51, and contained the smallest number of species used, at 31. Healers most often used each plant species alone, but a few combination therapies were noted, but are not be analyzed here.

Hot–Cold Classification

The symptom categories recognized by the members of the QMHA as well as the plants used to treat these symptoms are also classified as being with hot, cold, or hot and cold (Table 1, Table 2). Of the 14 symptom categories recognized by the healers, ten are classified as being hot symptoms and four are classified as being cold symptoms, indicating inflammation is traditionally classified as a hot condition for the most part. Of the 107 plants used to treat inflammation, 62 species (58%) are classified as cold plants (negative hot–cold score), 40 species (37%) are classified as hot plants (positive hot–cold score), and five species (5%) are classified as neutral plants (hot–cold score of 0). The Maya healers explained they often employ the principle of opposites, as hot symptoms, such as many of those related to inflammation, are preferentially treated with cold plants. Therefore, it is not surprising that a majority of plants used by the QMHA in the

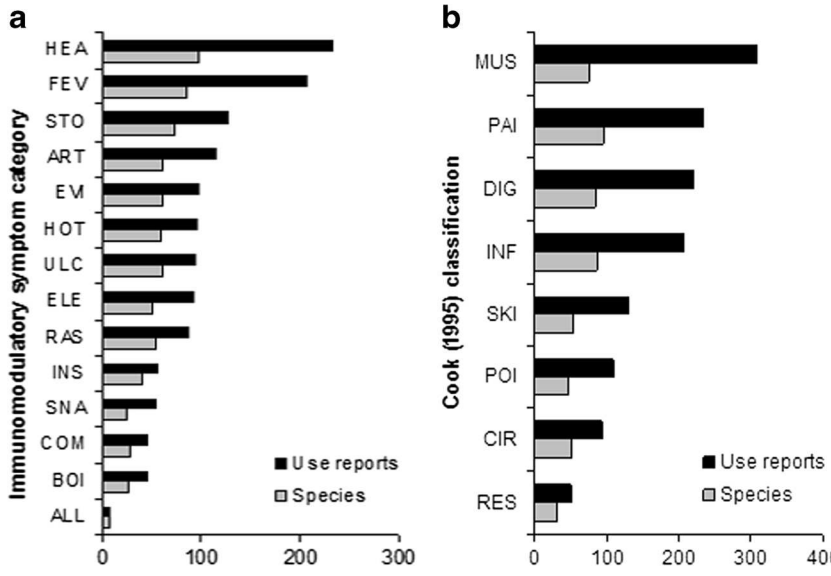

Fig. 1. Distribution of use reports and medicinal plant species to immunomodulatory usage categories (**a**) and Cook (1995) classification (**b**). Total use reports = 1359; total species = 107. Plant species may appear in more than one category.

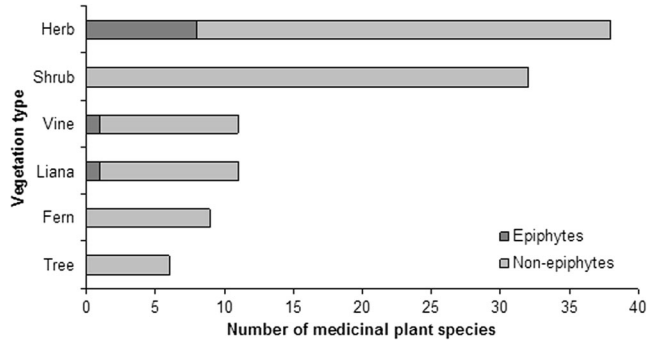

Fig. 2. Classification of the 107 immunomodulatory plant species in terms of life form type, assessed by researchers.

treatment of inflammatory-related symptoms are classified as cold plants.

Vegetation Types and Habitat

The 107 species inhabited six different vegetation types, with herbaceous and shrub growth forms being the most widely used with 38 and 32 species, respectively (Fig. 2). Vine and liana vegetation types included 11 species each, and the remaining 15 species were either ferns or trees. In total, 10 species were epiphytic, eight of which were herbs. The majority of plants species, 83 in total, were collected from broadleaf subtropical moist forest, 36 coming from 2° lowland broadleaf subtropical moist forest, 24 from 1° elevated lowland broadleaf subtropical moist forest, and 23 from 2° elevated lowland broadleaf subtropical moist forest (Fig. 3). Sixteen species were collected from managed open yards, six from milpas, and two from the market in Punta Gorda. In total, five species were collected from riverbanks exclusively. The Q'eqchi' Maya immunomodulatory pharmacopeia contains species from a wide variety of environments. However, the vast majority, 78%, are collected from broadleaf subtropical moist forest, indicating that the immunomodulatory ethnobotany of the Q'eqchi' Maya is predominately a rainforest ethnobotany.

Healer Consensus

Frequency of use data for species (F_{use}) showed that 56 species (52% of the total) were used by all healers (Fig. 4). The F_{use} value was 0.8 for 30 species, 0.6 for 15 species, and 0.4 for 6 species. When considering symptom categories (Table 3), the Trotter and Logan informant consensus factor (F_{ic}) was greater than 0.5 for the top three categories of headache, fever, and snake bites. When the Cook classification was used, the F_{ic} values were even higher (all > 0.4) and > 0.6 for the top three categories (Table 4). As shown in Table 3, the number

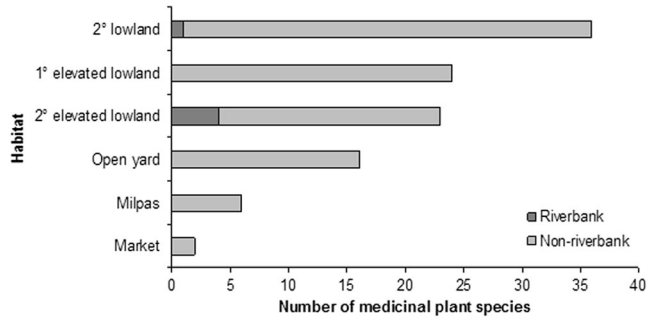

Fig. 3. Classification of the 107 immunomodulatory plant species in terms of habitats assessed by researchers. 2° lowland is low elevation secondary forest near the Atlantic Ocean, 1° elevated lowland is primary forest found on the Maya mountains, and 2° lowland is secondary forest on the Maya mountains (all are semi-evergreen tropical forest). Milpas are shifting agriculture fields and Market represent plants sold in markets.

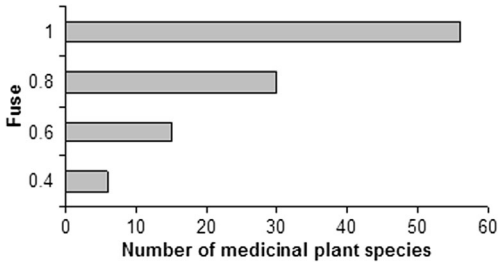

Fig. 4. Distribution of the frequency of utilization (F_{use}) of the 107 immunomodulatory plants species among the five healers. An $F_{use} = 1$ indicates use by all healers and 0 by none of the healers.

of taxa and use reports for symptom categories used to calculate F_{ic} was substantial ($N_{taxa} > 25$, $N_{ur} > 40$) with the exception of allergies. Overall, these results show a remarkable consensus on both useful plants and symptom category treatments, especially when we note that the healers were interviewed separately and reported being trained by different individuals in different villages.

Discussion

A major finding of this study is that the treatment of inflammation is an important focus in Q'eqchi' Maya medicine. In particular, 14 Q'eqchi' usage categories were found and over 100 species used for these symptoms were identified. The most common treatment categories are headaches, fevers, and stomach cramps in both use reports and number of taxa used. The most preferred family is Piperaceae, in terms of the number of species used, while five families have five or more species represented. Plants from the rainforest are clearly preferred, reflecting the healer's belief that relatively undisturbed forests provide more potent medicines. Finally, there is strong consensus among healers for plant species used and within usage categories.

Comparing these results to other Mesoamerican ethnobotanical studies, it was found that a relatively large proportion of medicinal plant treatments are classified in usage categories associated with inflammation. Of the plant species used by Yucatec Maya healers in southern Mexico, the usage categories of gastrointestinal system disorders, dermatological conditions, and illnesses associated with pain or fever represented 35%, 19%, and 13%, respectively (Ankli et al. 1999). In an ethnobotanical survey of Popoluca and Mixe healers in Mexico, dermatological conditions, gastrointestinal conditions, and illnesses associated with pain or fever represented a large proportion of the medicinal flora used by both of these groups (Leonti et al. 2003). In the case of the Popoluca healers, dermatological conditions, gastrointestinal conditions, and illnesses associated with pain or fever made up 21.7%, 18.5%, and 8.5% of the total medicinal flora, respectively. Among the Mixe healers, dermatological conditions, gastrointestinal conditions, and illnesses associated with pain or fever made up 20%, 20.6%, and

TABLE 3. INFORMANT CONSENSUS FACTORS (F_{IC}) FOR EACH Q'EQCHI' IMMUNOMODULATORY SYMPTOM CATEGORY WITH DETAILS OF THE NUMBER OF TAXA (N_{TAXA}) AND THE NUMBER OF USE REPORT (N_{UR}). A TAXON MAY BE LISTED IN SEVERAL OF THE IMMUNOMODULATORY USAGE CATEGORIES.

Q'eqchi' usage category	N_{taxa}	N_{ur}	F_{ic}
Headache (HEA)	97	234	0.59
Fever (FEV)	87	208	0.58
Snake bites (SNA)	25	54	0.55
Arthritis, rheumatism (ART)	62	115	0.46
Elevated heart rate, breathing rate (ELE)	52	93	0.45
Stomach cramps (STO)	73	128	0.43
Boils (BOI)	26	44	0.42
Rash, contact dermatitis (RAS)	54	88	0.39
Common cold (COM)	28	45	0.39
Hot/cold swelling (HOT)	60	96	0.38
Evil spirit swelling (EVI)	62	98	0.37
Ulcers, heartburn (ULC)	62	94	0.34
Insect bites and stings (INS)	40	56	0.29
Allergic rhinitis, hay fever (ALL)	6	6	0.00
	107	1359	

TABLE 4. INFORMANT CONSENSUS FACTORS (F_{IC}) FOR EACH COOK (1995) CLASSIFICATION WITH DETAILS OF THE NUMBER OF TAXA (N_{TAXA}) AND THE NUMBER OF USE REPORT (N_{UR}). A TAXON MAY BE LISTED IN SEVERAL OF THE IMMUNOMODULATORY USAGE CATEGORIES.

Cook usage category (1995)	N_{taxa}	N_{ur}	F_{ic}
Muscular–skeletal system disorders (MUS)	75	309	0.76
Digestive system disorders (DIG)	84	222	0.62
Skin/subcutaneous cellular tissue disorders (SKI)	54	132	0.60
Pain (PAI)	97	234	0.59
Infections/infestations (INF)	87	208	0.58
Poisonings (POI)	47	110	0.58
Circulatory system disorders (CIR)	52	93	0.45
Respiratory system disorders (RES)	31	51	0.40
	107	1359	

16.5% of the total medicinal flora, respectively. A consensus analysis carried out by Heinrich et al. (1998) revealed that gastrointestinal system disorders and dermatological conditions had F_{ic} values of 0.71 and 0.52, respectively, indicating a strong degree of consensus for treatments within these usage categories by Yucatec healers in Mexico, and comparable to the F_{ic} values reported in this study. Taken together, these results indicate that various traditional Maya healers in Mexico, as seen in the Q'eqchi' Maya of Belize, possess a large proportion of medicinal plant treatments with potential immunomodulatory activity and that the degree of consensus within these groups is high for these usage categories. The F_{ic} value is only one of several ways to calculate consensus. For example, Romney et al. (1986) suggested using a factor analysis to evaluate cultural consensus and to determine how strong it is. Consensus information is important to determine culturally important plants that can prioritize pharmacological assessment, conservation, cultivation, education, and practical use. In our collaboration with Cree communities, for instance, the quantitative prioritization of culturally important plants (Leduc et al. 2006) led to an in-depth study of five medicinal and food species that are now assisting Cree communities to address a growing type 2 diabetes problem.

Our finding that the immunomodulatory ethnobotany of the Q'eqchi' Maya is predominately a rainforest ethnobotany is counter to the findings of other researchers who found significant representation of weeds in the medicinal floras of the Highland Maya in Chiapas, Mexico, and in the medicinal flora of native North Americans (Stepp and Moerman 2001). The explanation provided by the Q'eqchi' healers for their preference is that potent medicinal herbs must be collected in undisturbed (and therefore sacred) forest settings.

Although we did not analyze the data formally, the reports of humoral classification were quite consistent among healers. This is not the case in previous studies with Guatemalan women, who demonstrated wide variation in responses (Garro 1986). A possible explanation is that the healers are medicinal plant experts trained by a previous generation of elders following a defined system, and are proud and protective of their ability to retain a large quantity of plant-specific information. The Guatemalan women may have considered plant classification less seriously.

Further study of plant family selection will be considered in the future. Moerman (1991) developed a regression method to identify medicinally preferred or underused families, while alternative updated mathematical analyses as described in Turi and Murch (2013) could also be applied.

In a priority setting workshop between the QMHA, local health workers, and researchers, the healers expressed their sincere desire to see Maya medicine recognized nationally and internationally as a safe and effective practice. The workshop recommendation to achieve that goal was to study the plants scientifically. Laboratory study of anti-inflammatory activity of one prominent Q'eqchi' medicinal plant, *Neurolaena lobata*, has already been undertaken (Walshe-Roussel et al. 2013). Using a bioassay with lipopolysaccharide stimulated monocytes, this study revealed greater activity in lowering TNF-α production by *N. lobata* extracts and isolated active principles compared to the well-known commercial medicinal plant, feverfew, and its active principle parthenolide. Clearly, there is a pharmacological basis to the use of this and possibly other species.

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