Proving that Traditional Knowledge Works: The antibacterial activity of Northern Peruvian medicinal plants

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Research

Abstract

Bacterial infections and inflammation are among the ailments treated by traditional healers. The World Health Organization has expressed high interest in Traditional Medicine (TM), and it is important to demonstrate scientifically that the remedies employed in folk medicine are indeed therapeutically active. In order to evaluate the antibacterial activity of species used in traditional medicine in Northern Peru, 525 plant samples of at least 405 species were tested in simple agar-bioassays for antibacterial activity under simple laboratory conditions in a private clinic in Trujillo, Peru. Antibacterial activity was investigated against *Staphylococcus aureus* Rosenbach 1884, *Escherichia coli* (Migula 1895) Castellani & Chalmers 1919, *Salmonella enterica* Typhi (ex Kauffmann & Edwards 1952) Le Minor & Popoff 1987, and *Pseudomonas aeruginosa* (Schröter 1872) Migula 1900. The aim of the study was to scientifically test whether plants used in TM for the treatment of infections showed antibacterial activity, and to delineate a number of candidates for further in-depth study of their Minimum Inhibitory Concentration (MIC) and toxicity. One-hundred-ninety-three ethanolic extracts and 31 water extracts were active against *S. aureus*. In twenty-one cases only the water extract showed activity. None of the aqueous extracts were active against the other three bacteria, with the activity of the ethanolic extracts also much reduced, as only 36 showed any activity against *E. coli*, and 3 each against *S. enterica* Typhi and *P. aeruginosa*. Two-hundred-twenty-five extracts came from species that are traditionally employed against bacterial infections. One-hundred-sixty-six (73.8%) of these were active against at least one bacterium. Of the three-hundred extracts from plants without traditional antibacterial use, only 96 (32%) showed any activity Plants used for respiratory disorders, inflammation/infection, wounds, diarrhea, and to prevent post partum infections were efficacious in 70-88% of the tests. Plants used for “kidney inflammation” had a much lower efficacy against bacteria and fell within the range of species that are traditionally used to treat other bodily disorders.

Resumen

Infecciones bacterianas e inflamación se encuentran entre las enfermedades tratadas por curanderos tradicionales. **La Organización Mundial de Salud se ha expresada como altamente interesada en la Medicina Tradicional, y es importante demostrar científicamente que los remedios usados en la medicina popular de veras son terapéuticamente activos**. **En este trabajo evaluamos la propiedad antibacteriana de** 525 **muestras de plantas medicinales del Perú septentrional de mínimo** 405 **especies contra** *Staphylococcus aureus* Rosebach 1884 *Escherichia coli* (Migula

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1895) Castellani & Chalmers 1919, *Salmonella enterica* Typhi (ex Kauffmann & Edwards 1952) Le Minor & Popoff 1987 **e** *Pseudomonas aeruginosa* (Schröter 1872) Migula 1900, **usando un método de difusión en agar bajo de condiciones simples de laboratorio en Trujillo, Perú**. **La meta de este estudio fue de científicamente probar si plantas usadas en la Medicina Tradicional para tratar infecciones mostraron actividad antibacteriana, y para delinear candidatos para estudios futuros de Concentración Inhibitoria Mínima y toxicidad**. **Ciento noventa y tres extractos etanolicos y 31 extractos en agua mostraron actividad en contra de** *S. aureus*. **En 21 casos solo los extractos acuosos fueron eficaces**. **Ninguno de los extractos acuosos tuvo actividad contra las otras bacterias, y solo 36 de los etanolicos mostraron eficaz contra** *E. coli*, **y 3 en cada caso contra** *S. enterica* Typhi **e** *P. aeruginosa*. **Doscientos veinticinco extractos pertenecieron a especies tradicionalmente usadas como antibacterianas**. **De estos** 73.8% **fueron activos**. **De los** 300 **extractos de plantas no tradicionalmente usadas contra bacterias**, **solo** 32% **tuvieron un efecto positive**. **Plantas usadas para el tratamiento de infecciones respiratorias**, **inflamación**/**infección**, **heridas**, **diarrea e infecciones después del parto fueron eficaces en** 70-88% **de los casos**. **Plantas usadas para inflamaciones de los riñones y otros desordenes tuvieron una eficaz mucho mas baja en contra de bacterias**.

Introduction

In developing countries, Traditional Medicine (TM) is often the only accessible and affordable treatment available. In Latin America, the World Health Organization (WHO) Regional Office for the Americas (AMRO/PAHO) reports that 71% of the population in Chile and 40% of the population in Colombia has used TM. In many Asian countries TM is widely used, even though Western Medicine is often readily available. In Japan, 60–70% of allopathic doctors prescribe traditional medicines for their patients. In the US the number of visits to providers of Complementary Alternative Medicine (CAM) now exceeds by far the number of visits to all primary care physicians (WHO 1999a, b, 2002).

CAM is becoming increasingly popular in many developed countries. Forty-two percent of the population of the U.S.A. have used CAM at least once (WHO 1998), and a national survey reported the use of at least one of 16 alternative therapies increased from 34% in 1990 to 42% in 1997 (UNCTD 2000).

The expense for the use of TM and CAM is exponentially growing in many parts of the world. The 1997 out-of-pocket CAM expenditure was estimated at $ 2.7 billion in the U.S.A. The world market for herbal medicines based on traditional knowledge was estimated at US$60 billion already over a decade ago (Breevort 1998). It is however important to demonstrate scientifically that the remedies employed in folk medicine are indeed therapeutically active (Baker *et al*. 1995, Cox & Balick 1994, Elisabetsky & Castilhos 1990, Farnsworth *et al*. 1985, Muñoz & Sauvain 2002, Schultes 1994).

Peru is a country rich in biodiversity. For millennia, traditional healers have used the flora to treat ailments. The same plants are still being used today. Traditional Medicine continues to be very popular since a large part of the population has either no access to, or cannot afford, Western Medicine. Bacterial infections and inflammation are among the ailments treated by traditional healers. Northern Peru is believed to be the center of the Central Andean Health Axis (Camino 1992, 1999), and traditional medicinal practices in this region remain an important component of everyday life (Bussmann 2006, Bussmann & Sharon 2006, De Feo 1992, Joralemon & Sharon 1993, Polia 1988, Sharon 1978, 1980, 1994, 2000, Sharon & Bussmann 2006). TM is also gaining respect by national governments and health providers. Peru's National Program in Complementary Medicine and the Pan American Health Organization recently compared Complementary Medicine to allopathic medicine in clinics and hospitals operating within the Peruvian Social Security System (EsSalud 2000). According to the WHO (2002), the sustainable cultivation and harvesting of medicinal plant species is one of the most important challenges in the next few years. The WHO has expressed high interest in TM.

Plants with potential medicinal activity have recently come to the attention of Western scientists, and studies have reported that some are bioactive (e.g., Perumal Samy & Ignacimuthu 2000). Potentially active compounds have been isolated from a few of the plants tested (D'Agostino *et al*. 1995 a, b, Okuyama *et al*. 1994, Rodriguez *et al.* 1994, Umana & Castro 1990).

Plant species from the Cordillera Blanca, one of the high-altitude areas of Peru, have been studied in recent years for their antimicrobial, anti-cancer, and wound-healing activities (Bussmann *et al.* 2008, Hammond *et al*. 1998, Lee *et al.* 1999, Neto *et al.* 2002, Villegas *et al.* 1997). However, despite the fact that the center of healing traditions in Northern Peru is located in the Trujillo / Chiclayo coastal region, no studies had been undertaken in this area until the work of the Minority Health Disparity International Research Training (MHIRT) Peru.

In this communication we report on antibacterial assays for 391 plant species with a wide range of traditional uses, conducted under simple laboratory conditions in a private clinic in Trujillo. The goal of this investigation was to validate the medicinal use of these plants. We hypothesize that plants that are traditionally used to treat illnesses caused by bacteria have a higher likelihood to being efficacious than plants that are not used traditionally as anti-

bacterials, in particular plants that are normally employed for purely spiritual healing purposes. However, we hypothesize that plants that are employed as baths for spiritual cleansing, and thus come in direct contact with the skin of the patient, might have measurable antibacterial effects, while plants that are used in protective amulets (**seguros**) are not active.

Materials and Methods

Plant Material

Plants in Peru were collected in the field, in markets, and at the homes of traditional healers (**curanderos**) in Northern Peru (Figure 1) in August-September 2001, July-August 2002, July-August 2003, June-August 2004, July-August 2005, July-August 2006, June-August 2007, June-August 2008, March-April 2009 and June-August 2009. A total of 116 informants (6 healers and 110 market venders, of which 20 also acted as healers) in the Trujillo and Chiclayo area were interviewed using structured questionnaires. The informants were always provided with fresh plant material, either collected with them, by them, or available at their market stands. The questionnaires did not include any leading reference as to disease concepts. The participants were only asked simple questions along the lines "What is this plant used for, which part, which quantity, how is it prepared, are any other plants added to the mixture." All questions were asked in the same order. All informants were of Mestizo origin, and spoke only Spanish as their native language. The study covered the four existing medicinal plant markets of the region, and included all venders present. All interviews were conducted with the same set of participants. The allopathic disease concept of "infection" was found to cover not only topical bacterial, viral and fungal diseases, but also external and internal inflammatory processes, when looked at from the local healing perspective. For this reason, all plants used to treat such symptoms were included in the study. The specimens are registered under the collection series "RBU/PL," "ISA," "GER," "JULS," "EHCHL," "VFCHL," "TRUBH," and "TRUVANERICA," depending on the year of fieldwork and collection location. Surveys were conducted in Spanish by fluent speakers. Surveyors would approach healers, collectors and market vendors and explain the premise for the study, including the goal of conservation of medicinal plants in the area.

Vouchers of all specimens were deposited at the Herbario Truxillensis (HUT, Universidad Nacional de Trujillo), and Herbario Antenor Orrego (HAO, Universidad Privada Antenor Orrego Trujillo). In order to recognize Peru's rights under the Convention on Biological Diversity, most notably with regard to the conservation of genetic resources in the framework of a study treating medicinal plants, the identification of the plant material was conducted entirely in Peru. Plant material was identified by the authors, using available floras as indicated in the nomenclature section, as well as herbarium vouchers in the herbaria where material was deposited. No plant material was exported in any form whatsoever.

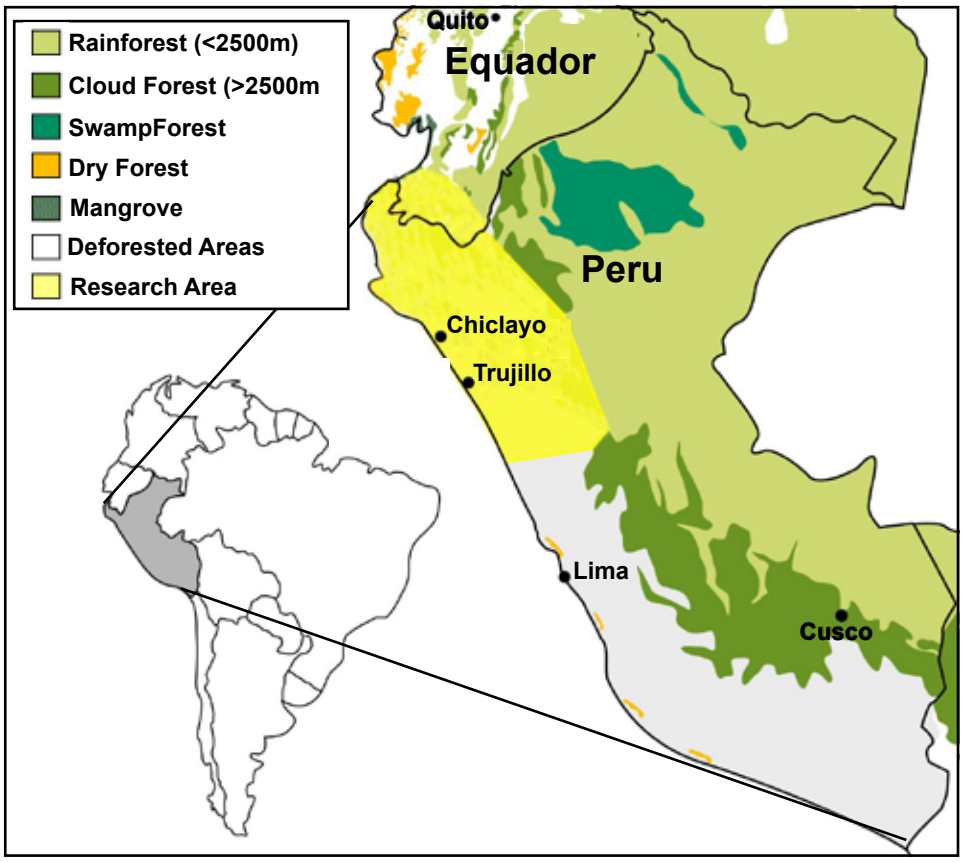

Figure 1. Trujillo and Chiclayo research area of northern Peru.

Nomenclature

The nomenclature of genera and species follows the Catalogue of the Flowering Plants and Gymnosperms of Peru (Brako Zarucchi 1993) and the Catalogue of the Vascular Plants of Ecuador (Jørgensen & León-Yanez 1999). Species were identified using the available volumes of the Flora of Peru (McBride 1936-1981), as well as Jørgensen and Ulloa Ulloa (1994), Pestalozzi (1998), and Ulloa Ulloa and Jørgensen (1993), and the available volumes of the Flora of Ecuador (Sparre & Harling 1978-2009), and reference material in the herbaria HUT, HAO, QCA, LOJA and QCNE. The plant family nomenclature was updated using the TROPICOS database (Tropicos 2010) which follows the Angiosperm Phylogeny Working Group III system of classification.

Disease concepts

In the context of our study, healers and market vendors used the terms “inflammation” and “infection” interchangeably for any indication that, to their understanding, was caused by a bacterial infection. We maintain this concept by simply using “inflammation” as a term that signifies potential antibacterial activity. In addition, we hypothesize that plants employed by healers for their concepts of “bronchitis, pneumonia, cough, wounds, diarrhea, kidney and urinary tract inflammation, blood purification and postpartum infections” also to be antibacterial, because in all these cases a bacterial infection could be suspected.

On the contrary, plants used to treat illnesses described as “diabetes, high blood pressure, arthritis, asthma, intestinal discomfort, or used as antihelminthics, anti-parasitics, menstrual regulation, abortion, contraceptive” etc. were clearly seen by the healers involved as non-antibacterial. We maintained this concept for our study.

A large part of the Peruvian pharmacopoeia (over 40%, Bussmann & Sharon 2006) is employed for “spiritual” healing. In such cases patients are either subjected to a healing bath, thus an herbal concoction coming in direct contact with the skin of the patient, or receive a **seguro**, a flask or bottle containing herbs in alcohol. The latter however is not ingested or allowed to come in direct contact with the patient in any way, but rather serves basically as an amulet. Because of their high abundance, “spiritually” used plants provide an ideal comparison group to antibacterial plants. In addition, cleansing baths are often employed when the healer suspects that sorcery has caused an illness, often manifesting as visible inflammation. For this reason, we hypothesized that plants of this kind are in fact antibacterial, although the healers would not mention them when addressing the western effect concept.

Preparation of Extracts

For each species tested, above ground material (in case of trees: leaves or bark as indicated by the collaborating healers) was collected during the same time period to avoid any seasonal variations, and the entire material was used for extract preparation. This corroborates with the traditional preparation (Bussmann & Sharon 2006). Plant material was dried at 35°C for three days. After drying, the material was ground with an industrial grinder, and 2 samples of 5g of plant material each were weighed out. Traditionally most plants are prepared in water extracts. In order to investigate if this method yielded the best antibacterial results, or if an ethanol extraction would prove more effective against bacteria, one sample was submerged in 100ml of 96% ethanol and left to macerate for 7 days, while another sample was submerged in 100ml of boiling distilled water and left to macerate for 24h. After maceration the plant material was filtered using standard 10cm filters and 100ml 96% ethanol was added to the water extracts to allow faster solvent removal. The solvent was then evaporated to complete dryness using a standard Buchi rotary-evaporator. The resulting dry extracts were re-suspended in 5ml distilled water. In order to determine the real concentration of each extract, 1ml of previous homogenization of the respective extracts was removed and again completely oven-dried and then weighed to determine the exact amount of extract per ml of final solution.

Antimicrobial assays

Bacteria

Staphylococcus aureus Rosenbach 1884 ATCC 25923, *Escherichia coli* (Migula 1895) Castellani & Chalmers 1919 ATCC 25922, *Salmonella enterica* (ex Kauffmann & Edwards 1952) Le Minor & Popoff 1987 serogroup Typhi (from a patient sample), and *Pseudomonas aeruginosa* (Schröter 1872) Migula 1900 (from a patient sample) were used for the current study.

Bioassays

The antibacterial activity of the crude plant extracts was determined using an agar-diffusion method (Koneman *et al.* 1997). Bacterial strains were obtained as listed above. Bacterial cultures were grown on 5% sheep red blood agar (SBA) and then inoculated onto Mueller-Hinton Agar (PML) for testing.

Following the initial incubation, bacteria were suspended in 10ml of distilled water and their concentration equilibrated to a 0.5 McFarland standard. Using a sterile cotton swab, each sample was transferred onto Mueller-Hinton Agar. Six millimeter blank paper disks were then saturated with 10µl of each plant extract, dried, and applied to the agar surface. Disks with Doxycycline (for *S. aureus* assays, 3µg/ml, 17mm inhibition), Ampicillin (for *E. coli*

assays 1µg/ml, 15mm inhibition), Ceftriaxone (for *S. enterica* Typhi assays, 3µg/ml, 8mm inhibition) and Ciprofloxacin (for *P. aeruginosa* assay, 0.5µg/ml, 10mm inhibition) were applied as controls. These respective antibiotics were chosen because they are often employed as first line antibiotics in the respective bacterial infections. Disks with distilled water were used as negative controls. Plates were incubated at 37°C. After 24h, zones of inhibition appearing around disks were measured and recorded in millimeters. At least three replicates were run for each assay. The antibiotic controls showed an inhibition zone of at least 6mm after 24h exposure in all assays. Extracts from plant species were considered anti-bacterially active if the inhibition zone was least 6mm.

Results

In order to evaluate the antibacterial activity of species used in TM in Northern Peru, 525 plant samples of at least 405 species were tested in simple agar-bioassays for antibacterial activity against *S. aureus*, *E. coli*, *S. enterica* Typhi and *P. aeruginosa*. Table 1 shows the results of the antibacterial assays. A much larger number of ethanolic plant extracts showed any antibacterial activity compared to water extracts for all antibacterial activity. One-hundred-ninety-three ethanolic extracts and 31 water extracts were active against *S. aureus*. In twenty-one cases only the water extract showed activity (for all bacterial species) compared to ethanol only. None of the aqueous extracts were active against the other three bacteria, with the activity of the ethanolic extracts also much reduced, as only 36 showed any activity against *E. coli*, and 3 each against *S. enterica* Typhi and *P. aeruginosa*. Eighteen ethanol extracts were effective against both *E. coli* and *S. aureus*, while in two cases the ethanol extract showed activity against *E. coli* and the water extract against *S. aureus*. The ethanol extract of *Dioscorea trifida* L.f. was effective against *E. coli*, *S. aureus* and *P. aeruginosa*. *Caesalpinia spinosa* (Molina) Kuntze was the only species that showed high activity against all bacteria, including *S. enterica* Ttyphi and *P. aeruginosa*, when extracted in ethanol. This is of particular interest for potential further research.

Two-hundred-twenty-five extracts came from plant species that are traditionally employed against bacterial infections. One-hundred sixty-six (73.8%) of these were active against at least one bacterium. Of the three-hundred extracts from plants without traditional antibacterial use, only 96 (32%) showed any activity (Figure 2). This shows clearly that plants traditionally used as antibacterial had a much higher likelihood to be antibacterially active than plants without traditional anti-bacterial use. However, the efficacy of plants used traditionally for antibacterial related applications did vary, which underlines the need for studies aiming to clearly understand traditional disease concepts. Plants used for respiratory disorders, inflammation/infection, wounds, diarrhea, and to prevent postpartum infections were efficacious, based on antibacterial activity, in 70-88% of the tests. Plants used for "kidney inflammation" had a much lower efficacy against bacteria, and fell within the range of species that are traditionally used to treat other bodily disorders. Only species used for spiritual/ritual treatments scored worse. Of these only 22% showed some antibacterial; activity (Figures 3, 4). However, amongst the "spiritual" plants 38% of the species used for cleansing baths did in fact show activity, while only 15% of the plants often used in protective amulets (mostly species with the families of Lycopodiaceae and Caprifoliaceae) showed limited antibacterial activity.

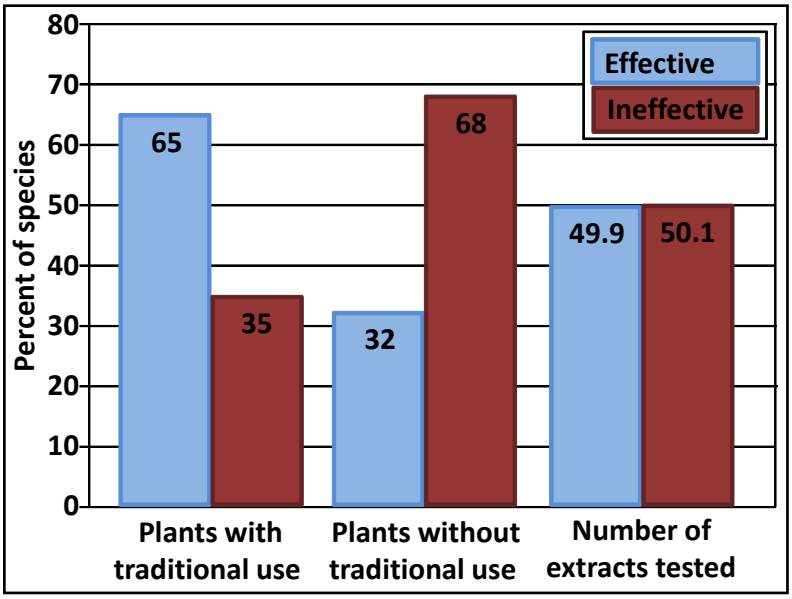

Figure 2. Evaluation of 225 plant species extracts that are traditionally employed against bacterial infections in the area of Trujillo and Chiclayo, northern Peru.

A variety of species showed higher efficacy than the control antibiotics employed: *Ambrosia peruviana* Willd., *Iresine herbstii* Hook., *Niphogeton dissecta* (Benth.) J.F. Macbr., *Opuntia ficus-indica* (L.) Mill., *Smilax kunthii* Killip & C.V. Morton were particular effective against *E. coli*. *Berberis buceronis* J.F. Macbr., *Caesalpinia paipai* Ruiz & Pav., *C. spinosa*, *Cestrum strigilatum* Ruiz & Pav., *Cydista aequinoctialis* (L.) Miers, *D. trifida*, *Escallonia pendula* (Ruiz & Pav.) Pers., *Escobedia grandiflora* (L.f.) Kuntze, *Eucalyptus citriodora* Hook., *Eucalyptus globulus* Labill., *Eugenia obtusifolia* Cambess., *Eustephia coccinea* Cav., *Gallesia integrifolia* (Spreng.) Harms,

Table 1. Antibacterial activity of 525 plant samples from 405 species used in traditional medicine in Northern Peru. Each were tested in simple agar-bioassays for antibacterial activity against *Staphylococcus aureus* Rosenbach 1884, *Escherichia coli* (Migula 1895) Castellani & Chalmers 1919, *Salmonella enterica* (ex Kauffmann & Edwards1952) Le Minor & Popoff 1987 serogroup Typhi and *Pseudomonas aeruginosa* (Schröter1872) Migula 1900. Ethanol extracts noted in black, Water extracts noted in red. The positive control antibiotics led to bacterial inhibition in all assays. For details see Materials and Methods. The negative control (a disk with distilled water) did not cause any antibacterial effect in any assay. Antibacterial species are noted as:
Plants with efficacy AND traditional antibacterial use.
Plants with traditional antibacterial use BUT WITHOUT efficacy.
Plants with efficacy, but NOT traditionally used as antibacterial.
Traditional applications: Abortifacient (Ab); Asthma (As); Arthritis (Ar); Blood pressure (Bp); Blood purification (Bl); Bronchitis(Br); Contraceptive(C); Diabetes (Db); Diarrhea (Dr); Infection (If); Inflammation (In); Intestinal (It); Kidney Inflammation (K); Nerves (N); Parasites (Pa); Postpartum infection (Pi); Respiration (R); Spiritual cleansing(S); Wounds (W).

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Pteridaceae								
Adiantum concinnum Humb. & Bonpl. ex Willd.	**Culantrillo**	ACR91		8				Bl
Amaranthaceae								
Alternanthera halimifolia (Lam.) Standl. ex Pittier	**Sanguinara**	KMM468	10					In
Alternanthera porrigens (Jacq.) Kuntze	**Moradilla**	AKT149/ KMM395						Blood circulation
Alternanthera villosa Kunth	**Hierba de Oso**	ACR 103						S
Amaranthus hybridus L.	**Yuyo**	GER190		11				In
Chenopodium ambrosioides L.	**Paico**	ACR31						Anthelminthic
Gomphrena globosa L.	**Siempre viva**	ACR101						S
Iresine herbstii Hook.	**Color**	ACR162	17					In
Iresine herbstii Hook.	**Sanguinaria**	JULS75	10	16				In
Amaryllidaceae								
Allium sativum L.	**Ajo**	ACR107						As
Eustephia coccinea Cav.	**Pumapara**	RBU/PL313		7				In
Eustephia coccinea Cav.	**Para Para**	ACR138		13	20			In
	Fosforito	KMM542						S
	Pumapara	ACR119						In
Anacardiaceae								
Mauria heterophylla Kunth	**Chacur**	ACR77/ JULS17	14	22				In
Schinus molle L.	**Molle**	KMM404						In
Schinus molle L.	**Molle**	JULS196		14				In

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Annonaceae								
Annona muricata L.	**Guanabana**	ACR81		11				In
Apiaceae								
Ammi visnaga (L.) Lam. cf.	**Bisnaga**	KMM566						S
Apium graveolens L.	**Apio del campo**	KMM439		11				In
Arracacia xanthorrhiza Bancr.	**Racacha de zorro**	KMM466						S
Coriandrum sativum L.	**Cilantro**	KMM548		12				Dr
Foeniculum vulgare Mill.	**Hinojo**	ACR82		10				In
Foeniculum vulgare Mill.	**Inojo**	KMM409						In
Niphogeton dissecta (Benth.) J.F. Macbr.	**Hornamo Toro**	AKT1196	16	10				W
Petroselinum crispum (Mill.) Fuss	**Perejil**	JULS225		15				If
Apocynaceae								
Mandevilla antennacea (A.DC.) K. Schum.	**Bejuco Colambo**	GER236		8				S
Mandevilla cf. *trianae* Woodson	**Bejuco Negro**	ISA14	13	24				S
Mandevilla cf. *trianae* Woodson	**Bejuco negro**	AKT1221						S
Nerium oleander L.	**Laurel**	ACR34		13	11			W
Thevetia peruviana (Pers.) K. Schum.	**Machil**	KMM416						Ar
Aquifoliaceae								
Ilex guayusa Loes.	**Gauyusa**	KMM513		14				In
Araceae								
Anthurium sp.	**Patecina negra**	KMM486						S
Araliaceae								
Hydrocotyle globiflora Ruiz. & Pav.	**Sombrero**	KMM467						K
Oreopanax eriocephalus Harms	**Maqui Maqui**	KMM445						If
Oreopanax eriocephalus Harms	**Maqui Maqui**	JULS39		8				If
Aristolochiaceae								
Aristolochia cf. ruiziana (Klotzsch) Duch.	**Bejuco Colambo / Bejuco del Aire**	AKT1217/ KMM563						S
Asteraceae								
Acanthoxanthium spinosum (L.) Fourr.	**Juan Alonzo**	AKT1127						In

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Achillea millefolium L.	**Milenrama**	AKT1188/ ACR139						Gastritis
Achyrocline alata (Kunth) DC.	**Hierba de Ishpingo**	AKT1199		10				Ar
Achyrocline sp.	**Espina de Hoja**	KMM547						
Ambrosia peruviana Willd.	**Marco o Altamisa**	ACR11	17	12				Pi
Arctium lappa L.	**Lampazo**	GER227		15				Urinary If
Artemisia absinthium L.	**Ajenjo**	KMM432/ AKT1099						Menstrual regulation
Baccharis genistelloides (Lam.) Pers.	**Karqueja**	AKT1144						If
Baccharis glutinosa Pers.	**Pega Pega**	KMM556						Db
Baccharis latifolia (Ruiz & Pav.) Pers.	**Chilca Grande**	ISA115		12				Ar
Baccharis salicifolia (Ruiz. & Pav.) Pers.	**Cedron**	AKT1126						S
Baccharis salicifolia (Ruiz. & Pav.) Pers	**Chilco Hembra**	GER125		10				S
Baccharis sp	**Chilca chica**	KMM562						Ar
Baccharis sp.	**Chilca**	KMM498			9			Ar
Baccharis cf. *vaccinioides* Kunth	**Sigueme Sigueme**	KMM565						S
Bidens pilosa L.	**Amor seco**	KMM427						K
Chersodoma deltoidea M.O. Dillon & Sagást.	**Arquitecta**	ACR46/ KMM446						S
Chromolaena sp.	**Asma chilca**	ACR113						As
Chromolaena sp	**Asma chilca**	KMM555						As
Chuquiraga spinosa Less. ssp. *humanpita* C. Ezcurra	**Huaman pinta**	KMM434						In
Chuquiraga weberbaueri Tovar	**Amaro**	KMM551/ ACR85			10			Br
Cynara cardunculus L.	**Alcachofa**	KMM414		14				Bl
Diplostephium sagasteguii Cuatrec.	**Gato Simuro**	ACR124,153/ AKT1145, 1192/KMM478		13				S
Eupatorium cf. *gayanum* Wedd.	**Asma chilca**	KMM555						As
Flaveria bidentis (L.) Kuntze	**Mata gusanos**	KMM412		9				Br

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Gnaphalium americanum Mill.	**Lechugilla**	ACR41/ KMM393		9				Db
Loricaria cf. *ferruginea* (Ruiz & Pav.) Wedd.	**Pata de Gallina**	ACR63/ AKT1174		15				S
Loricaria pauciflora Cuatrec.	**Palma**	KMM473	9					S
Loricaria sp.	**Palma Bendita**	ACR182		8				S
Matricaria frigidum (Kunth) Kunth.	**Lavanda (la banda)**	AKT1175						In
Matricaria recutita L.	**Manzanilla**	ACR6						W
Munnozia lyrata (A. Gray) H. Rob. & Brettell	**Caniahuanga**	KMM519						S
Munnozia sp.	**Salvia blanco**	ACR148						S
Onoseris odorata (D. Don) Hook. & Arn.	**Hierba Aguila**	ACR150		7				N
Oritrophium peruvianum (Lam.) Cuatrec.	**Huamanripa**	JULS58		14				Pneumonia
Perezia multiflora (Bonpl.) Less.	**Escorsonera**	KMM535/ AKT1153						As
Picrosia cf. *longifolia* D. Don.	**Achicoria**	KMM436,540/ ACR29, 39						Bl
Porophyllum ruderale (Jacq.) Cass.	**Hierba de Gallinazo**	KMM515		23				S
Pseudogynoxys cordifolia (Cass.) Cabrera	**Hierba San Juan**	AKT1168		8				S
Schkuhria pinnata (Lam.) Kuntze ex Thell.	**Encanchallacha**	ACR17	12					Urinary If
Senecio canescens (Humb. & Bonpl.) Cuatrec.	**Vira Vira**	ACR44		8				Br
Senecio cf. *tephrosioides* Turcz.	**Huamanripa**	ACR65						As, Br
Senecio chionogeton Wedd.	**Hornamo Leon Amarillo**	GER60	13	18				In
Senecio cf. *hypsiandinus* Cuatrec.	**Ornama blanco**	KMM523						S
Senecio sp.	**Huamanripa**	KMM449		10				As, Br
Senecio sp.	**Ornamo**	KMM480						S
Senecio sp.	**Ornamo tigre**	AKT1158						S
Smallanthus sonchifolius (Poepp. & Endl.) H. Rob.	**Yacon**	ACR197						Db, Prostate

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Sonchus oleraceus L.	**Serraja**	KMM438						High blood pressure
Stevia sp.	**Pastomiel**	KMM588						Cholesterol
Tagetes elliptica Sm.	**Culantrillo Serrano**	GER184		13				Br
Tagetes erecta L.	**Flor de Muerto**	JULS156		20				In
Tagetes filifolia Lag.	**Anis**	KMM524						Dr
Tanacetum parthenium (L.) Sch. Bip.	**Manzanilla de campo**	ACR14						S
Taraxacum officinale F.H. Wigg.	**Amargon**	JULS150		20				In
Tessaria integrifolia Ruiz. & Pav.	**Pajaro bobo**	KMM465						In
Trixis cf. *cacalioides* (Kunth) D. Don	**Añasquero**	KMM497						S
Verbesina sp.	**Sabadilla**	ACR154		13				W
Werneria nubigena Kunth	**Hierba de halago**	ACR205						S
Werneria sp.		AKT1178						S
	Churguis	KMM405						S
	Hierba de Amor	KMM522						S
	Miscichilca	KMM490						S
	Olvido	KMM538						S
Balanophoraceae								
Corynaea crassa Hook. f.	**Huanarpo**	ACR130						Fertility
Corynaea crassa Hook. f.	**Huanarpo**	AKT1169		11				Fertility
Berberidaceae								
Berberis buceronis J.F. Macbr.	**Palo Amarillo**	KMM573	8	21				Hepatitis
Betulaceae								
Alnus acuminata Kunth	**Aliso**	KMM418			10			W
Alnus acuminata Kunth	**Aliso**	ACR75		14				W
Bignoniaceae								
Crescentia cujete L.	**Turuma**	AKT1157	9					Healing of belly button
Cydista aequinoctialis (L.) Miers	**Bejuco Amarillo**	ISA6	7	21				In from sorcery
Jacaranda acutifolia Humb. & Bonpl.	**Arabisco**	ACR89	7	16				Br

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Bixaceae								
Bixa orellana L.	**Achiote**	KMM429		11				K
Boraginaceae								
Borago officinalis L.	**Borraja**	ACR9						Bl
Cordia alliodora (Ruiz. & Pav.) Oken.	**Ajo Sacha**	KMM489		13				Br
Cordia lutea Lam.	**Obero**	AKT1114						K
Heliotropium curassavicum L.	**Alacran**	ACR57						S
Tiquilia paronychioides (Phil.) A.T. Richardson	**Flor de arena**	KMM406		12				In
Brassicaceae								
Brassica oleracea L.	**Col**	JULS147		11				Gallstones
Capsella bursa-pastoris (L.) Medik.	**Bolsa pastor**	KMM451						K
Rorippa nasturtium-aquaticum (L.) Hayek	**Berros**	ACR94/ AKT1163		7				Br
Bromeliaceae								
Puya hamata L.B. Sm.	**Hierba del carnero**	KMM520						S
Tillandsia cf. *cacticola* L.B. Sm.	**Siempre viva**	ACR183						S
Tillandsia sp.	**Brocamedia/ Brocamelia**	KMM571						S
Burseraceae								
Bursera graveolens (Kunth) Triana & Planch.	**Palo Santo**	ACR132						Br
Commiphora sp.	**Mirra**	KMM579						S
Cactaceae								
Echinopsis pachanoi (Britton & Rose) H. Friedrich & G.D. Rowley	**San Pedro**	ACR95						W caused by witchcraft
Opuntia ficus-indica (L.) Mill.	**Tuna**	AKT1220	21					Db
	Orillo de Brujo	ACR93						S
Calceolariaceae								
Calceolaria percaespitosa Wooden	**Canillahuanga**	AKT1195						S
Calophyllaceae								
Mammea americana L.	**Mamey**	KMM568						Dr
Campanulaceae								
Centropogon articulatus Drake	**Conchalalay**	EHCHL119		6				S

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Centropogon sp.	**Canchalagua**	KMM536/ ACR17						S
Centropogon sp.	**Canchalaly**	ACR147						S
Centropogon sp.	**Trinoso**	KMM545	16	16				Skin problems
Lobelia decurrens Cav.	**Contoya**	KMM443/ ACR157						S
Capparidaceae								
Capparis crotonoides Kunth	**Simura**	KMM586						Ar
Capparis scabrida Kunth	**Zapote**	KMM554						In
Caprifoliaceae								
cf. *Belonanthus*	**Baton de Oro**	ACR127/ KMM494						S
Dipsacus fullonum L.	**Cardo Santo**	EHCHL90		12				Db
Lonicera cf. *japonica* Thunb. ex Murray	**Madre de Selva**	KMM390						Depression
Lonicera japonica Thunb. ex Murray	**Madre Selva**	JULS28		9				Depression
Phyllactis rigida (Ruiz & Pav.) Pers.	**Estrella**	KMM481		15				S
Phyllactis rigida (Ruiz & Pav.) Pers.	**Valeriana estrella**	AKT1117						S
Sambucus peruviana Kunth	**Sauco**	ACR66/ AKT1103						Br, Yellow Fever
Sambucus peruviana Kunth	**Sauco**	KMM539		6				Br, Yellow Fever
Scabiosa atropurpurea L.	**Ambarilla**	ACR158		10				Br
Valeriana cf. *bonplandiana* Wedd.	**Fortuna**	ACR181						S
cf. *Valeriana plantaginea* Kunth	**Ornamo caballero**	ACR120		9				S
Valeriana sp.	**Hornamo del Caballo**	AKT1140						S
Valeriana sp.	**Ornamo**	AKT1141			11			S
Valeriana sp.	**Valeriana**	AKT1213		10				S
Valeriana sp.	**Valeriana Delgada**	KMM394		12				S
Valeriana sp.	**Valeriana gruesa**	KMM396		13	13			S

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Caryophyllaceae								
Dianthus caryophyllus L.	**Claveles**	AKT1125						Depression
Chloranthaceae								
Hedyosmum racemosum (Ruiz. & Pav.) G. Don.	**Asancsito**	KMM505		18				Br
Clethraceae								
Clethra castaneifolia Meisn.	**Hierba del olvido**	KMM549		11				S
Clethra castaneifolia Meisn.	**Olvido**	ACR109	8					S
Clusiaceae								
Clusia minor L.	**Chusgon**	JULS280		16				N
Hypericum laricifolium Juss.	**Chinchango**	AKT1912/ KMM533						S
Hypericum laricifolium Juss.	**Pachuli**	AKT1172		12				S
Hypericum silenoides Juss.	**Cintaura**	AKT1154/ KMM387/ ACR152		13				Dr
Convolvulaceae								
Cuscuta foetida Kunth	**Pelo de duende**	ACR98						Goiter
Ipomoea pauciflora M. Martens & Galeotti	**Huanarpo**	GER222		16				Cold
Crassulaceae								
Echeveria peruviana Meyen	**Pin Pin**	ACR169/ AKT1165						K
Cucurbitaceae								
Sicana odorifera (Vell.) Naudin	**Cecana**	ACR96		11				S
Cupressaceae								
Cupressus sempervirens L.	**Pino silvestre**	AKT1181/ KMM506						Hemorrhage
Cyperaceae								
Oreobolus goeppingeri Suess.	**Hierba del Carpintero**	KMM493/ ACR126		12				S
Scirpus californicus Steud. ssp. *tatora* (Kunth) T. Koyama	**Totora**	ACR204						Fever
Dioscoreaceae								
Dioscorea sp.	**Papa de Buenas Tardes**	KMM462						K

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Dioscorea tambillensis R. Kunth	**Papa semintona**	KMM583						K
Dioscorea tambillensis R. Kunth	**Papa semitona**	KMM583		12				K
Dioscorea trifida L.f.	**Papa madre**	KMM503	11	30			11	W, Cancer
Ephedraceae								
Ephedra americana Humb. & Bonpl. ex Willd.	**Diego Lopez**	AKT1159						Fractures
Ephedra americana Humb. & Bonpl. ex Willd.	**Diego Lopez**	KMM511	8	22				Fractures
Equisetaceae								
Equisetum bogotense Kunth	**Cola de caballo**	ACR1		9				W
Ericaceae								
Bejaria aestuans Mutis ex L.	**Hierba de la postema**	KMM527		12				In
Bejaria aestuans Mutis ex L.	**Purunrosa/ FlorPostema**	AKT1109						In
Gaultheria erecta Vent.	**Mullaca**	KMM472/ JULS288		13	11			Br
Gaultheria reticulata Kunth	**Maike**	KMM531		9				Ar
Escalloniaceae								
Escallonia pendula (Ruiz & Pav.) Pers.	**Chuque**	ISA23		18				Ar
Euphorbiaceae								
Acalypha mandonii Müll. Arg.	**Chilca Dulce**	RBU/PL294		11				Liver In
Hura crepitans L.	**Habilla**	AKT1225						S
Jatropha macrantha Müll. Arg.	**Piñones**	AKT1230/ KMM487						S
	Chilca Dulce	ACR151						Bl
Fabaceae								
Acacia macracantha Humb. & Bonpl. ex Willd.	**Faique**	JULS172		15				W
Caesalpinia paipai Ruiz & Pav.	**Pai pai**	KMM581/ GER40		14	20			W
Caesalpinia spinosa (Molina) Kuntze	**Taya or Tara**	ACR111	10	23		10	11	Tonsilitis, Skin In, W
Cajanus cajan (L.) Huth	**Chibato**	ACR10						S
Cassia fistula L.	**Caña Fistula**	RBU/PL386		12				N

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			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Cassia fistula L.	**Ceiña Fistala**	ACR88						N
Desmodium molliculum (Kunth) DC.	**Manda yupa**	AKT1162/ KMM392		8				W
Leucaena leucocephala (Lam.) De Wit	**Arabisca**	JULS104	7					W
Lupinus mutabilis Sweet	**Chochos**	ACR102						Nutrition
Medicago sativa L.	**Trebol de agua**	KMM463/ ACR51	10	7				Br
Melilotus albus Medik.	**Fenogreco**	KMM459						Ifs
Mimosa albida Humb. & Bonpl. ex Willd.	**Tapa Tapa**	ACR79						S
Mimosa albida Humb. & Bonpl. ex Willd.	**Tutapure**	KMM560/ ACR190/ AKT1118		12				W
Myroxylon balsamum (L.) Harms	**Quina Quina**	JULS287		12				Br
Myroxylon balsamum (L.) Harms	**Quina Quina**	AKT1223						Br
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	**Algarrobina**	ACR203		15				Br
Senna cf. *bicapsularis* (L.) Roxb.	**Alcaparilla**	ACR194		15				Bl
Senna monilifera H.S. Irwin & Barnaby	**Sen**	KMM470/ AKT1112						Purgative
Senna monilifera H.S. Irwin & Barnaby	**Sen**	KMM470		17				Purgative
Spartium junceum L.	**Ratanica**	AKT1222/ KMM407		14				Bl
Spartium junceum L.	**Retama**	ACR108						Bl
Trifolium repens L.	**Trebol**	AKT1194/ KMM577						K
Gentianaceae								
Coutoubea ramosa Aubl.	**Genciana**	GER173		12				W
Gentiana sedifolia Kunth	**Horma de amarilla**	ACR92						S
Gentianella bicolor (Wedd.) Fabris ex J.S. Pringle	**Amargon**	ACR156						Ar
Gentianella bicolor (Wedd.) Fabris ex J.S. Pringle	**Corpusway**	KMM526		18				Ar
Gentianella brunneotincta (Gilg.) J.S. Pringle	**Yanga macha**	KMM403						Uterus If after birth

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			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Gentianella crassicaulis J.S. Pringle	**Agagencia**	ACR20/ KMM422		13	12			Db
Gentianella dianthoides (Kunth) Fabris ex J.S. Pringle	**Chagape**	ACR155		10				Bl
Gentianella dianthoides (Kunth) Fabris ex J.S. Pringle	**Genciana**	KMM576						Bl
Gentianella graminea (Kunth) Fabris	**Sumaran**	AKT1164						Bl
Gentianella sp.	**Hornamo asmarillo**	ACR92						Bl
Geraniaceae								
Erodium cicutarium (L.) L'Hér. ex Aiton	**Agujilla**	AKT1171						Br
Erodium cicutarium (L.) L'Hér. ex Aiton	**Cachujillo**	KMM578		15				Br
Geranium ayavacense Willd. ex Kunth	**Pasuchaca**	JULS48		12				If
Geranium cf. *ayavacense* Willd. ex Kunth	**Pasuchaca**	KMM401						If
Geranium sessiliflorum Cav.	**Pasuchaca**	KMM400		20	15			If
Geranium sessiliflorum Cav.	**Pasuchaca**	ACR38		12				If
Pelargonium cf. *odoratissimum* (L.) L'Hér.	**Malva de Olor**	ACR26		8				Bl
Gigartinaceae								
Gigartina chamissoi (C. Agardh) J. Agardh	**Cochayuyo**	AKT393, 1226						Cholesterol
Iliciaceae								
Illicium verum Hook. f.	**Anis estrella**	AKT1208						Expel residues from the stomach of newborns
Iridaceae								
Hesperoxiphion niveum (Ravenna) Ravenna	**Hierba de la justicia**	AKT1100/ ACR45			9			S
Juglandaceae								
Juglans neotropica Diels	**Nogales**	AKT1111/ KMM435/ ACR71		11				W

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			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Krameriaceae								
Krameria lappacea (Dombey) H.M. Burdet & B.B. Simpson	**Retamia**	ACR48	12	15				In
Lamiaceae								
Clinopodium pulchellum (Kunth) Govaerts	**Panizara**	ACR97						S
Hyptis sidifolia (L'Hér.) Briq.	**Albaca serrana**	ACR18			12			Colic
Hyptis sidifolia (L'Hér.) Briq.	**Perroreya**	ACR69, 18	10	13				Colic
Marrubium vulgare L.	**Cordon de Muerto**	KMM452						S
Melissa officinalis L.	**Toronjil**	ACR4						N
Mentha X *piperita* L.	**Poleo**	JULS29		6				Colic
Mentha X *piperita* L.	**Poleo**	ACR68						Colic
Mentha spicata L.	**Menta**	KMM453		12				Anthelminthic
Minthostachys mollis (Kunth) Griseb.	**Chancas de muerto**	AKT1142						Colic
Ocimum basilicum L.	**Albaca**	KMM437, 428/ ACR82		13				Ifs after birth
Origanum majorana L.	**Mejorana/ Tomillo**	ACR24		13				Colic
Origanum vulgare L.	**Oregano**	KMM509		13	17			Colic
Otholobium glandulosum (L.) J.W. Grimes	**Culen**	KMM419/ AKT1134		10				Dr
Otholobium mexicanum (L.f.) J.W. Grimes	**Culen**	ACR67		14				Dr
Rosmarinus officinalis L.	**Romero**	ACR16/ AKT1129		17	11			Br
Salvia cuspidata Ruiz & Pav.	**Salvia Blanca**	RBU/PL315		18				S
Salvia discolor Kunth	**Llatama**	ISA151		13				Cough
Salvia sagittata Ruiz & Pav.	**Salvia Negra**	RBU/PL318		12				Cough
Salvia sp.	**Alamo Silvestre**	ACR184		14				Cough
Salvia sp.	**Hierba del Aire**	AKT1160						S
Salvia sp.	**Hierba de los sieta vientos**	KMM572						S
Salvia sp.	**Paja Amargoza**	KMM567						S
Salvia sp.	**Paja del Aire**	ACR115						S

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			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Salvia sp.	**Unquia Real**	KMM550						S
Satureja pulchella (Kunth) Briq.	**Panizara**	KMM543		11				Br
Satureja sericea (C. Presl & Benth.) Briq.	**Romerio**	KMM397/ ACR100						S
Scutellaria cf. *scutellarioides* (Kunth) Harley	**Poleo Gentil**	ACR178						S
Stachys lanata Crantz	**Veronica Macho**	JULS13		12				Br
Thymus vulgaris L.	**Tomillo**	EHCHL169		16				Cough
	Salvia Real	ACR25		18				S
Lauraceae								
Cinnamomum verum J. Presl	**Canela**	KMM575		14				Br
Persea americana Mill.	**Palta**	AKT1120/ KMM444		10				Cough
Lichenes								
Siphula sp.	**Pelo de Pierda**	ACR187		10				Liver In
Linaceae								
Linum cf. *usitatissimum* L.	**Linaza**	KMM504						K
Loganiaceae								
Buddleja utilis Kraenzl.	**Flora Blanca**	AKT1131						Menstruation
Lycopodiaceae								
Huperzia sp.	**Condor**	AKT1170						S
Huperzia sp.	**Condor**	KMM541						S
Huperzia sp.	**Condor crespo**	KMM477						S
Huperzia sp.	**Condor Misha**	KMM479						S
Huperzia sp.	**Condor Purga**	KMM482						S
Huperzia sp.	**Condor Purga**	AKT1212						S
Huperzia sp.	**Corontilla**	KMM391						S
Huperzia sp.	**Enredadera**	AKT1183						S
Huperzia sp.	**Trencilla blanca**	KMM483						S
Lycopodium thyoides Humb. & Bonpl. ex Willd.	**Trencilla**	AKT1198, 1191						S
Lycopodium sp.	**Guamingo**	AKT1206	10					S
Lycopodium sp.	**Simba**	ACR116						S
Lythraceae								
Cuphea sp.	**Hierba del Toro**	KMM448		13				Bl

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			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Cuphea strigulosa Kunth	**Sanguinaria**	JULS33		12				Bl
Malpighiaceae								
Banisteriopsis caapi (Spruce ex Griseb.) C.V. Morton	**Ayohuasca**	ACR135						S
Malvaceae								
Gossypium cf. *barbadense* L.	**Algodon Pardo**	AKT1227						W (dressing)
Malva cf. *parviflora* L.	**Malva rosa**	AKT1200		8				Br
Malva cf. *sylvestris* L.	**Malva Blanca Alta**	ACR8						W
Malva sp.	**Malva Real**	AKT1201						Br
Ochroma cf. *pyramidale* (Cav. ex Lam.) Urb.	**Balsa**	ACR206						Construction
Urena cf. *lobata* L.	**Buenas Horas**	ACR185						Dementia
Maranthaceae								
Monotagma plurispicatum (Körn.) K. Schum.	**Patiquina**	ACR114	7					S
Melastomataceae								
Brachyotum naudinii Triana	**Carcilleja**	ACR140		14				Blood circulation
Brachyotum naudinii Triana	**Zarcilleja**	AKT1189						Blood circulation
Brachyotum tyrianthinum J.F. Macbr.	**Sarzilleja**	EHCHL55		10				Blood circulation
Miconia salicifolia ((Bonpl. ex Naudin) Naudin	**Mococho/ Porotillo**	ACT204/ KMM544		11				Burns
Menispermaceae								
Abuta grandifolia (Mart.) Sandwith	**Abuta**	ACR136	10	12		8		C
Monimiaceae								
Peumus boldus Molina	**Boldo (Chilean)**	AKT1132		15				K
Moraceae								
Brosimum rubescens Taub.	**Palo Sangre**	KMM570						Ar
Ficus carica L.	**Higo**	ACR73		8				Db
Ficus carica L.	**Higo**	AKT1128						Db
Myrtaceae								
Eucalyptus citriodora Hook.	**citradora**	KMM 454		20	10			Db

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			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Eucalyptus globulus Labill.	**Eucalipto**	AKT1110/ KMM408		20	18			Br
Eugenia cf. *obtusifolia* Cambess.	**Rumilanche**	AKT1143		14	18			In
Eugenia obtusifolia Cambess.	**Limoncillo**	ACR180, 76		15				In
Eugenia sp.	**Arrayn**	ACR19		13				In
Myrcianthes discolor (Kunth) McVaugh	**Lanche**	RBU/PL271		16				In
Psidium guajava L.	**Guanabana**	KMM339		7				Cancer
Scutia spicata (Humb. & Bonpl. ex Willd.) Weberb.	**Pial**	ACR207		12				S
Syzygium aromaticum (L.) Merr. & L.M. Perry	**Clavo de olor**	ACR188						Pain
Syzygium jambos (L.) Alston	**Poma Rosa**	GER173/ ACR174		10				Dr
Olacaceae								
Heisteria acuminata (Humb. & Bonpl.) Engl.	**Chuchu Wassi**	KMM507	12	14				Cough
Ximenia americana L.	**Limoncillo**	JULS184	12	10				Menstrual regulation
Oleaceae								
Jasminum sp.	**Jasmin**	AKT1211		15				S
Onagraceae								
Fuchsia sp.	**Añasquero**	AKT1187						Ar
Orchidaceae								
Aa paleacea (Kunth) Rchb.f.	**Hierba Sola**	ACR144/ AKT1158/ KMM530						C
Epidendrum sp.	**Caballero**	ACR168						S
Epidendrum sp.	**Espadilla**	ACR165						S
Epidendrum sp.	**Hierba de la Espada**	AKT1177		8				S
Epidendrum sp.	**Hierba del Gallo**	AKT1176						S
Epidendrum sp.	**Lancilla**	KMM484						S
Maxillaria sp.	**Huome Huome**	AKT1193						S
Stelis sp.	**Hierba del Olor**	KMM492						S
Stelis sp.	**Oro**	AKT1152						S

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Orobanchaceae								
Escobedia grandiflora (L.f.) Kuntze	**Azafran**	JULS110		22				Br, Pneumonia
Papaveraceae								
Argemone mexicana L.	**Cardo Santo**	KMM433						S
Argemone mexicana L.	**Cardo Santo**	ACR61/ AKT1135			16			S
Passifloraceae								
Malesherbia ardens J.F. Macbr.	**Veronica**	AKT1232		9				Br
Passiflora ligularis A. Juss.	**Hoja de granada**	KMM420		8				In
Passiflora ligularis A. Juss.	**Hoja de granadilla**	AKT1097/ AKT1105/ KMM420						In
Passiflora punctata L.	**Norgo**	KMM510						Menstrual pain
Passiflora quadrangularis L.	**Ajo Sacha**	ACR121						Menstrual pain
Passiflora sp.	**Hierba del Partero**	AKT1122						Menstrual pain
Phyllanthaceae								
Phyllanthus niruri L.	**Chanca Piedra**	KMM517/ AKT1151		18				In
Phyllanthus urinaria L.	**Chanca Piedra**	JULS133		14				In
Phytolaccaceae								
Petiveria alliacea L.	**Mocura**	ACR52/ KMM447						S
Phytolacca bogotensis Kunth	**Ailambo**	KMM457		7				Malaria, Dengue, Yellow Fever
Gallesia integrifolia (Spreng.) Harms	**Palo de Ajo**	ACT116		19				Br
Piperaceae								
Peperomia fraseri C.DC.	**Hierba de Dolor**	AKT1133						S
Peperomia inaequalifolia Ruiz. & Pav.	**Congona**	KMM534/ AKT1148						S
Peperomia quadrifolia (L.) Kunth	**Piri Piri**	KMM532						S
Peperomia sp.	**Congonilla**	AKT1190						S
Peperomia sp.	**Lancetillo**	ACR21						S
Piper acutifolium Ruiz.& Pav.	**Matico (sierra)**	ACR15						Liver In

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Piper aduncum L.	**Matico**	ACR12/ AKT1150	12					W, Br
Plantaginaceae								
Galvezia fruticosa J.F. Gmel.	**Macacha**	ACR64						Ar
Plantago linearis Kunth	**Llanten Serrano**	JULS35		10				W
Plantago major L.	**llanten**	KMM411		11				Br
Plantago sericea Ruiz. & Pav.	**Pajilla blanca**	ACR186						S
Plantago sericea Ruiz. & Pav. var. *lanuginosa* Griseb.	**Paja Blanca**	KMM499/ AKT1182/ ACR186		13	15			Vaginal discharge
Poaceae								
Arundo donax L.	**Carrizo**	KMM389		12				Haemorrhoids
Cymbopogon citratus (DC.) Stapf	**Hierba Luisa**	ACR5						Panacea
Cynodon dactylon (L.) Pers.	**Gramadulce**	KMM450/ ACR64						Ovarian cysts
Digitaria ciliaris (Retz.) Koeler	**Pata de Gallina**	JULS220		8				S
Distichlis spicata (L.) Greene	**Gramadulce**	AKT1096						S
Gynerium sagittatum (Aubl.) P. Beauv.	**Carrizo**	ACR47						S
Saccharum officinarum L.	**Cana cana**	AKT121/ KMM502						K
	Barra de oro	KMM415						S
Polemoniaceae								
Cantua buxifolia Juss. ex Lam.	**Cantuta o Cando**	ACR86						S
Cantua quercifolia Juss.	**Adormidora**	AKT1161						S
Polygonaceae								
Polygonum hydropiperoides Michx.	**Pica Pica**	ACR80/ JULS223		9				W
Rumex crispus L.	**Mala Hierba**	KMM496						K
Polypodiaceae								
Polypodium cf. *crassifolium* L.	**Calaguala**	AKT1137						K
	Contra Hierba	KMM464			9			S
Proteaceae								
Oreocallis grandiflora (Lam.) R. Br.	**Proteaceae**	ACR176/ KMM514/ AKT1173		10				K

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Pteridaceae								
Argyrochosma nivea (Poir.) Windham	**Doradillo**	KMM460						S
Cheilanthes pruinata Kaulf.	**Cuty Cuty**	KMM461		13				S
Cheilanthes sp.	**Cuti Cuti**	AKT1108		14				S
Jamesonia alstonii A.F. Tryon	**Baston del Inca**	ACR112						S
Notholaena sulphurea (Cav.) L. Sm.	**Doradilla**	KMM458						S
Ranunculaceae								
Laccopetalum giganteum (Wedd.) Ulbr.	**Pacra**	AKT1119		9				Br
Ranunculus krapfia DC. ex Deless.	**Marrajudio**	ACR179						S
Thalictrum decipiens B. Bovin	**Chontilla**	ISA15	12	14				Mumps
Rosaceae								
Cydonia oblonga Mill.	**Membrillo**	JULS194		11				Depression
Cydonia oblonga Mill.	**Membrillo**	ACR56						Depression
Margyricarpus pinnatus (Lam.) Kuntze	**China Lincla Verde**	ACR146		8				S
Polylepis racemosa Ruiz. & Pav.	**Quinal**	ACR3		14				If after birth
Prunus serotina Ehrh.	**Capuli**	ACR172						Ar
Prunus serotina Ehrh. ssp. *capuli* (Cav.) McVaugh	**Helialiso**	EHCHL94		12				W
Rubus robustus C. Presl.	**Sarsa mora**	ACR70			16			Br
Sanguisorba minor Scop.	**Pinpinela**	ACR23		13	13			Menstrual regulation
	Ornamo Leon	AKT1214						S
Rubiaceae								
Cinchona officinalis L.	**Cascarilla**	ACR123/ KMM525		8				Cough
Morinda citrifolia L.	**Noni**	ACR160						Panacea
Uncaria tomentosa (Willd. ex Roem & Schult.) DC.	**Uña de Gato**	ACR198	8	10				Br
Rutaceae								
Citrus limetta Risso	**Lima**	KMM425		10				N
Citrus limon (L.) Osbeck	**Limon**	KMM424						K
Citrus sinensis (L.) Osbeck	**Naranja**	JULS202		16				N

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Ruta graveolens L.	**Ruda Seca**	AKT1105/ KMM430		14				Ab
Salicaceae								
Salix chilensis Molina	**Sause**	ACR42/ AKT1006		12				Malaria, Fever
Santalaceae								
Phoradendron sp.	**Suelda con suelda**	ACR189	7		10			S
Scrophulariaceae								
Capraria peruviana Benth.	**Flor Arenilla**	RBU/PL374		11				K
Capraria peruviana Benth.	**Te de Judio**	KMM574			12			K
	Chiciricoma	KMM440			17			W
Smilacaceae								
Smilax kunthii Killip & C.V. Morton	**Palo de la China**	KMM20	16	18				Cancer
Smilax sp.	**Palo China**	KMM516		10				Cancer
Solanaceae								
Brugmansia candida Pers.	**Misha Blanca**	KMM564				8		S
Brugmansia sanguinea (Ruiz & Pav.) D. Don	**Misha**	KMM528						S
Brugmansia sp	**Misha**	ACR90						S
Brugmansia sp	**Misha**	AKT1149						S
Brugmansia suaveolens (Humb. & Bonpl. ex Willd.) Bercht. & C. Presl	**Floripondio**	AKT1116						S
Capsicum chinense Jacq.	**Aji Panca**	GER203	9	15				S
Cestrum auriculatum L'Hér.	**Hierba Santa (Sierra)**	ACR36		10				W
Cestrum humboldtii Francey	**Hierba Santa**	ACR83		9				W
Cestrum sp.	**Agrasejo**	AKT1121						W
Cestrum sp.	**Hierba Santa**	KMM426						W
Cestrum strigilatum Ruiz & Pav.	**Santa Maria**	JULS245	13	19				Menstrual regulation
Datura ferox L.	**Floripondio**	KMM441, 582						S
Lycopersicon hirsutum Dunal	**Ambulluco de Muerto**	ISA31		26				S
Nicotiana tabacum L.	**Tabaco**	KMM388, 557		8				S
Nolana cf. *humifusa* (Gouan) I.M. Johnst.	**Hierba de Señorita**	AKT1124						S

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
Solanum americanum Mill.	**Hierba Mora/ Cushay**	ACR37, 99		16				Sinusitis
Solanum mammosum L.	**Torito**	AKT1138						S
Tropaeolaceae								
Tropaeolum minus L.	**Mastuerzo**	JULS81		17				In of the stomach
Ulmaceae								
Celtis loxensis C.C. Berg	**Palo Huaco**	KMM561		6				Fertility, Br
Urticaceae								
Pilea microphylla (L.) Liebm.	**Contra Hierba**	RBU/PL282		8				K
Urtica magellanica Juss. ex Poir.	**Ortiga Negra**	ACR72						Bl
Urtica urens L.	**Chin Chin**	ACR199						S
Verbenaceae								
Aloysia scorodonioides (Kunth) Cham.	**Santa Maria**	ACR43		12				Depression, Pain
Aloysia triphylla Royle	**Cedron**	KMM398		13				Depression, Pain
Aloysia triphylla Royle	**Cedron**	AKT1126/ ACR159						Depression, Pain
Lantana scabiosiflora Kunth	**Pacha Rosa**	AKT1123/ ACR50						Cold
Lantana sp.	**Hierba del Hombre**	AKT1202			9			Cold
Verbena litoralis Kunth	**Verbena**	JULS77		12				W
	Hierba de Susto	AKT1210						S
Violaceae								
Viola sp.	**Pensamiento**	ACR27						S
Viola sp.	**Violeta**	KMM426						S
Viola tricolor L.	**Cinta de Novia**	ACR195						S
Zingiberaceae								
Zingiber officinale Roscoe	**Gengibre**	ACR196						Br
	Chimipampana Blanca	KMM485		12				W
Unknown								
	Ajo Caspi	KMM518		9				S
	Ajo Caspi	ACR133						S

Plant Family Species	Common name	Collector & Col#	Inhibition diameter (mm). Blank cells indicate lack of antibacterial activity					Traditional application
			E. coli	*S. aureus*	*S .aureus*	*S. enterica*	*P. aeuroginosa*	
	Anti ajo	AKT1219						S
	Arnica	ACR193		11			2	W
	Bejuco de montaña	ACR173						S
	Bledaco	KMM501		13				
	Canchalagua Morada	ACR143						S
	Cardo Bendito	KMM508						S
	Chimipanpana	AKT1139						S
	Chivato	KMM569						S
	Choloque	ACR84						S
	Cina Cina	ACR164						S
	Contra Hechizo	ACR106						S
	Cucho	ACR161						S
	Flor Dracaena	KMM559						S
	Hercampuri	ACR200						S
	Huarate	AKT1209		11				Db
	Lengua perro	ACR117						S
	Llanten Blanco	AKT1231			14			S
	Llanten Blanco	AKT1123						S
	Milagroso	AKT1130						S
	Misqui Chilca	ACR137						S
	Motelilla	KMM488						S
	Paja del Susto	ACR104						S
	Pegajosa	ACR60						S
	Polen de Zapote	AKT1230						Tuberculosis
	Poma Rosa	ACR174			8			Nutrition
	Violeta	KMM423						S
	Yelama	ACR110						S
	Zarzaparrilla	AKT1136						S

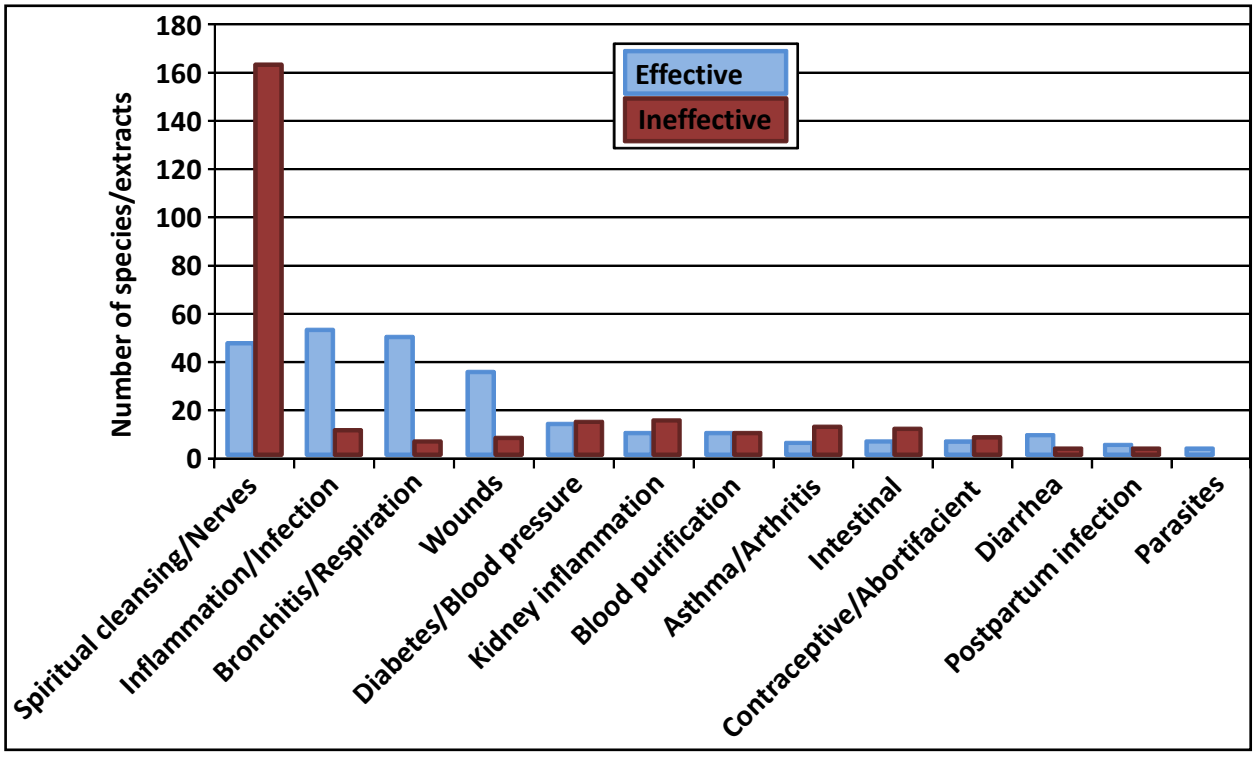

Figure 3. Antibacterial efficacy of plants traditionally used as anibacterials in the area of Trujillo and Chiclayo, northern Peru.

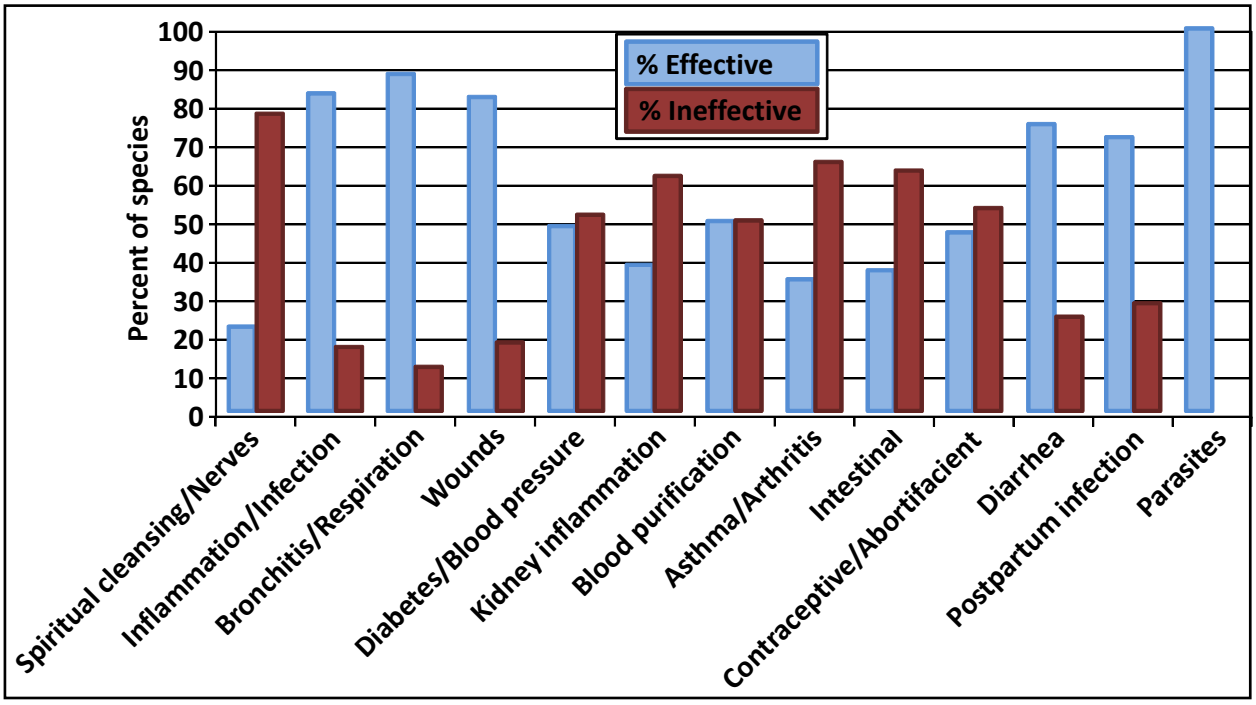

Figure 4. Efficacy percent per application category Trujillo and Chiclayo research area of northern Peru.

Geranium sessiliflorum Cav., *Hedyosmum racemosum* (Ruiz. & Pav.) G. Don., *I. herbstii*, *Lycopersicon hirsutum* Dunal, *Mauria heterophylla* Kunth, *Phyllanthus niruri* L., *Porophyllum ruderale* (Jacq.) Cass., *Salvia cuspidata* Ruiz & Pav., *Senecio chionogeton* Wedd., *Smilax kunthii* Killip & C.V. Morton, *Tagetes erecta* L. and *Taraxacum officinale* F.H. Wigg. showed high activity against *S. aureus*. The same holds true for *Ephedra americana* Humb. & Bonpl. ex Willd., *Gentianella bicolor* (Wedd.) Fabris ex J.S. Pringle, *Mandevilla trianae* Woodson. However, extracts of these three species were highly inconsistent in their efficacy.

Discussion

The results of the presented study give potentially interesting leads for future antibiotic research. They do however also give close insight into traditional plant selection, and last, caution against the simple transfer of traditional applications into Western science. The comparison of closely related species traditionally employed for different purposes (e.g., different *Alternanthera* spp., *Passiflora* spp., *Senecio* spp. and *Salvia* spp. for spiritual purposes and against bacterial infections) showed that the "spiritual" species normally were not effective against bacteria, while the species used as antibacterials had increased effectiveness. The example of *Plantago sericea* Ruiz. & Pav. var. *sericea* (used in **seguros**, no efficacy) and *Plantago sericea* Ruiz. & Pav. var. *lanuginosa* Griseb. (used for vaginal infections, high efficacy against *S. aureus*) is a particularly compelling case that indicates the sophistication of traditional knowledge. However, we did find examples like *Chuquiragua* spp., where closely related species were used as antibacterials, but only one of them did in fact show efficacy, clearly indicating that in this case traditional knowledge did not produce reliable results.

On the other hand, extracts of the same species traditionally used to treat infections often produced vastly diverging results when collected from different localities. Good examples are *Iresine herbstii* Hook., *Schinus molle* L., *Eustephia coccinea* Cav., *Oreopanax eriocephalus* Harms, *Myroxylon balsamum* (L.) Harms, *Spartium junceum* L., or *Gentianella dianthoides* (Kunth) Fabris ex J.S. Pringle. These species did not produce particularly high inhibition rates in any case, and were not the first choice of healers when trying to find remedies for bacterial infections. Many traditional remedies for concepts like "kidney inflammation" did not produce any antibacterial results, which underlines that research into efficacy does need to closely take traditional disease concepts into account.

Many remedies used for spiritual healing and other non-infection purposes did show antibacterial efficacy *in-vitro*, but were not listed as such by the local healers. This might be explained by the fact that they either are very inconsistent in their activity (e.g., *Brachyotum naudinii* Triana, *Cydonia oblonga* Mill., *Hypericum laricifolium* Juss., *Hyptis sidifolia* (L'Hér.) Briq., *Lonicera japonica* Thunb. ex Murray, *Loricaria* spp., *Mentha* X *piperita* L., *M. trianae*), or are so closely related that identification, especially when dried, can be a problem, e.g. in the case of *Baccaris* spp., *Gentianella* spp., and *Valeriana* spp., or are prone to toxic side effects like *E. americana* and *Brugmansia* spp.

Almost all remedies are traditionally prepared as water extracts, although ethanol (in the form of sugarcane spirit) is readily available. This might at a first glance seem astonishing, given the low efficacy of water extraction found in this study. However, initial results from Brine-Shrimp toxicity assays indicate that the ethanolic extracts are by far more toxic than water extracts of many species, and thus ethanolic extraction might in many cases not be suitable for application in patients. This again indicates the considerable sophistication and care with which traditional healers in northern Peru chose their remedies for a specific purpose.

Conclusions

Simple agar assays alone are not reliable for determining the efficacy of plants used in traditional medicine. The present study however confirms that simple laboratory methods are indeed well suited for the initial assessment of the efficacy of traditionally used medicinal plants in inhibiting bacterial growth. A comparison to the traditional uses also indicated that local knowledge can provide important leads for the development of new drugs: Our hypotheses that plants traditionally used as antibacterials do have a much higher incidence of efficacy than other medicinally used species, and that plants used for cleansing baths are more likely to have antibacterial properties than other species used for ritual purposes could be verified. However, if traditional knowledge is to serve as a lead, the results clearly indicate, that a very careful assessment of traditional disease concepts is needed in order to draw the right conclusions. It also needs to be taken into account that many plants are usually traditionally prepared in complex mixtures, and single species are rarely applied (Bussmann & Sharon 2006, 2007). An efficacy analysis of these mixtures, as well as assays to evaluate the toxicity of single species as well as mixtures would be an interesting comparative study.

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