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Full Length Research Paper

Medicinal plants used in Northern Peru for the treatment of bacterial and fungal infections and inflammation symptoms

Rainer W. Bussmann* and Ashley Glenn

William L. Brown Center, Missouri Botanical Garden, P. O. Box 299, St. Louis, MO 63166-0299, USA.

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A total of 96 plant species belonging to 84 genera and 46 families were documented and identified as anti-infective herbal remedies in Northern Peru. Most species used were Asteraceae (18 species, 18.95%), followed by Fabaceae and Euphorbiaceae (7.37% and 5.26%). The most important anti-infectious families are somewhat over-represented in comparison to the overall medicinal flora, while some other medicinally important families (e.g. Lycopodiaceae, Cucurbitaceae) are completely missing from the anti-infective portfolio. The majority of herbal preparations were prepared from the leaves of plants (31.34%), while the whole plant (18.66%), flowers (12.69%) and stems (17.16%) were used less frequently. In almost 67% of the cases fresh plant material was used to prepare remedies. Only about 55% of the remedies were applied orally, while the remaining ones were applied topically. Over half of all remedies were prepared as mixtures of multiple ingredients. The information gained on frequently used traditional remedies against infectious disease agents might give some leads for future targets for further analysis in order to develop new drugs. However, more detailed scientific studies are needed to evaluate the efficacy and safety of the remedies employed traditionally.

Key words: Ethnobotany, traditional medicine, wounds, inflammation, infectious disease.

INTRODUCTION

Bacterial infections and inflammation are among the ailments responsible for a large number of deaths world-wide, and are often treated by traditional healers. The World Health Organization (WHO) 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. Traditional medicine is used globally and is rapidly growing in economic importance. In developing countries, traditional medicine is often the only accessible and affordable treatment (WHO, 2002). The WHO reports that traditional medicine is the primary health care system for 80% of the population in developing countries. In Latin America, the 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 traditional medicine. In many Asian countries traditional medicine is widely used, even though Western medicine is often readily available. In Japan, 60 -70% of allopathic doctors prescribe traditional medicines WHO, 2002).

Complementary /alternative medicine is also becoming more popular in many developed countries. Forty-two percent of the population in the US have used complementary /alternative medicine 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 (UNCCD, 2000). The number of visits to providers of complementary/ alternative medicine (CAM) now exceeds by far the number of visits to all primary care physicians in the US (WHO, 1999; 2002). The expenses for the use of traditional and complementary/ alternative medicine are exponentially growing in many parts of the (WHO, 1999) world. The 1997 out-of-pocket

*Corresponding author. E-mail: rainer.bussmann@mobot.org. Tel: +1-314-577-9503. Fax: +1-314-577-080.

Figure 1. Location of the study area.

Complementary/ alternative medicine expenditure was estimated at US$ 2,700 million in the USA. The world market for herbal medicines based on traditional knowledge is now estimated at US$ 60,000 million (Breevort, 1994; 1998).

Northern Peru is believed to be the center of the Central Andean Health Axis (Camino, 1992), and traditional medicinal practices in this region are still an important component of everyday life (Bussmann and Sharon, 2006; Bussmann, 2006; De Feo, 1992; Joralemon and Sharon, 1993; Polia, 1988; Sharon, 1978; 1980; 1994; 2000; Sharon and Bussmann, 2006). Traditional medicine is also gaining more 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 WHO (2002), the sustainable cultivation and harvesting of medicinal species is one of the most important challenges for the next few years.

The present study attempts to give an overview of medicinal plant species employed in traditional therapies in Northern Peru to treat bacterial and fungal infections, and compare this use to the western scientific evidence regarding their efficacy.

MATERIALS AND METHODS

Plant collections

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 veners, 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 reference as to disease concepts, plant parts or preparations. In contrast, 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 include 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.

Nomenclature

The nomenclature of plant families, genera, and species follows the Catalogue of the Flowering Plants and Gymnosperms of Peru (Brako and Zarucchi, 1993) and the Catalogue of Vascular Plants of Ecuador (Jørgensen and León-Yanez, 1999). The nomenclature was compared to the TROPICOS database. 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); Ulloa-Ulloa and Jørgensen (1993), and the available volumes of the Flora of Ecuador (Sparre and Harling, 1978; 2009), and reference material in the herbaria HUT and HAO.

RESULTS

A total of 96 plant species belonging to 84 genera and 46 families were documented and identified as anti-infective herbal remedies in Northern Peru. Twenty percent of the species were introductions, while 80% belonged to the native flora of Peru. Most species used belong to Asteraceae (18.95%), followed by Fabaceae and Euphorbiaceae (7.37 and 5.26%). Most other families contributed only one species each to the pharmacopoeia (Table 1). A complete overview of all plants encountered, including data on use-recipes and preparation, is shown in Appendix 1. The most important anti-infectious families were over-represented in comparison to the overall medicinal flora, while some other medicinally important families (e.g. Lycopodiaceae, Cucurbitaceae) are completely missing from the anti-infective portfolio (Table 2).

The majority of herbal preparations were prepared from the leaves of plants (31.34%), while the whole plant (18.66%), flowers (12.69%) and stems (17.16%) were used less frequently (Table 3). In almost 67% of the cases fresh plant material was used to prepare remedies. Only about 55% of the remedies were applied orally, while the remaining ones were applied topically. Over half of all remedies were prepared as mixtures of multiple ingredients by boiling plant material either in water or in sugarcane spirit.

DISCUSSION

Infections, in particular by strains of *Staphylococcus aureus* are very common, and increasingly difficult to treat, due to widespread formation of drug resistance. Fungal infections, due to the structure of the organisms involved, have always been a hard task to treat. Given the high importance of infections, it is not surprising that anti-infective agents are high on the list for drug development, and a large number of species used traditionally, have undergone screening. Almost 43% of the plants used in Nortnern Peru to treat infections, or their congeners have been studied for their medicinal properties, and the respective references are given in the following section. Biella et al. (2008) reported on the antibacterial efficacy of *Alternanthera tenella*. Mango (*Mangifera indica*) has shown antibacterial efficacy in a wide variety of studies (Carlier et al., 1996; Garrido et al., 2004; Leiro et al, 2004; Farinacci et al., 2008). Compunds of *Schinus molle* shoed anti-inflammatory activity (Yuequin et al., 2003). Oleandrin, isolated from *Nerium oleander*, was found to be active in inhibiting the kappa-B inflammation cascade (Sreenivasan et al., 2003). Rinaldi et al. (2009) showed anti-inflammatory activity in *Cocos nucifera*. China's traditional preparations like Guizhi-Fuling, containing *Cinnamomum vulgare*, have shown anti-inflammatory activity also (Giner-Larza et al., 2000; Prieto et al., 2003; Li et al., 2007; Lin et al., 2008). A wide range of Asteraceae has strong anti-bacterial and anti-inflammatory properties. Nemeth and Bernath found anti-infective potential in Yarrow (*Achillea millefolium*). Many species of *Baccharis* proved effective (Cifuente et al., 2001; Paul et al., 2009), as did *Bidens pilosa* (Pereira et al., 1999; Chang et al., 2005; Yoshida et al., 2006). Other efficacious member of the sunflower family include *Eupatorium* (Clavin et al., 2000; Habtemaria, 1998; 2001; Muschetti et al., 2001; Chomnawang et al., 2005), *Matricaria recutita* (Ganzera et al., 2006), *Tagetes patula* (Kasahara et al., 2002), and *Taraxacum officinale* (Dandeloin) (Kashiwada et al. 2001; Javanovic et al. 2004; Park et al. 2010). *Caspsella bursa-pastoris* (Shepperd's pouch) was found to act as anti-inflammatory (Kuroda and Takagi, 2008), while *Dioscorea* was found to have immuno-stimulating properties (Su et al., 2008; Hiransai et al., 2010). Zeng et al. (2006) reported pain relieving properties in *Gaultheria yunnanensis*. Jones (2003) found antibacterial activity in *Croton lechleri* (Sangre de drago). Other examples for plants with anti-bacterial potential found in Peru include *Manhiot esculenta* (Adeyemi et al., 2008), *Solanum nigrum* and *Ricinus communis* (Hirko et al., 2008; Lomash et al., 2010), *Solanum* sp. (Kawano et al., 2009), *Caesalpinia* spp. (Wahiyama et al., 2009; Shukla et al., 2010), *Mezoneuron benthamianum* (Mbagwu et al., 2007), *Desmodium triflorum* (Lai et al., 2009), *Leucaena leucocephala* (Souza-Pinto et al., 1996), Red clover (*Trifolium pretense*, Krenn and Paper, 2009).

Salvitorin A, extracted from *Salvia* spp. (Carrasco et al., 2009; Fichna et al., 2009; Jung et al., 2009) showed immuno-modulatory properties. Other Lamiaceae with anti-infective compounds include Satureja *hortensis* (Zulú et al., 2003). *Buddleja* spp. was found to be mainly anti-inflammatory and anti-oxidant (Backhouse at al., 2008; Lee et al., 2008). *Plantago* sp. (Chiang et al., 2003), *Cynodon dactylon* (Sindhu et al., 2009), and *Polypodium* sp. (Calahuala, Manna et al., 2003; Yoshino et al., 2006), (Zattra et al., 2009), all commonly used in Peru, show cox-2 inhibition, and thus anti-inflammatory properties. Cat's claw (*Uncaria tomentosa*) has long been marketed as traditional anti-cancer remedy, leading to serious over-harvesting and flooding of the market with adulterated material (Bussmann and Sharon, 2006). Sandoval-Chacon et al. (1998); Setty and Sigal (1005); Hardin (2007) could confirm anti-inflammatory properties of the species.

Calvo (2005); Speroni et al. (2007) confirmed analgesic activity in *Verbena* sp. A few plant groups have been studied more in depth. Rutacea (*Citrus* spp.) have proven anti-inflammatory (Sood et al., 2009; Oben et al., 2009; Vafeiadou et al., 2009; Ghanim et al., 2010), as did *Gardenia* sp. (Koo et al., 2006; Oh et al., 2006), while many species of *Smilax* exhibit immuno-modulatory

Table 1. Most represented botanical families in number of genera and species of medicinal plants used in Northern Peru.

Family	Genera	Species	%
Asteraceae	15	18	18.78
Fabaceae	6	7	7.33
Euphorbiaceae	4	5	5.25
Poaceae	4	4	4.16
Malvaceae	3	4	4.16
Amaranthaceae	3	3	3.12
Anacardiaceae	3	3	3.12
Brassicaceae	3	3	3.12
Lamiaceae	2	3	3.12
Apiaceae	2	2	2.08
Rutaceae	2	2	2.08
Solanaceae	2	2	2.08
Dioscoreaceae	1	2	2.08
Equisetaceae	1	2	2.08
Linaceae	1	2	2.08
Piperaceae	1	2	2.08
Plantaginaceae	1	2	2.08
Amaryllidaceae	1	1	1.04
Annonaceae	1	1	1.04
Apocynaceae	1	1	1.04
Araliaceae	1	1	1.04
Arecaceae	1	1	1.04
Asphodelaceae	1	1	1.04
Betulaceae	1	1	1.04
Boraginaceae	1	1	1.04
Ericaceae	1	1	1.04
Erythroxylaceae	1	1	1.04
Gentianaceae	1	1	1.04
Lecythidaceae	1	1	1.04
Loganiaceae	1	1	1.04
Lythraceae	1	1	1.04
Myrtaceae	1	1	1.04
Nyctaginaceae	1	1	1.04
Papaveraceae	1	1	1.04
Passifloraceae	1	1	1.04
Polemoniaceae	1	1	1.04
Polygalaceae	1	1	1.04
Polypodiaceae	1	1	1.04
Rosaceae	1	1	1.04
Rubiaceae	1	1	1.04
Scrophulariaceae	1	1	1.04
Smilacaceae	1	1	1.04
Tiliaceae	1	1	1.04
Urticaceae	1	1	1.04
Verbenaceae	1	1	1.04
Zygophyllaceae	1	1	1.04
Indet.	1	1	1.04
Total	84	96	100

Table 2. Comparison of infection treatments to the ten most important plant families of the medicinal flora of Northern Peru (Bussmann & Sharon 2006).

Family	%	Family	%
Asteraceae	18.95	*Asteraceae*	13.64
Fabaceae	7.37	*Fabaceae*	6.82
Lamiaceae	3.16	*Lamiaceae*	4.87
Solanaceae	2.1	*Solanaceae*	4.09
Euphorbiaceae	5.26	*Euphorbiaceae*	2.33
Poaceae	4.21	*Poaceae*	2.33
Apiaceae	2.1	*Apiaceae*	2.14
Lycopodiaceae	0	*Lycopodiaceae*	1.95
Cucurbitaceae	0	*Cucurbitaceae*	1.75
Rosaceae	1.05	*Rosaceae*	1.75

Table 3. Plant parts used for traditional preparations.

Plant part	%	Species number
Leaves	31.34	42
Whole plant	18.66	25
Stems	17.16	23
Flowers	12.69	17
Root	5.22	7
Seeds	4.48	6
Fruit	4.48	6
Bark	3.73	5
Latex	2.24	3

effects (Ageel et al., 1989; Jiang and Xu, 2003; Man et al., 2008).

Conclusions

An often-limiting factor to these investigations is lack of comprehensive ethnobotanical data to help choose plant candidates for potency/ efficacy tests. Since, the plant parts utilized in preparation of anti-infective remedies are reported in this survey, it serves as an indication of species that may need further ecological assessment on their regeneration status. The results of this study show that both indigenous and introduced species are used for treatment of infections and inflammations. The information gained on frequently used traditional remedies against infectious disease agents might give some leads for future targets for further analysis in order to develop new drugs. However, more detailed scientific studies are desperately needed to evaluate the efficacy and safety of the remedies employed traditionally.

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