

REVIEW

THE ETHNOBOTANY OF FERNS AND LYCOPHYTES

H. A. KELLER¹ & G. T. PRANCE²

¹Consejo Nacional de Investigaciones Científicas y Tecnológicas, Instituto de Botánica del Nordeste, Sargento Cabral 2131, Corrientes, Argentina.

²Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, UK, corresponding author: siriaian01@yahoo.co.uk

Keywords: Fern ethnobotany, ethnopteridology, archaeobotany, medicinal plants, ornamental plants

ABSTRACT

A summary is presented of the most important ways in which ferns have been important to humanity. Many of these categories are positive such as the use of ferns for subsistence. On the negative side is their role as weeds and as bearers of substances harmful to human health. Many of the traditional uses such as for medicines have been transferred to modern life as societies have modernized. Some uses have even become important in industrial society, for example in the assay of new medicines.

INTRODUCTION

Ferns are distributed in all climate zones of the planet, but have a greater diversity in the tropics (Smith *et al.*, 2006; Strasburger *et al.*, 2003). The discipline that studies the relationship between the uses of ferns and humans has been termed ethnopteridology, and it was well explained and amplified by Boom (1985). These reciprocal interactions may or may not be related to a particular use category in family or regional cultures, but the concept of ethnobotany goes beyond the utilitarian spheres of economics and uses to include symbolic values, nomenclature, religion and also the place that particular plants occupy in the cosmology of peoples. Strictly economic aspects of uses are addressed by the discipline of economic botany. It is not easy to separate economic botany and ethnobotany and indeed economic botany implies a type of relationship between human groups and plants.

The object of this work is to present a global panorama of the state of the art in ethnobotany of pteridophytes. We will show the great diversity of relationships between these plants and humans. Pteridophytes feature in some way in many papers about ethnobotany and economic botany and here we will concentrate mainly on papers whose object was specifically about the study of ferns or lycophytes. A few previous papers have addressed similar topics at least locally. For example, May (1978) made a summary of the economic and folkloric uses of ferns. Díaz de León *et al.* (2007) reviewed the many uses of ferns and lycophytes in Mexico and to some extent the rest of the world. Murillo (1983) produced a major work on the uses of ferns in South America with a special emphasis on the ferns of Colombia. Mannar Mannan *et al.* (2008) gave a short review of the potential uses of ferns. We have used the names as cited in the various papers rather than trying to update the nomenclature in any way. The literature about the reciprocal relationships between humans and pteridophytes is so extensive that here we cannot possibly cover it all, but we hope to show the variety of possible relationships through presenting a number of wide-ranging examples.

ARCHAEOBOTANY

Archaeobotany is the study of ancient plant remains found in archaeological contexts. The name is obviously a parallel to, and a derivative from, ethnobotany. In both archaeobotany and ethnobotany the focus of attention is upon the uses of plants by, and their association with people (Wiley, 1995). Since remote times human populations in many parts of the world knew and made use of ferns and lycophytes. The archaeological literature offers much evidence of the close relationship between humans and these plants over many generations. Anderson & White (2001) suggested that *Cyathea* was used for consumption by humans at least 888 years ago in Norfolk Island. Dental evidence from human remains in New Zealand show ancient use of the rhizomes of *Pteridium esculentum* (G.Forst.) Cockayne (Houghton, 1978). In China there was use of edible ferns at least 3000 years ago (Zhang, 2007). There is evidence of the prehistoric use of the leaves of *Marattia fraxinea* Sm. in ritual involving the incipient use of iron in Africa (Schmidt & Avery, 1983).

FERNS IN PRE-LINNEAN LITERATURE

Our study has shown that fern ethnobotany is nothing new and that there is much about ferns and local cultures in ancient literature. We have mainly concentrated here on the more recent literature, but a good example of early studies of fern ethnobotany is that of Georgius Everhardus Rumphius (1627-1702) in Ambon, now in Indonesia (Rumphius, 2011). Rumphius devoted 44 pages to descriptions of ferns, lycophytes and their uses. The pre-Linnean names are often hard to identify to species, but the good drawings and the interpretation by E. D. Merrill (1917) make it possible to relate to current species names. These pages are full of ethnobotanical information about fern uses by the Ambonese and natives of other islands in the seventeenth century. Many of these uses come under the subheadings we have used below. For example one chapter is entitled "The Edible Fern" and is about *Athyrium esculentum* (Retz.) Copel. Rumphius said that this fern and related species "are a renowned potherb of all of these islanders. One can make a good salad from its leaves and shoots....it cools moderately and loosens the bowels, especially if one drinks some tree-wine after it." Rumphius describes the culinary use of several different species of ferns together with great details about the effects of eating them. The Balinese stick the tops of *Tectaria crenata* Cav. behind their ears when they go to war, because this plant will keep them from getting hurt by dart poison, rendering it powerless. They also rub the dry leaves over their bodies when bathing to get rid of sweat and odours. The lower stems of *Lygodium circinnatum* (Burm. f.) Sw. are split into four strips and used for seams around the edges of baskets by the Ambonese. An interesting use of the leaves of *Drynaria sparsisora* (Desv.) Moore is to tie them to a baited fishhook and use them as sails to carry the hooks out to sea until fish bites. The leaves of the same species are suspended over little children to keep them safe from evil spirits. The pages of Rumphius contain much interesting fern ethnobotany and many similar uses are reported in the more recent literature on the subject.

ETHNOPTERIDOLOGY

In the literature surveyed we found a number of articles that were specifically about ethnopteridology of human groups and also ethnobotany about individual species of pteridophytes, and we highlight examples of recent works from different continents. From the Americas, Navarrete *et al.* (2006) presented information on the uses attributed to more than 200 species of pteridophytes of Ecuador, Peru and Bolivia. Boom (1985)

treated the use of ferns by the Chácobo tribe of Amazonian Bolivia and Macía (2004) compared the ethnopteridology of the Tacana of Bolivia with that of the Huaorani of Ecuador. The only species in common was *Cyathea pungens* (Willd.) Domin. Hernández Cibrián & Sutherland (2007) carried out an ethnobotanical study of the ferns of a national park in Honduras and found only eight species that were used by the local population. For Argentina Keller *et al.* (2011) treated the various uses of 50 species of ferns and lycophytes by the Guaranies of Misiones Province (Figures 1-3) and Hurrell & De La Sota (1996) did the same for the villagers of Santa Victoria in Salta Province. In Asia Christensen (1997) studied the ethnopteridology of ethnic groups in Malaysia. A study of the ethnobotanical uses of ferns in the Indian States of Jammu and Kashmir (Kirm & Kapahi, 2001) listed 17 species of which 11 were medicinal, four used for thatching roofs and three as foods. Joshi (1997) listed ethnobotanical uses of 44 species of ferns in Uttar Pradesh State of India.

For Africa the ethnopteridological study of ethnic groups by Nwosu (2002) mentioned 36 species in 23 families. In addition to fern uses for food and medicines, many of these studies mention uses in rituals of love, for magic ceremonies, as indicators of cardinal points and the presence of animals and also as material to make crafts and weapons. The demands of today's markets have led various indigenous groups to commercialize ornamental ferns and flowerpots made out of erect rhizomes and the trunks of tree ferns.

FERNS IN TRADITIONAL MEDICINE

Studies of uses of ferns in ethnomedicine are abundant on all inhabited continents. In Córdoba (Argentina) the study of ferns used in traditional medicine has developed to



Figure 1. *Microgramma squamulosa* (Kaulf.) de la Sota, a multipurpose species for the Guaraní, used for slimming, menstrual analgesic, post partum washing, and treatment of lumbago.

such an extent that anatomical and morphological evidence is used to detect adulterants of the products (Luján *et al.*, 2007; 2011). However, the adulteration of medicinal ferns is nothing new. Hipólito Ruiz (1805) described the species *Polypodium calguala* Ruiz with the intention of clearly differentiating this medicinal ethnospecies of the indigenous peoples of Peru from other fern species that were being imported into Spain from the New World as adulterants of the legitimate “*calaguala*.”

In a comparison between the ethnopteridology of the Tacana of Bolivia and the Huaorani of Peru, Macía (2004) found that 76% of the recorded uses for ferns were medicinal either for people or for animals to heal wounds or expel parasites. Most of the uses by the Tacana are external, whereas the Huaorani uses are mainly internal. This study cites uses for 24 species of ferns and lycophytes. There are many medicinal uses of ferns in India. For example, Sharma and Vyas (1985) described the use of six species in Rajasthan. Srivastava (2007) emphasised the importance of ferns in tribal medicine from a study made in various places throughout India. Benniamin (2011) reported on the use of 51 species of ferns in the east of India and Kumari *et al.* (2011) gave information about the use of 66 species in ethnomedicine in India. Dixit (1982) is an example of the ethnobotanical use of a single species, *Selaginella bryopteris* (L.) Bak. This species is much revered in local medicine and commands a high market price. The medicinal use of *Helminthostachys zeylanica* (L.) Hook. has had serious effects on its state of conservation in Himalaya (Joshi, 2011). *Osmunda regalis* L. is used as a medicine in the north of Spain (Molina *et al.*, 2009).

Of the 36 species of ferns reported in the ethnobotany study of ferns of Southern Nigeria by Nwosu (2002), 34 have medicinal uses. The paper reads like a complete



Figure 2. *Alsophylla setosa* Kaulf. The base of the rhizomes are used as stands for ornamental plants. The Guaranis and local farmers agree that the presence of this fern is an indicator that the soil is not suitable for agriculture. The Guaranis use a soup of the petioles for the treatment of herpes.

pharmacy to treat many different ailments and all from pteridophytes. Ferns supply treatment for external injuries and wounds and many are taken internally to treat such diseases as malaria, ulcers, intestinal worms, liver disease etc. Many of the species listed have multiple uses, for example, a decoction of the rhizome and leaves of *Polypodium microrhizoma* Clarke ex Bak. is used for the relief of gastrointestinal disorders, backache and jaundice; a paste from the dried leaves (dried over an open fire) is applied externally for fissures on hands and wound healing; and a paste mixed with palm-kernel oil is applied externally to domestic animals such as sheep and cattle. The whole plant of *Osmunda regalis* is taken internally for psychosis as it is believed that the tonic can chase away evil spirits, and an infusion of the roots is used to treat malaria and jaundice.

The importance of medicinal ferns is evidenced by the growing interest in methods for their reproduction. An example is the achievement of *in vitro* propagation of the Asiatic fern *Drynaria quercifolia* (L.) J.Sm. that is much used in traditional phytotherapy (Mazumder *et al.*, 2011).

VETERINARY

The literature has many examples of the use of ferns for treating animals. According to Nwosu (1922), the leaves of *Tectaria macrodonta* (Fée) C.Chr. are powdered and mixed with castor oil and given to goats and sheep to stop a running stomach; young fronds are chewed by cows after delivery of a calf to accelerate the expulsion of the afterbirth.

EDIBLE FERNS

Fern rhizomes were an important source of food for Native Americans in western North



Figure 3. The rhizome of *Dicksonia sellowiana* Hook. in a Guarani basket offered for sale at a roadside stand.

America. Turner *et al.* (1992) produced a summary of this in a detailed paper that listed at least 15 species of ferns together with their native nomenclature. Ferns are much eaten in India. For example, Pandey and Pangtey (1987) list seven different species of ferns consumed in Western Himalaya and Joshi (1997) lists 10 edible species used in Uttar Pradesh State. For China, Liu *et al.* (2012) listed a total of 42 edible pteridophytes, but they estimated that the potential total could be as high as 144 species. Some ferns are eaten as though they were sweets, as in the case of *Pechuma pectinatiformis* (Lindm.) M.G.Price, where the sweet leaves are commonly chewed by Guaraní children in Misiones, Argentina (Keller *et al.*, 2011).

Some species of *Polypodium* are known for their property of sweetness. A variety of *Polypodium vulgare* L. was used to flavour tobacco for its liquorice taste and it contains small amounts of ostadin, a steroid saponin 3000 times as sweet as sucrose. In former times the fronds of this species were used in Ireland to treat coughs, colds and asthma. *Polypodium glycyrrhiza* D.Eaton also has a liquorice flavour and was eaten by Native American peoples (Mabberley, 2008).

FERNS AS BUILDING MATERIALS

The Guaranies of southeastern Brazil use the stems of *Dicksonia sellowiana* Hook. to support the walls of their traditional houses (Prudente, 2007).

Joshi (1997) lists *Cyathea spinulosa* Wall. ex Hook. and *Dicranopteris liniaris* (Burm. f.) Underw. as used for thatching roofs in India. Kirn and Kapahi (2001) mention *Pteridium aquilinum* (L.) Kuhn. var. *wightianum* (Ag.) Tryon, *Pteris vittata* L., *Thelypteris erubescens* (Wall. ex Hook.) Ching and *Woodwardia unigemmata* (Makino) Nakai for the same purpose.

FERNS IN ORNAMENTATION AND ART

Ferns are often used for body ornamentation. The stipes of *Cheilanthes farinosa* (L.) Brogn. and *Adiantum lunulatum* Burm. are used as nose and ear studs by children and poor women in Uttar Pradesh (Pande & Pangey, 1987) and *Adiantum venustum* D. Don is used as ear studs by girls in Kashmir (Kirn & Kapahi, 2001). The tree ferns *Cyathea divergens* var. *tuerckenheimii* R.M.Tryon and *C. fulva* (Martens & Galeotti) Fée are harvested to produce handicrafts for garden ornamentation by artisans of the mountains of Cuetzalan, Mexico (Elutério, 2006). In the Philippines the petiole and leaf rachis of *Lygodium japonicum* (Thunb.) Sw. are used to decorate baskets (Novellino, 2006). In Argentina the Guaranies use the petioles of various ferns to make necklaces (Keller *et al.*, 2011).

USES OF FERN SPORES

Frye (1934) reported that the spores of *Lycopodium clavatum* L. were used for dusting on open raw wounds and chafed infants by natives of northwestern North America. The spores are fine and light and so repel water and prevent stickiness. Lycopodium powder has also been used as a lubricating dust on latex gloves and condoms, though the latter use is not recommended (see Balick & Beitel, 1989), because these spores have been known to cause allergic reactions, ranging from hay-fever to more serious giant cell granulomas. May (1978) reported that the easily flammable spores of species of *Lycopodium* have been used in theatre as a flash powder.

FERNS AS PLACE NAMES

The importance of ferns to local communities has often led to the names of places, topographic formations, watercourses and political divisions. In Misiones Province (Argentina), the most tropical and wettest province of Argentina, there are various places based on plant names. The 'Diccionario geográfico toponímico' of Stefañuk (2009) gives several examples. "Los helechos" is the name of a stream and a municipality in this province. In the town of Oberá there is a place and a stream named "Samambaya" the common name for ferns derived from the Guaraní word for them "amambái" which translated into English is a generic name of ferns. Locally amambái refers to the large populations of *Pteridium arachnoideum* (Kaulf.) Maxon. In the Department of L.N. Alem there is a stream called "Chachi" which is the Guaraní name for the tree fern *Cyathea atrovirens* (Langsd. & Fisch.) Domin (Cyatheaceae). In the Department of San Martín there is stream called "Culandrillo", a term that refers to species of the genus *Adiantum* (Pteridaceae). In Paraguay the derivation of the name of the political division Amambay Department is derived from the Guaraní word for fern. There are many place names in the United Kingdom associated with ferns, for example, Ferndown in Dorset, Fernilee in Derbyshire and Ferness in the Highlands. Fern is a town in Tayside and Fernie a stream and a castle in Fife. Bracken (*Pteridium aquilinum*) features in Brackenfield in Derbyshire and Brackenthwaite in Cumbria.

FERNS IN PHARMACOLOGY

Substances with antioxidant activity are now used in medicine to reduce the effects of oxidation stress. Antioxidant activity has been reported in *Adiantum capillus-veneris* L., a widely distributed fern (Kumar, 2009). A recent study of the lateral branches of *Equisetum giganteum* L. of South and Central America showed that they can be used as a source of antioxidant compounds (Ricco *et al.*, 2011). In Malaysia studies have shown similar properties in various ferns: *Blechnum orientale* L., *Cibotium barometz* (L.) J.Sm., *Cyathea latebrosa* (Wall. ex Hook.) Copel., *Dicranopteris linearis* Burm., *Drynaria quercifolia* (L.) J.Sm. and *Stenochlaena palustris* (Burm. f.) Bedd. (Chai *et al.*, 2012; Lai & Lim, 2011, Lai *et al.*, 2010). In China several fern rhizomes have been shown to have antioxidant properties: *Drynaria fortunei* (Kze.) J.Sm., *Pseudodrynaria coronans* (Wall. ex Mett.) Ching, *Davallia divaricata* Bl., *D. mariesii* Moore ex Bak., *D. solida* (Forst.) Sw., and *Humata griffithiana* (Hook.) C.Chr. (Chang *et al.*, 2007).

Ferns also contain substances with antibacterial activity as was shown in the study by Thomas (2011) of *Osmunda regalis*. India has made important advances in this area and Kumarpal (2013) showed that there was good antimicrobial activity in three species of ferns from three different families used in traditional medicines in Darjeeling, *Athyrium filix-femina* (L.) Roth (Woodsiaceae), *Dicranopteris linearis* (Burm. f.) Underw. (Gleicheniaceae) and *Pleopeltis macromarpa* (Bory ex Willd.) Kaulf. (Polypodiaceae). Patric Raja *et al.* (2012) found antibacterial and antifungal activity in *Cyathea nilgiriensis* Holttum, *C. crinita* (Hook.) Copel., *Leptochilus lanceolatus* Fée and in *Osmunda hugeliana* Presl. Studies made in Romania by Soare *et al.* (2012) showed that the bladder fern *Cystopteris fragilis* (L.) Bernh. and *Polypodium vulgare* L. strongly inhibited various bacteria, especially *Escherichia coli*. Most of the species that have been studied for their pharmaceutical properties have notable antecedents in traditional medicine. The development of pharmaceuticals from plants used in the pharmacopeia of local peoples ought to ensure that the benefits are shared with the traditional communities from where the original information came (Prance, 1991).

FERNS IN TOXICOLOGY

The relationship between plants and people is not always a positive one. This includes those species that have strong substances that are damaging either to human health or to that of domesticated animals. *Pteridium aquilinum* has been studied for the relationship between the various uses and its toxicity (Alonso Amelot, 1999; Franca *et al.*, 2002; Ortega, 1993; Vetter, 2011). Recent studies show that *Blechnum orientale* is able to absorb heavy metals from the environment and it is therefore a potentially toxic source of food and medicine. The accumulation is mostly in the rhizomes and leaves, the very parts of the plant that are eaten (Zhu *et al.*, 2013). A positive side for the environment of this absorptive capacity of ferns is the accumulation of arsenic by *Pteris vittata* L., which could be used as a method of decontaminating toxic sites. Phytoremediation of arsenic contaminated environments will involve growing the arsenic hyperaccumulator ferns in the contaminated environment, harvesting the arsenic-rich biomass and the safe disposal of the biomass (Gumaelius, 2004; Rathinasabapathi *et al.*, 2006).

FERNS AS ORNAMENTAL PLANTS

A large number of fern species are used as ornamentals in the gardens around the world, and this dates back to ancient times and often to domestication for other uses. Studies of the ornamental potential of pteridophytes of regional floras has led to an increase of their use as cultivated plants. Abraham *et al.* (2012) listed a total of 153 ferns and 18 lycophytes from Nilgiris, India with ornamental potential. Macaya (2004) mentioned 20 species of ferns native to Chile that are cultivated as ornamentals and in Macaya (2008) he expanded this to a list of 75 species. An example of the relevance of ethnobotany for making strategies for use of populations of native vegetation is that of Baldauf *et al.* (2007), who made an ethnobotanical study of the management systems of *Rumohra adiantiformis* (G. Forst.) Ching. This species is used as an ornamental in southern Brazil. Another fern of the southern cone region of South America with high ornamental potential is *Blechnum tabulare* (Thunb.) Kuhn, a species that resembles the Cycadaceae in appearance. A population study of this species was made in southern Brazil (Rechenmacher *et al.*, 2007). The stems of some tree ferns are used extensively as a substrate for the cultivation of epiphytes. However, the indiscriminate use of this resource is threatening populations of these plants in some places. An example of this is the use of *Dicksonia sellowiana* Hook., the conservation of which has led to studies of growth, phenology and germination of spores (Filippini *et al.*, 1999; Schmitt *et al.*, 2009).

FERNS AND SOIL QUALITY

Azolla Lam. has long been used as a fertilizer in rice paddies (Jones, 1987). In Misiones, Argentina farmers identify compacted and degraded soils by means of observations on the presence of *Pteridium aquilinum*. In the central Andean region of Peru indigenous peoples of the Quechua language group use the fronds of *Dennstaedtia glauca* (Cav.) Looser to fertilize the soils where they cultivate potatoes (Camino & Jhons, 1988), which is similar to the use of bracken peat as a fertilizer in some places in the United Kingdom.

CONCLUSIONS

This brief summary has shown the diversity of important uses to which humans have put ferns and lycophytes, and some of these are illustrated in Figures 1-3. Many of these use categories originated in traditional societies (the white area of Figure 4) such as use in rituals, the construction of houses and to make weapons. Other uses are typical of

contemporary society (the dark area of Figure 4) such as the large scale commercialization of ornamental plants and for drug prospecting. However, the division between traditional and modern uses is not precise because many uses fall into both social categories (the grey area of Figure 4). For example many medicinal uses arose in traditional societies that have gradually modernized, still using ferns in their medicine but also leading to prospecting and use in pharmacology. This much more intensive use of ferns in modern societies has led to the destruction of the habitats where they grow. This has increased the importance of habitat conservation of ferns and the development of commercial production rather than harvesting from the wild.

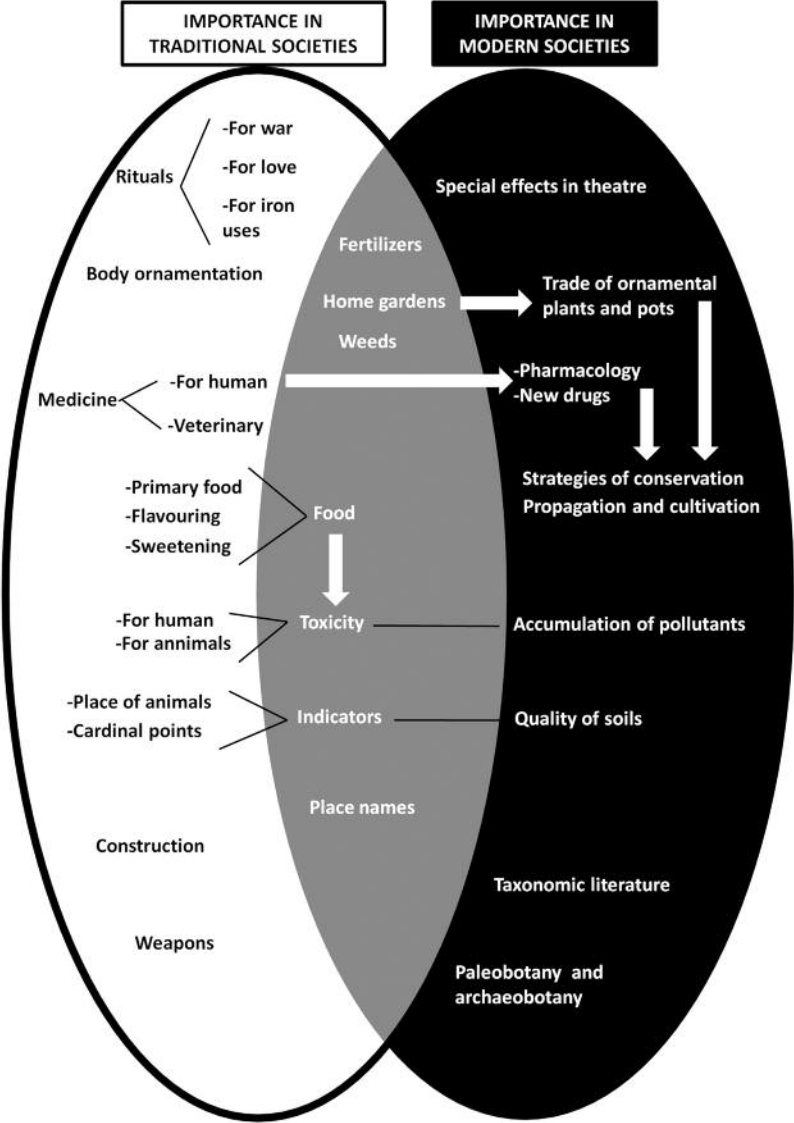


Figure 4. Examples of the importance of ferns in traditional and modern contexts.

ACKNOWLEDGMENTS

We thank Blanca León for helpful suggestions when reviewing the manuscript.

REFERENCES

- ABRAHAM, S., RAMACHANDRAN, V.S. & SOFIA, C. 2012. Potential ornamental Ferns from Nilgiris, Tamil Nadu. *Advances in Applied Science Research* 3 (4):2388-239.
- ALONSO AMELOT, M. E. 1999. Helecho macho, salud animal y salud humana. *Rev.Fac. Agron. (LUZ)* 16: 528-541.
- ANDERSON, A. & WHITE, P. 2001. Approaching the Prehistory of Norfolk Island. *Records of the Australian Museum, Supplement* 27: 1–9.
- BALDAUF, C., HANAZAKI, N. & SEDREZ DOS REIS, M. 2007. Caracterização etnobotânica dos sistemas de manejo de samambaia-preta (*Rumohra adiantiformis* (G. Forst) Ching - Dryopteridaceae) utilizados no sul do Brasil. *Acta bot. bras.* 21(4): 823-834.
- BALICK, M. J. & BEITEL, J. M. 1989. *Lycopodium* spores used in condom manufacture: associated health hazards. *Economic Botany* 43: 373-377.
- BENNIAMIN, A. 2011. Medicinal ferns of North Eastern India with special reference to Arunachal Pradesh. *Indian Journal of Traditional Knowledge* 10(3): 516-522.
- BOOM, B. M. 1985. Ethnopteridology of the Chácobo Indians in Amazonian Bolivia. *Amer. Fern J.* 75:19–21.
- CAMINO, A. & JOHNS. T. 1988. Laki-Laki (*Dennstaedtia glauca*, Polypodiaceae): A Green Manure Used in Traditional Andean Agriculture. *Economic Botany* 42(1):45-53.
- CHRISTENSEN, H. 1997. Uses of ferns in two indigenous communities in Sarawak, Malaysia. In JOHNS, R. J. (Ed.) *Holtum Memorial Volume*, pp. 177-192. Royal Botanic Gardens, Kew.
- CHAI, T.-T., PANIRCHELVUM, E., ONG, H.-C. & WONG, F.-C. 2012. Phenolic contents and antioxidant properties of *Stenochlaena palustris*, an edible medicinal fern. *Botanical Studies* 53: 439-446.
- CHANG, H.C., HUANG, G.J., AGRAWAL, D.C., KUO, C.L., WU, C.R. & TSAY, H.S. 2007. Antioxidant activities and polyphenol contents of six folk medicinal ferns used as “Gusuibu”. *Bot. Stud.* 48: 397-406.
- CLINE, W. 1937. *Mining and Metallurgy in Negro Africa*. George Banta Pub. Co.: Menasha, Wisconsin.
- DÍAZ DE LEÓN, M. E. M., MENDOZA-RUIZ, A. & PÉREZ-GARCÍA, B. 2007. Usos de los helechos y plantas afines. *Etnobiología* 5: 117-125.
- DIXIT, R.D. 1982. *Selaginella bryopteris* (L.) Bak. – An ethnobotanical study IV. *J. Econ. Tax. Bot.* 3: 309-312.
- ELUTÉRIO, A.A. 2006. Management of tree fern (*Cyathea* spp.) for handicraft production in Cuetzalan, Mexico. *Economic Botany* 60: 182-191.
- FILIPPINI, E.C.P., DUZ, S.R. & RANDI, Á.M. 1999. Light and storage on the germination of spores of *Dicksonia sellowiana* (Presl) Hook., Dicksoniaceae. *Revta. Bras. Bot.* 22: 21-26.
- FRANCA, T. N., TOKARNIA, C. H. & PEIXOTO, P. V. 2002. Enfermidades determinadas pelo princípio radiomimético de *Pteridium aquilinum* (Polypodiaceae). *Pesq. Vet. Brass.* 22(3): 85-96.
- FRYE, T. C. 1934. *Ferns of the Northwest*. Metropolitan Press, Portland.
- GUMAELIUS, L., LAHNER, B., SALT, D. E. & BANKS, J. A. 2004. Arsenic

- hyperaccumulation in gametophytes of *Pteris vittata*. A new model system for analysis of arsenic hyperaccumulation. *Plant Physiol.* 136:3198–3208.
- HERNÁNDEZ CIBRIÁN, R. K. & SUTHERLAND, C. H. N. 2007. Etnobotánica de los Helechos de Honduras. *Ceiba* 48(1-2): 1-10.
- HOUGHTON, P. 1978. Dental evidence for dietary variation in prehistoric New Zealand. *Journal of the Polynesian Society* 87(3): 257-263.
- HURREL, J. A. & DE LA SOTA, E. R. 1996. Etnobotánica de las Pteridofitas de los Pastizales de altura de Santa Victoria (Salta, Argentina). *Revista Mus La Plata (NS). Botánica* 15(105): 353–364.
- JONES, D. L. 1987. *Encyclopaedia of Ferns. An Introduction to ferns. Their structure, biology, importance, cultivation and propagation.* Lothian Publishing Company PTY LTD. Melbourne, Sydney, Auckland.
- JOSHI, P. 1997. Ethnobotany of Pteridophytes of hilly districts of Uttar Pradesh, India. *Indian Fern J.* 14: 14-18.
- JOSHI, P. 2011. Ecology and Medicinal Uses of *Helminthostachys zeylanica* (L.) Hook. “An endangered flora of India” reported at Foothills of Kumaun Himalaya (Kashipur), Uttarakhand. *Researcher* 3(4): 51-54.
- KELLER, H.A., MEZA-TORRES, E.I. & PRANCE, G.T. 2011. Ethnopteridology of the Guaranis of Misiones Province, Argentina. *Amer. Fern J.* 101(3): 193-204.
- KIRN, H.S. & KAPAH, B.K. 2001. Ethnobotanical notes on some ferns and fern-allies of Jammu and Kashmir State, India. *Indian Fern J.* 18: 35-38.
- KUMAR A. 2009. Antioxidant effect of *Adiantum capillus veneris* Linn. on human lymphocyte: an *in vitro* study. *Journal of Cell and Tissue Research* 9 (2): 1899-1902.
- KUMARI, P., OTAGHVARI, A. M., GOVINDAPYARI, H., BAHUGUNA, Y. M. & UNİYAL, P. L. 2011. Some ethno-medicinally important Pteridophytes of India. *Int. J. Med. Arom. Plants* 1(1): 18-22.
- KUMARPAL, S. 2013. Study of Activity of Some Medicinal Ferns of Darjeeling. *International Journal of Scientific and Research Publications* 3(8): 1-4.
- LAI, H.Y. & LIM, Y.Y. 2011. Evaluation of Antioxidant Activities of the Methanolic Extracts of Selected Ferns in Malaysia. *International Journal of Environmental Science and Development* 2(6): 442-447.
- LAI, H.Y., LIM, Y. Y. & KIM, K.H. 2010. *Blechnum Orientale* Linn - a fern with potential as antioxidant, anticancer and antibacterial agent. *BMC Complementary and. Alternative Medicine*, vol.10: 15.
- LIU, Y., WUJISGULENG, W. & LONG, C. 2012. Food uses of ferns in China: a review. *Acta Soc. Bot. Poloniae* 81: 263-270. (52 species used)
- LOOSER, G. & RODRÍGUEZ, R. 2004. Los helechos medicinales de Chile y sus nombres vulgares. *Gayana Bot.* 61(1): 1–5.
- LUJÁN, M. C., MORERO, R., BONZANI, N. E. & BARBOZA, G. E. 2007. Sobre la identidad de algunos helechos medicinales que se comercializan en Córdoba (Argentina). *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas* 6(6): 376-377.
- LUJÁN, M. C., MORERO, R. & BARBOZA, G. E. 2011. Estudios epidérmicos en helechos y licófitas medicinales de la Provincia de Córdoba, Argentina. *Hoehnea* 38(4): 609-659, 2 tab., 28 fig.
- MABBERLEY, D.J. 2008. *Mabberley’s Plant-book*, ed. 3: 690. Cambridge Univ. Press
- MACAYA, J. 2004. Helechos nativos de Chile cultivados con fines ornamentales. *Chloris Chilensis* 7(1) URL: <http://www.chlorischile.cl>.
- MACAYA, J. 2008. Helechos introducidos en Chile con fines ornamentales (parte I). *Chloris Chilensis* Año 11, N°2. URL: www.chlorischile.cl.

- MACÍA, M.J. 2004. A comparison of useful Pteridophytes between two Amerindian Groups from amazonian Bolivia and Ecuador. *Amer. Fern J.* 94: 39-46.
- MANNAR MANNAN, M., MARIDASS, M. & VICTOR, B. 2008. A Review on the Potential Uses of Ferns. *Ethnobotanical Leaflets* 12: 281-285.
- MAY, L. W. 1978. The economic uses as associated folklore of ferns and fern allies. *Bot. Rev.* 44: 491-528.
- MAZUMDER, P. B., MAZUMDER, B., CHOUDHURY, M D. & SHARMA, G.D. 2011. In Vitro Propagation of *Drynaria quercifolia* (L.) J. Sm., a Medicinal Fern. *Assam University Journal of Science & Technology, Biological and Environmental Sciences* 7(1): 79-83.
- MERRILL, E. D. 1917. An interpretation of Rumphius's "Herbarium Amboinense". Manila Bureau of Printing.
- MOLINA, M., REYES-GARCIA V. & PARDO-DE-SANTAYANA, M. 2009. Local knowledge and management of the Royal Fern (*Osmunda regalis* L.) in Northern Spain: Implications for Biodiversity Conservation. *Amer. Fern J.* 99 (1): 45-55.
- MURILLO, M.T. 1983. Usos de los helechos en Suramérica con especial referencia a Colombia. Ed. Instituto de Ciencias Naturales, Biblioteca José Jerónimo Triana, N°5, 156 pp. Bogotá.
- NAVARRETE, H., LEÓN, B., GONZALES, J., AVILES, D. K., SALAZAR LECARO, J., MELLADO, F., ALBAN, J. & ØLLGAARD, B. 2006. Helechos. In: MORAES R., M., ØLLGAARD, B., KVIST, L. P., BORCHSENIUS, F. & BALSLEV, H. (Eds.): *Botánica Económica de los Andes Centrales*. Universidad Mayor de San Andrés, La Paz, p: 385-411.
- NOVELLINO, D. 2006. An introduction to basketry in Island Southeast Asia. *Proceedings of the IVth International Congress of Ethnobotany (ICEB 2005)*, 2006: 621-625.
- NWOSU, M. O. 2002. Ethnobotanical studies on some Pteridophytes of southern Nigeria. *Econ. Bot.* 56: 255-259.
- ORTEGA, F. 1993. La etnobotánica de *Pteridium aquilinum* (L.) Kuhn en Venezuela y sus posibles riesgos asociados a la carcinogénesis. *Medula* 2 (3-4): 51-56.
- PANDE, P.C. & PANGTEY, Y.P.S. 1987. Studies on ethnobotany –I. On some less known edible and economic ferns of Kumaun region of Western Himalaya. *J. Econ. Tax. Bot.* 11: 81-85.
- PATRIC RAJA, D., JOHNSON, M., IRUDAYARAJ, V. & JANAKIRAMAN, N. 2012. Antimicrobial efficacy of selected ferns of Western Ghats, South India. *International Journal of Current Pharmaceutical Research* 4 (2): 58-60.
- PRANCE, G. T. 1991. What is ethnobotany today? *J. Ethno-pharmacol.* 32: 209-216.
- PRUDENTE, L. T. 2007. Arquitetura Mbyá-Guaraní na Mata Atlântica do Rio Grande do Sul. Estudo do caso do Tekoá Nhüu Porã. Tese (Mestrado) em engenharia. Universidades Federal do Rio Grande do Sul. Escola de Engenharia. Porto Alegre, 164 pp.
- RATHINASABAPATHI, B., MA, L. Q. & SRIVASTAVA, M. 2006. Arsenic Hyperaccumulating Ferns and their Application to Phytoremediation of Arsenic Contaminated Sites. *Floriculture, Ornamental and Plant Biotechnology* 3: 304-311.
- RECHENMACHER, C., SCHMITT, J. L. & BUDKE, J. C. 2007. Estrutura e distribuição espacial de uma população de *Blechnum tabulare* (Thunb.) Kuhn (Pteridophyta, Blechnaceae) em um mosaico floresta-campo no sul do Brasil. *Pesquisas, Botânica* 58: 177-186.
- RICCO, R. A., AGUDELO, I., GARCÉS, M., EVELSON, P., WAGNER, M. L. & GURNI, A. A. 2011. Polifenoles y actividad antioxidante en *Equisetum giganteum* L.

- (Equisetaceae). Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 10 (4): 325 – 332.
- RUIZ, H. 1805. Memoria sobre la legítima calaguala y otras dos raíces que nos vienen de la América meridional. Imprenta de D. José del Collado, Madrid, 60 pp.
- RUMPHIUS, G. E. 2011. The Ambonese Herbal vol 5: 121-165. English translation by E.M. BEEKMAN of The Ambonese herbal first published in 1741, Yale University Press.
- SHARMA, B.D & VYAS, M.S. 1985. Ethnobotanical studies on the ferns and fern allies of Rajastan. Bull. Bot. Survey India 27: 1-4.
- SCHMITT, J. L., SCHNEIDER, P. H. & WINDISCH, P. G. 2009. Crescimento do cáudice e fenologia de *Dicksonia sellowiana* Hook. (Dicksoniaceae) no sul do Brasil. Acta bot. bras. 23(1): 282-291.
- SCHMIDT, P. R. & AVERY, D. H. 1983. More Evidence for an Advanced Prehistoric Iron Technology in Africa. Journal of Field Archaeology 10(4): 421-434.
- SMITH, A. R., PRYER, K. M., SCHUETTPELZ, E., KORALL, P., SCHNEIDER, H. & WOLF, P. G. 2006. A classification for extant ferns. Taxon 55(3): 705-731.
- SOARE, L. C., FERDEŞ, M., DELIU, I. & GIBEA, A. 2012. Studies regarding the antibacterial activity of some extracts of native pteridophytes. U.P.B. Sci. Bull., Series B 74(1): 21-26.
- SRIVASTAVA, K. 2007. Importance of Ferns in Human Medicine. Ethnobotanical Leaflets 11: 231-234.
- STEFANUK, M. Á. 2009. Diccionario geográfico toponímico de Misiones. Contratiempo Ediciones. Buenos Aires, 817 pp.
- STRASBURGER, E., NOLL, F., SCHENCK, H. & SCHIMPER, A. F. W. 2003. Tratado de Botánica, 35ª edición, actualizada por SITTE, P., WEILER, E. W., KADEREIT, J. W., BRESINSKY, A. & KÖRNER, C. Ediciones Omega, Barcelona, 1134 pp.
- THOMAS, T. 2011. Preliminary Antibacterial and Phytochemical Assessment of *Osmunda regalis* L. International Journal of Pharmaceutical & Biological Archives; 2(1): 559-562.
- TURNER, N.J, JOHNSON GOTTESFELD, L.M., KUHNLEIN, H.V. & CESKA, A. 1992. Edible wood fern rootstocks of western North America: solving an ethnobotanical puzzle. J. Ethnobiol. 12: 1-34.
- VETTER, J. 2011. Toxicological and medicinal aspects of the most frequent fern species, *Pteridium aquilinum* (L.) Kuhn. Chapter 25. In H. Fernández *et al.*, (eds.): Working with ferns: Issues and applications. Springer Sciences & Business Applications. P. 361.
- WILEY, G. R. 2003. Archaeobotany: Scope and Significance . In: Richard Evans Schultes & Siri Von Reis (Eds.): Ethnobotany. Timber Press, Portland. P: 400-406.
- ZHANG, Y. M. 2007. A preliminary investigation of the history of pteridophyte eating in China. Journal of Southwest Agricultural University (Social Science Edition) 5(4): 103–106.
- ZHU, X., KUANG, Y., XI, D., LI, J. & WANG, F. 2013. Absorption of Hazardous Pollutants by a Medicinal Fern *Blechnum orientale* L., BioMed Research International Vol. 2013: 1-6.

A SHORT BIOGRAPHY OF THE AUTHORS

Héctor Alejandro Keller, holds a Forestry Engineer's degree from the Universidad Nacional of Misiones, Argentina (2000), and a Ph.D. in Natural Resources from the Universidad Nacional del Nordeste (2008). He is currently lecturer in botany and vegetation systematics at the National University of Misiones. Technical officer responsible for the Multiple-use Guaraní Reserve, 2006-2007. Since 2010 Scientific Researcher of the National Council for Scientific and Technological Research of Argentina. He has collected 12,300 herbarium specimens, mainly from Misiones Province, Argentina including ten new species and one new beetle. Author of one book chapter and 87 articles in scientific journals on ethnobotany, ethnography, ethnobiology and floristic studies. Eponyms: : *Lasiodactylus kelleri* Cline (Nitidulidae); *Gaya kelleri* Krapov. (Malvaceae), *Phaeostemma kelleri* Morillo (Asclepiadaceae).

Professor Sir Ghilleen Prance, University of Oxford BA in Botany (1960) M.A., D.Phil. (1963); research assistant The New York Botanical Garden 1963, B A Krukoff Curator of Amazonian Botany (1966), Director and Vice-President of Research (1976-1982), Senior Vice President for Science (1982-1988). 39 expeditions to Amazonia, collected 350 new species of plants. Director of the Royal Botanic Gardens, Kew 1988 -1999; McBryde Professor, National Tropical Botanical Garden Hawaii 2001-02, McBryde Senior Fellow (2003-). Visiting Professor at Reading University; author of 20 books and 529 scientific and general papers in taxonomy, ethnobotany, economic botany, conservation and ecology; International COSMOS Prize 1993; Fellow of the Royal Society; Knight Bachelor; 1995; Victoria Medal of Honour of Royal Horticultural Society, 1999; David Fairchild Medal for plant exploration, 2000; Allerton Award in 2005; Commander of the Order of the Southern Cross Brazil, 2000; Order of the Rising Sun from Japan, 2012.



The authors in a Guaraní village in Misiones, Héctor Keller at left, Ghilleen Prance second from left.