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Original article

Using quantitative indices to evaluate the cultural importance of food and nutraceutical plants: Comparative data from the Island of Bali (Indonesia)

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ABSTRACT

Different quantitative indices were proposed to determine the cultural importance of ethnobotanically valuable plants in order to develop a tool for the evaluation of immaterial cultural heritage. These indices were applied to an ethnobotanical survey of food and nutraceutical plants traditionally consumed in Bali, Indonesia. The uses of the plants were grouped into 6 use categories. The Cultural Food Significance Index (CFSI), use value (UV), relative frequency of citation (RFC), relative importance (RI), cultural value (CVs), and informant consensus factor (ICF) were calculated for a list of plants cited by fifty informants in different traditional villages on the island. This evaluation of the cultural importance of plants through different indices produced interesting variations. *Colocasia esculenta* (L.) Schott came highest in the preference ranking for RFC, UV and CVs. *Arenga pinnata* (Wurmb) Merr. was in first place for CFSI and RI. *Artocarpus heterophyllus* Lam., *Lablab purpureus* (L.) Sweet and *Cinnamomum burmanni* (Nees & T. Ness) Blume were also high in the CFSI, RI, and CVs. The ICF results revealed a well-defined food tradition. The combined use of these indices, as opposed to any single index, makes it possible to quantify the role that a given plant plays within a particular culture.

1. Research aims

This paper compares six culturally important indices proposed in the literature, in order to assess both the cultural significance for traditional ethnobotanical knowledge (TEK) of plant species in a relevant area, and the suitability of such indices for the identification of cultural conservation needs. For the comparison, we used data concerning food and nutraceutical plants traditionally consumed in Indonesian Island of Bali.

2. Introduction

Ethnobotany falls within the "knowledge and practices concerning nature and the universe", which constitute humanity's intangible cultural heritage as defined by UNESCO in 2003 [1,2]. This declaration was a fundamental step towards the recognition of all orally transmitted traditional knowledge (TK) systems as an integral part of worldwide cultural heritage in need of protection and safeguarding [3]. Many authors have stressed the urgent need of ethnobotanical documentation in order to contrast the rapid decline of TEK due to plant extinction and, above all, to the disappearance of traditional cultures [4–8].

Different ethnobotanical cultural importance indices were developed in order to establish the main parameters needed to evaluate which are the most important plants within a culture and to determine conservation requirements [9–11]. In particular, indices for use value (UV) [12], relative importance (RI) [13], relative frequency of citation (RFC) [14], cultural value (CVs) [15,16], and informant consensus factor (ICF) [17–19] seem highly relevant in quantitative ethnobotanical study.

Within the context of traditional plant use, the field of food and nutraceutical plants now seems highly relevant for ongoing efforts to improve biodiversity in food culture and food security [20–23]. It is important to document plants traditionally consumed within a particular geographical and cultural context in order to develop culturally important indices of quantitative ethnobotanical data. Such documentation is also necessary in order to understand cultural issues related to food acceptance and to develop insights

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into the investigation of phytochemical compounds [24]. A cultural food significance index (CFSI) was introduced in the field of food ethnobotanical study, taking into account seven indices, such as frequency of use, frequency of citation of species, availability, the part of the plant used, multi-functional food use, taste score appreciation, and medicinal applications [24].

Ethnobotany is particularly important in tropical countries, where local cultures are undergoing rapid changes [4–6,8], with a similar situation taking place in Europe [3]. In Indonesia, several ethnobotanical studies have, over the last few decades, focused on the use of medicinal plants [25–28]. Despite this, only a few of the ethnobotanical studies carried out across the whole South East Asia region have focused on medicinal, aromatic, and food plants [18,28–31], and only one ethnobotanical study has carried out a quantitative evaluation of biocultural diversity on the island of Bali [32].

3. Materials and methods

3.1. Study area

The study area is located on the Indonesian island of Bali, and is delimited by the islands of Lombok to the East and Java to the West [33]. Bali is extremely interesting for the study of cultural heritage due to the exceptional architectural treasures represented by its active and well-preserved Hindu temples [34], and to its unique landscape (the Subak, an irrigation system for paddy fields unique to Bali was listed as a UNESCO world heritage site in 2012) [35]. A valuable example of immaterial cultural heritage is preserved in Balinese daily life, and includes rituals, traditional medicines, and local foods [23,36,37], but the problem of cultural erosion in this area seems to be increasing, as observed in a previous contribution [8].

Bali still has several aga (indigenous) villages, i.e. villages inhabited by families whose ancestors have lived in Bali for many generations. These inhabitants belong to Bali's aga ethnic group, and identify strongly with Hindu religious customs and traditions. Their economy is based on agriculture and wild natural resources. The ages of settlements vary (from the 11th to 14th century) [34], and are typically composed of two to five thousand inhabitants [33]. Building styles and social customs reflect traditional Balinese culture [34]. TEK data was collected in 13 Bali aga villages located between 242 and 1187 m above sea level. Most villages are found at higher altitudes, and this is probably connected to a reduced impact from tourism, which is concentrated mainly in coastal areas (Fig. 1).

Bali's traditional culture is based on the selling of agricultural products, such as green vegetables, fruit, beans, and the staple food of rice [33]. Cultivated plants, which have played an important role in the local food economy, are represented by *Oryza sativa* L., *Manihot esculenta* Crantz, *Ipomoea batatas* (L.) Lam., *Luffa acutangula* (L.) Roxb., *Musa paradisiaca* L., *Artocarpus heterophyllus*, *Carica papaya* L., and *Salacca zalacca* (Gaertn.) Voss. These plants have long represented the main food source for locals. Bali's traditional food and nutraceutical culture includes a wide variety of plants that are gathered in forests or grown in home gardens and on farmland [23,29,31,33].

3.2. Data collection

Ethnobotanical information was obtained through semi-structured interviews with 50 informants (ages ranged between 14 and 76 years old) using the snowball method [8,38,39]. Most of the informants (90%) were male, reflecting the predominant role of men in Bali's traditional culture, especially in rural areas. A detailed analysis of the factors (e.g., age, gender, education level, occupation, monetary earning, geographical, and socio-economic characteristics) affecting differences in traditional knowledge of plant uses in the surveyed villages is provided in Sujarwo et al. [8].

Before each interview, prior informed consent was requested and international codes of ethics, as presented in Rosenthal [40], were observed throughout the study. After obtaining consent, various strata of informants (according to their occupation, such as: civil servants, farmers, village leaders, religious leaders, and others) were interviewed. For underage informants, consent was obtained beforehand from their parents. At least four informants per village were interviewed. Interviews were conducted in both Balinese and Indonesian. Informants were asked to provide, from memory, a list of traditional food and nutraceutical plants cultivated and consumed in their village. The informants were also asked to specify the following information for each plant mentioned: which part of the plant was used, how that plant part was used, its perceived availability, the frequency of use of the species, taste appreciation, and its medicinal properties when eaten [24].

All of the plants cited were collected with the assistance of the informants and identified by the first author with the help of professional experts from Bali Botanical Gardens. Voucher specimens were deposited at Bali Botanical Gardens' Herbarium Hortus Botanicus Baliense. The scientific nomenclature of plants used in this paper follows internationally approved checklists [41].

All detailed information on food and nutraceutical uses was recorded as freely given by informants before being sorted into the following six food and nutraceutical use categories: (1) vegetables, (2) edible fruits, (3) staple foods, (4) spices, (5) edible seeds, and (6) herbal drinks. The same plant could fall into more than one use category.

3.3. Quantitative analysis

Most indices are based on "informant consensus," i.e., the degree of agreement between interviewees [11]. Phillips [42] pointed out that these procedures tend to be more objective as they are designed to reduce bias in attributing relative importance. In this study, we have compared the importance of each species using the following six indices: cultural food significance index (CFSI), use value (UV), relative frequency of citation (RFC), relative importance (RI), cultural value index (CVs), and informant consensus factor (ICF), in accordance with the suggestion that a wider and more comparative use of indices should be made in ethnobotanical studies [7].

3.3.1. Cultural food significance index (CFSI)

The cultural food significance index, proposed by Pieroni [24], elaborated with the specific aim of evaluating the cultural significance of edible plants, was calculated as:

$$\mathrm{CFSI} = \mathrm{QI} \times \mathrm{AI} \times \mathrm{FUI} \times \mathrm{PUI} \times \mathrm{MFFI} \times \mathrm{TSAI} \times \mathrm{FMRI} \times 10^{-2}$$

The formula takes into account seven indexes, which express the frequency of quotation (QI), availability (AI), frequency of use (FUI), plant parts used (PUI), multi-functional food use (MFFI), taste score appreciation (TSAI), and the food-medicinal role (FMRI) [24,43,44].

3.3.2. Use value (UV)

The use value index (UV), which was first proposed by Prance et al. [12], indicates the relative importance of species known locally. Its value is based on the number of uses and the number of people that cite a given plant, and has been widely used within the ethnobotanical community to indicate the species that are considered most important by a given population [9–12].

It was calculated using the following formula [11,14,45,46]:

$$\mathrm{UV} = \Sigma U_i / N$$