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Traditional plant-based remedies to control insect vectors of disease in the Arribes del Duero (western Spain): An ethnobotanical study

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ABSTRACT

Ethnopharmacological relevance: In several Spanish rural communities, simple and effective plant-based remedies are employed for the control of vector-borne diseases. Hence, the aim of this study was to assess the knowledge and usage custom of traditional insect control in the Arribes del Duero–ARD–(Salamanca-Zamora, W Spain).

Materials and methods: Between 2005 and 2009, 116 semi-structured interviews of 80 non-specialist people (44 men and 36 women; mean age, 72) were conducted. This community was located in the Arribes del Duero Natural Park, representative of a highly heterogeneous Mediterranean landscape with a strong decline in the population and a significant proportion (almost 40%) age 65 or greater. We calculated the cultural importance for each species cited. To analyze how traditional ecological knowledge (TEK) varies with the characteristics of the informants, we performed an ANCOVA.

Results and conclusions: We documented the traditional use of 22 vascular plants as remedies to prevent or treat external parasites, and control mosquitoes, flies and other nuisance insects. There were described 27 plant remedies, of which 16 (59%) continue to be in use, including basil (*Ocimum basilicum* L. and *Ocimum minimum* L.) as a repellent for mosquitoes and houseflies. Most of the plant species contain phenols and/or terpenoids, and in several investigations bioassays have been performed to test their repellent and/or insecticidal properties. Three taxa (*Ballota nigra* L., *Cicer arietinum* L. and *Ocimum minimum*) have not been tested and these may offer excellent natural remedies. As well as allowing the discovery of new chemical compounds with insecticidal activity, this traditional knowledge may be paramount in the control of potential populations of vectors of emerging diseases in the Mediterranean region without harming the environment.

1. Introduction

Insects are vectors of pathogens that resulting human diseases of concern on a global scale. Some insect populations have developed resistance to pesticides, including DDT, other organochlorines, organophosphates and pyrethroids (Hemingway and Ranson, 2000; Whalon et al., 2008). Climate change has been implicated in the expansion of certain infectious disease vectors into new geographic areas (Khasnis and Nettleman, 2005; Parham et al., 2011). Globalization, characterized by social, political, and economic changes, has led to an increase in the worldwide transport of goods, and also increases risk of accidental transport of foreign species. The ease and speed of travel, tourism, and international trade now connects once-remote areas, eliminating many of the geographic barriers that used to limit the spread of vector-borne diseases (Kawachi and Wamala, 2007; Reiter, 2010). In Spain, as in other circum-Mediterranean countries, these factors are major causes of the recent resurgence of major public health problems.

The evolution of insecticide resistance is partly governing the resurgence. For example, infestations of the common bed-bug, *Cimex lectularius* L. (Hemiptera: Cimicidae), is on the rise (Romero et al., 2007). This obligatory hematophagous insect had remained almost absent for decades (Fuentes et al., 2010), but the increasing migratory flux of Latin-American populations and the ever more common use of beds, mattresses, etc., by large numbers of people have been proposed to be some of the causative elements of increases in bed-bug infestation in large cities (Fuentes and Sainz-Elipe, 2005; Bueno Marí et al., 2009). It should be mentioned, that Chagas disease, another less commonly encountered disease, is also on the rise (Gascón and Muñoz, 2005).

Global warming also favours the expansion of the Asian tiger mosquito, *Aedes albopictus* (Skuse) (Diptera: Culicidae), into eastern Spain (Aranda et al., 2006; Delacour-Estrella et al., 2010). This

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species is acquiring increasing importance in Spanish Public Health after recent human cases of West Nile virus infections have been reported (Kaptoul et al., 2007; Bueno Marí and Jiménez Peydró, 2010).

For decades, the control of these harmful insects has relied heavily on the application of adulticides and larvicides. Due to the development of resistance, biocide pollution (an important cause of biodiversity loss in Europe; see European Environment Agency, 2010), and the toxicity of many insecticides (implicated in certain congenital anomalies; see Dugas et al., 2010), control methodology is increasingly focused on insect pest management practices (Wall, 2007). New tools and techniques are also being developed, such as genetically modified insect pathogens (see Gilbert and Gill, 2010) and semiochemicals, which chemically modify the behaviour and physiology of the target insects (Weeks et al., 2011). Additionally, examination of traditional practices has been proposed as a potential avenue for new strategies. Thus, Berkes et al. (2000) and others authors have focused their research on the documentation and analysis of the traditional ecological knowledge (TEK) of different human communities. In this context, Ethnobotany is an important method of sourcing candidate plants (see Moore et al., 2006).

In Spain, the ability of some plants to repel insect pests has been used traditionally, and some of these remain in use today. Such plants are a natural resource that can be grown locally and used for their insect-repellent properties and pleasant aroma (Blanco, 1995a). However, although some works have addressed the analysis of anti-insect activity of extracts from certain wild plant species (e.g. Pascual-Villalobos and Robledo, 1998, 1999), in the ethnobotanical literature there are few data confirming their alleged activities. Only a few published papers (Blanco, 1995a, b), or pages within books (e.g. Criado, 2010; Tejerina, 2010), and a partial bibliographic review of these folklore remedies are offered (Ortiz Suárez, 2010).

Therefore, it is prudent to investigate unexplored areas in the realm of Ethnobotany. In the present work, the use vascular plants for anti-insect purposes was studied as part of ethnobotanical research carried out in the Arribes del Duero area – henceforth the ARD – (Salamanca and Zamora provinces) (González et al., 2010, 2011). This community has been extremely isolated up until the mid-twentieth century and is now characterized by a marked decline in the population, and still living a subsistence existence.

Thus, the aims of the present study were as follows: (i) to document the TEK of the inhabitants of the ARD in relation to the use of plant species as insecticides, and/or insect repellents; (ii) to discuss the potential use of these plants on the basis of their known anti-insect chemical compounds; and (iii) to contribute to the dissemination of the results to the scientific community so that researchers from additional disciplines may become involved.

2. Methodology

2.1. Study area

Although the works cited above include a broad description of the study area, it is worth noting that the territory of the ARD forms the administrative border between Spain and Portugal along a stretch of some 120 km (40°50′–41°35′ N, 6°00′–6°41′ W; see Fig. 1 in González et al., 2010). It is a high-quality protected area (Arribes del Duero Natural Park, declared a Site of Community Importance) with singular geomorphological, ecological and floristic traits (Amich et al., 2004). Traditionally, the population has been based on a subsistence economy that, owing to the limited potential of the soils of the region, has mainly focused on livestock rearing. Therefore, this territory can be said to be a good example of a very heterogeneous local Mediterranean landscape with a marked alternation of habitats and land uses (Calabuig, 2008). Likewise, the ARD area is characterized by a strong demographic deterioration, which nearly 40% of the population over age 65 (Morales and Caballero, 2003).

2.2. Ethnobotanical data collection

Interviews were conducted with individuals that had a sound knowledge of useful plants, i.e. those who were elderly and long-time residents that were born in the region. Information was obtained from 116 semi-structured interviews, conducted from 2005 to 2009. The interviewers were 80 people (44 men and 36 women; age range, 45–98 years; mean age, 72) from 18 localities: 6 in the province of Zamora and 12 in Salamanca. Questions were asked about the use of plants sought to establish knowledge about their past and present use as insect control methods.

The plant taxonomy and nomenclature followed the "Flora iberica" (Castroviejo, 1986–2010) for the families included therein and the "Flora Europaea" (Tutin et al., 1964–1993) for the remaining ones. Voucher specimens were deposited at SALA (the Herbarium of the University of Salamanca, Spain). In the case of some species for which no voucher was available, a digital photography number (PHO) is included.

2.3. Data analysis

For quantitative analysis of the data, as in our previous works (e.g. González et al., 2010), each plant species mentioned by an informant within a use-category (defined attending to the insect group target) was counted as a "use-report" (UR). To estimate the relative significance of each species in addition to indicating their frequency of citation (number of informants who mention the use of the species – FC –), the cultural importance index provided by Tardío and Pardo-de-Santayana (2008) was used, with the following formula:

$$\mathrm{CI}_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} \frac{UR_{ui}}{N}$$

The index was obtained by adding firstly the UR of all the informants (from i_1 to i_N) in each use-category mentioned for a species (s) and finally adding all the UR of each category (from u_1, only one use, to u_{NC}, the total number of categories, *NC*), divided by the number of informants (*N*).

Special emphasis is placed on remedies used currently, for which we indicate the frequency of current use (FCU): i.e. the number of informants who continue to use them today.

In order to analyze how TEK varied according to the characteristics of the different interviews, we performed an Analysis of Covariance (ANCOVA), taking "UR" as the variable to model (number of use-reports provided by each informant), "age" (a quantitative variable) and "gender" (a qualitative variable that takes values of *m* = male or *f* = female) as explanatory variables, and using the XLSTAT 2009 program.

3. Results and discussion

3.1. Primary ethnobotanical data

Owing to their toxicity or penetrating smell, some vascular plants are used as insecticides and/or insect repellents in the ARD. We documented the use of 22 species as 27 described remedies to prevent or treat certain ectoparasitoses, control or