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Article in *Journal of Ethnopharmacology* · May 2016

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# Why ritual plant use has ethnopharmacological relevance

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## ARTICLE INFO

### Article history:

Received 7 October 2015

Received in revised form 2 May 2016

Accepted 4 May 2016

Available online xxx

### Keywords:

Rituals

Benin

Gabon

Traditional medicinal knowledge

Pharmacological effect

Public health

## ABSTRACT

### Ethnopharmacological relevance

Although ritual plant use is now recognised both for its socio-cultural importance and for its contribution to nature conservation, its potential pharmacological effects remain overlooked.

### Aim of the study

Our objective was to see whether ritual plant use could have ethnopharmacological relevance through practices that involve direct physical contact with the human body. We hypothesise that ritual practices reflect traditional knowledge on biological activities of plant species, even if plants are used in a symbolic way.

### Materials and methods

Data were collected in collaboration with traditional healers and ritual plant vendors and harvesters in Benin (West Africa) and Gabon (Central Africa). Both ritual and medicinal uses of plants were recorded. Voucher specimens were collected and identified. We documented different administration routes of ritual plants and selected those whose uses involved direct contact with the human body. Based on our quantitative market surveys and field inventories, we identified 24 commercially or otherwise culturally important species and compared their ritual uses with proven biological activity from the literature.

### Results

We recorded 573 plant species with 667 ritual uses, of which ca. 75% (442 species and 499 uses) implied direct contact with the human body. The most common route of administration for ritual treatments was baths, followed by oral ingestion and skin rubbing. One third (186 species) of all ritual plants doubled as medicine for physical ailments. In contrast to previous research that explained the effectiveness of ritual plant use to be a matter of belief, our results hint at the potential medicinal properties of these plants. Ritual treatment of madness caused by evil spirits by the consumption of *Rauvolfia vomitoria* roots, for example, may be based on the species' proven anticonvulsant properties.

### Discussion and conclusion

We discuss some of the possible implications of ritual plant use for public health and conclude by suggesting that ritual plant uses that do not involve contact with the human body may also be vehicles for the transmission of traditional medicinal knowledge.

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## 1. Introduction

According to the International Council for Science (ICSU, 2000), traditional knowledge is defined as the body of knowledge and practices developed and maintained by people to manage their environment. It includes beliefs in supernatural agents such as spirits, ancestors and gods, and how these relate to society (Reyes-García, 2010). Over the past two decades, traditional knowledge has received increasing recognition for its importance in nature conservation (Berkes et al., 2000), and for the advancement of biomedical science (Young, 1983). In the case of Africa, anthropologists have thoroughly studied traditions that involve the enactment of agency by supernatural entities (henceforth religious traditions Quiroz, 2015) and rituals (i.e. the practical matrix of religious traditions (Rappaport, 1999))

(Herskovits, 1938; Fernandez, 1982; Blier, 1995), but the plants associated with these practices have barely been documented (Verger, 1995; Raponda-Walker and Sillans, 1961; Vergiat, 1970; Akendengue, 1992; De Souza, 2006). With the exception of psychoactive plants that are central to some religious traditions (notably, *Tabernanthe iboga* (Sheppard, 1994; Alper et al., 2008)) and toxic species used in poison ordeals (e.g. *Erythrophleum suaveolens* (Abbiw, 1996; Ngounou et al., 2005)), African ritual plants use has received little attention in ethnopharmacology. This is probably due to the tendency of researchers in this discipline to base their studies almost exclusively on a combination of chemical, biological, and pharmacological sciences (Reyes-García, 2010). Moreover, from bioprospecting during the colonial era, the notion emerged that African ritual plant use is too much typified by witchcraft and sorcery to be of any medicinal benefit (Voeks, 2004). Not surprisingly, ritual plant use has been described as “superstitious” (Irvine, 1961), characteristic of “under-developed peoples” (Oliver-Bever, 1986), a demonstration of “the gullibility of the credulous” (Burkill, 1995), or has simply been omitted

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from the otherwise extensive inventories of useful plants (Abbiw, 1996).

This attitude of neglect is indisputably changing, as demonstrated by the number of publications that acknowledge ritual plant use as an integral part of traditional healing systems (Van Andel and Ruysschaert, 2011; Iwu, 2014). In practice, however, we now face the consequences of the historical disdain for ritual plants. For example, the Plant Resources of Tropical Africa (PROTA) series composed of eight volumes and a web database with over 1850 articles on useful plant species (PROTA, 2014) is probably the most valuable resource on useful plants for Africa to date. Although ritual, religious, or magic uses of plants are sometimes mentioned in the separate sections on medicinal uses given for each of the species treated, these appear to be proportionally underrepresented. This is an unfortunate situation, given that PROTA's mission is to make scientific information about useful plants accessible in Africa, yet an important aspect of societal life in the continent remains scantily covered.

Nowadays, with modern health facilities becoming more accessible to Africans, ethnomedical practitioners are likely to increasingly limit their services to illnesses that have medico-religious aetiologies (Anyinam, 1987). Today, hundreds of plant species are used for ritual practices in West and Central Africa (Quiroz and van Andel, 2015), and many of these are sold in large quantities on the medicinal plant markets in the region (Van Andel et al., 2012; Quiroz et al., 2014; Towns et al., 2014). The few detailed studies on ritual plant use in Africa reveal a variety of practices with potential pharmacological effects on the patients receiving the treatment (Bouquet, 1969). Earlier studies on ritual plants worldwide already indicated that these plants often have additional healing properties (Voeks, 1990; Van Andel and Ruysschaert, 2011), which could be the reason why they are considered sacred in the first place (Van Andel et al., 2013).

We documented ritual plants in Benin (West Africa) and Gabon (Central Africa) and assessed their possible pharmacological relevance. We hypothesise that ritual practices reflect traditional knowledge concerning biological activities of the specific plant species, even if plants are used in a symbolic way. Therefore, we posed the following research questions: (1) Which plant species are used for ritual purposes in Benin and Gabon? (2) How many of these plants have known medicinal uses? (3) What proportion of ritual implies direct contact with the human body? (4) Which species and applications suggest biological effects? (5) Do symbolic uses suggest biological activity?

## 2. Methods

### 2.1. Study areas

Located in the Dahomey Gap (Salzmann and Hoelzmann, 2005), Benin's vegetation is a mosaic composed by some 2800 forest-savannah species occurring intermittently among fallows, fields, and semi-evergreen, deciduous, and swamp forest islands (Adomou, 2005). Gabon is situated in the Lower Guinea rain forest block (White, 1979), and its vegetation consists of at least 4700 species (Sosef et al., 2006). In Benin, traditional faiths are considered official religions, whereas in Gabon these are tolerated by most of the population (US Department of the State, 2013). Vodoun or Orisha, the most prevalent traditional faith in the country, is based on the belief of supernatural gods that help the creator govern the natural world (Herskovits, 1938). In Gabon, "Bwiti" is a social and religious institution comprised by secret societies, each with its own passage rites and ceremonies (Świderiski, 1965). In both countries, ritual plants are the

most predominant type of plants sold at the herbal medicine markets (Quiroz et al., 2014; Towns et al., 2014).

### 2.2. Data collection

Fieldwork in Benin was undertaken between March and October 2011 in the departments of Kouffo, Zou, Plateau, Ouémè, Atlantique, Littoral, and Mono. There, we worked in the regions predominantly inhabited by people of Fon and Yoruba descent. In Gabon, we worked with members of Bantu-speaking ethnic groups in the provinces of Estuaire, Haut-Ogooué, Ngounié, Moyen-Ogooué, Ogooué-Ivindo, and Nyanga from June until December 2012. The informant pool consisted of 50 individuals in Benin. In Gabon we worked with 52 informants.

We started at the medicinal plant markets of both countries. We conducted informal interviews with market vendors in order to identify ritual plants (i.e. plants used in contexts involving the presence of supernatural entities such as ancestors, spirits, and gods) and salient ailments attributed a supernatural origin. We complemented our data on (commercial) ritual plant use gathered at the markets with ethnobotanical questionnaires administered to traditional healers by the main author. Traditional healers were reached by means of snowball sampling. In total, our sample consisted of 57 informants (35 traditional healers and 22 market vendors) in Benin and 46 informants (38 traditional healers and 8 market vendors) in Gabon. Special attention was paid to recording detailed information on plants' vernacular names, local terms for the conditions treated with these plants, preparation methods, dosage, and route of administration. Additionally, informants were asked to explain, whenever possible at length, the symptoms, causes, and effects of the health conditions in question. Participant observation techniques were also utilised to better understand the different contexts in which ritual plant were used. This implied that we participated not only in plant collection, but also in ritual ceremonies, food and medicine preparation, farming, and other daily activities of the communities where we worked that involved contact with supernatural entities.

Questionnaires were completed by the collection of voucher material from all plant species cited during the interviews. We purchased the plants mentioned by vendors directly at their market stalls. We accompanied traditional healers to the sites where they collected the plants they used during their ritual treatments. These sites included communal forests and grasslands, sacred forests, home gardens, and shrines. All plants were collected following standard botanical methods (Forman and Bridson, 1989). For each specimen, two vouchers were made: one was deposited at the national herbarium of the country where the plant was collected (BEN in Benin and LBV in Gabon) and the other one deposited at Naturalis Biodiversity Center (L). Plants were identified using the Flora of Benin (Akoegninou et al., 2006) and the Flora and Checklist of Gabon (Various editors, 1960–2008; Sosef et al., 2006, 2009). Current scientific names were updated using The Plant List ([www.theplantlist.org](http://www.theplantlist.org)).

### 2.3. Data analysis

We constructed a database of all ritual plant uses documented in Benin and Gabon and applied exclusion criteria to narrow down the list (Supplementary file 1). These criteria were set in order to only include plants that had been identified to the species level and to exclude: (1) plants that had been identified to family or genus level only; (2) plants that lacked any level of identification; and (3) plants that had unspecified ritual uses. To evaluate possible pharmacological relevance of ritual plant uses, we identified nine routes of administration:

oral ingestion (drink or food), baths, smoking (mixed with tobacco), scarification, skin rubbing, burning (and inhaling the smoke), amulets, incantations, and planting in the case of sacred and protective species. Plants that came in direct contact with the human body (by oral ingestion, baths, skin rub, smoking, burning or scarification) were ticked. We acknowledge the possibility that plants worn as amulets (e.g. power objects and charms) probably also touch people's skin, but since such protective charms were mostly planted in people's homes or fields, their contact with the human body was much less than plants from the other categories.

Finally, we highlighted several ritual plant species for which biological activities were reported in scientific, peer-reviewed articles. Given the large number of plants used in a ritual context, we limited our selection to 24 species that were either frequently sold at the medicinal plant markets in the countries of study (Quiroz et al., 2014; Towns et al., 2014), or otherwise were cultural keystone species (Quiroz, 2015). In order to assess their possible ethnopharmacological relevance, we compared their proven biological activity with the type of ritual use documented during our surveys. For this purpose, literature searches were conducted using Google Scholar, PubMed, and Scopus. We wanted to identify scientific publications and patents describing *in vitro* or *in vivo* studies of the 24 selected species and of bioactive components relevant to their ritual uses and applications. Following Farnworth (1990), we have taken plants that have been reported to produce a biological activity (by isolation of chemical compounds that were responsible for the ethnomedical claim) in consideration for potential ethnopharmacological relevance. The search for biological activity was conducted individually for each species. We combined the following keywords using the Boolean operator 'AND': "Genus species" (e.g. *Tetrapleura tetraptera*); "plant part used" (e.g. fruit, bark); "biological"; "pharmacological"; "activity"; "bioactivity".

#### 2.4. Ethical considerations

Following the guidelines of the African Union's Model Legislation for the Protection of Indigenous Knowledge (OAU, 2000) informants read and signed a free and prior informed consent. Whenever informants were not able to read and write, they were informed of our intent and their verbal permission was obtained. Informants were compensated for their time with a sum of money that was convened with them prior to the interview. In Benin, the Faculty of Agricultural Sciences and the Faculty of Science and Technology of the University of Abomey-Calavi issued formal invitations and research permits. In Gabon, we received a letter of invitation and a research permit from the National Center of Scientific and Technological Research (CENAREST). The National Agency of National Parks (ANPN) provided written consent to carry out research in the territories under its jurisdiction. The Plant Protection and Phytosanitary Control Service (Ministry of Agriculture, Livestock, and Fisheries) granted the permits necessary to export all botanical specimens collected during our stay in Benin. In Gabon, permits were provided by the Institute of Pharmacopeia and Traditional Medicine (IPHAMETRA). Digital copies of these documents are available upon request. Naturalis Biodiversity Center does not have an ethics committee or an institutional review board, but has formal partnerships with all the institutions above. Our partners confirmed that no additional ethical approval or permits were required.

### 3. Results

#### 3.1. Ritual plant species

Our initial database of ritual plant uses in Benin and Gabon contained 729 entries. We excluded 23 plants that could not be identified to species level and 39 plants with unspecified ritual uses. This resulted in a list of 667 plant products with detailed use in a ritual context. These corresponded to 573 botanical species, of which 381 were used in Benin and 243 in Gabon. Fifty-one species (7.6%) were used in both countries. Over a third of all plant species ( $n=186$ ) were indicated by our informants to have an additional medicinal (non-ritual) use. The botanical families most commonly used ritually were: Leguminosae (79 spp.), Euphorbiaceae (30 spp.), Malvaceae (29 spp.), Rubiaceae (26 spp.), Apocynaceae (21 spp.), Compositae (17 spp.), Cucurbitaceae (16 spp.), and Annonaceae and Lamiaceae (each 12 spp.). All species, including their vernacular and botanical names, plant parts employed, specific uses and route of administration are listed in the Supplementary File 1. About 75% ( $n=499$ ) of all ritual plant uses (442 species) involved direct contact with the human body (Fig. 1a). Scarification (rubbing plant extracts into skin incisions) and inhalation by smoking or burning made up for less than 4% of the total uses, and were therefore merged under the category "other" (Fig. 1b).

#### 3.2. Ritual plants with direct contact to the human body

##### 3.2.1. Baths and skin rubbing

Baths were the commonest route of administration of ritual plants ( $n=336$ , Fig. 1b). This practice consisted in the steeping of plants in water in order to cleanse the body of ritual plant users. In Benin, particularly, people elaborated soaps mixed with herbs in what is popularly known as *savon noir* (black soap). Almost 10% of plant species used in baths were also processed into ritual drinks. In fact, although many of the species used for herbal baths were not explicitly reported for their use as ritual drinks, we often observed how users would purposefully keep their mouths open while taking a bath. It is worth noting that after spiritual purification (for which often plants rich in essential oils, such as *Ocimum* spp. were used), herbal baths were often part of a (ritual) treatment of diseases, or taken by people in order to attain good luck.

Skin rubbing, which included the preparation of ritual plants into poultices and pomades, was a practice far less popular than ritual baths. Notably, skin rubs were used in treatments against snakebites and skin conditions that included Sakpata-related diseases and wounds of mystical origin. In the Beninese Vodoun religion, Sakpata is the god of smallpox and earth, who can cause diseases manifested by cutaneous eruptions (notably pustules). Also important in this category is the employment of plant-based pigments, which are a common element of ritual ceremonies. In Benin, the roots of *Baphia nitida* yielded a red pigment applied on the skin ceremonially. The powdered heartwood of the African padauk (*Pterocarpus soyauxii*) and the ground seeds of *Bixa orellana* were used for the same purpose in Gabon. Although the type of ceremonial use was not specified, henna (*Lawsonia inermis*) in Benin, and the bark of *Anisophyllea purpurascens* in Gabon were also indicated as ritual skin pigments. When rubbed on the skin, *P. soyauxii* has been found to have cytotoxic properties (Su et al., 2013), which might have a prolonged effect on the people who frequently use this plant (Table 1).

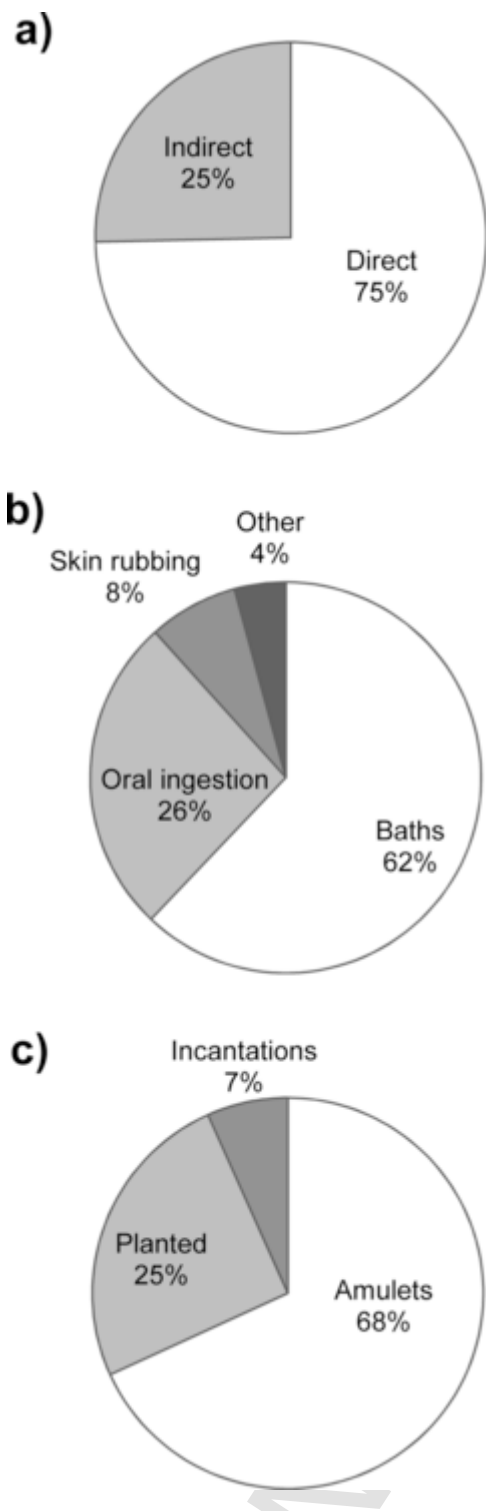


Fig. 1. (a) Proportion of ritual plants that come in contact with the human body, (b) type of direct contact with human body, (c) type of indirect contact with human body.

### 3.2.2. Oral ingestion

We identified 134 plant species that were orally ingested. The seeds of abata kola (*Cola acuminata*), bitter kola (*Garcinia kola*), and Guinea pepper (*Aframomum melegueta*) were simply chewed fresh as

ceremonial stimulants or to increase the power of ceremonial healing treatments. They were said to 'increase the power of words', in a way that someone's promise to achieve a goal would gain more weight after eating the seeds of these plants. *G. kola* nuts have been assessed for their properties in preventing damage to cellular DNA induced by aflatoxins: highly toxic and carcinogenic mycotoxins (Farombi et al., 2005). Some studies showed significant relationship between exposure of aflatoxin and the appearance of congenital abnormalities in hamsters (Goldblatt, 1969). This might explain why bitter kola nuts were preferred during healing ceremonies or the installation of charms to protect pregnant women in Benin, although *C. acuminata* seeds were more often used in all other types of ceremonies. Likewise, the seeds of *A. melegueta* seeds have been reported as effective in pain inhibition (Umukoro and Ashorobi, 2007), which may explain their importance in the ceremonial treatment of diseases. Although both kola nuts (*C. acuminata* and *G. kola*) were eaten as stimulants in Gabon, their use was less prevalent, likely because healing ceremonies took place as vigils under the analeptic effects of the iboga root (*Tabernaemontana iboga*).

We regularly encountered plants eaten in protection against enemies (e.g. the seeds of *Abrus precatorius* and the root of *Strophanthus hispidus*), weapons (the bark of *Spondias mombin*), or snakes (leaves of *Tylophora cameroonica* and *Bauhinia thonningii*). Because of its heart-shaped leaf, *Geophila afzelii* was eaten by people seeking to find love in Gabon. Some food plants were prepared as condiments or in sauces, chiefly for two purposes: in protection against diseases (including the return of recently cured diseases, e.g. the seeds of *Panda oleosa*) or to be presented as ceremonial offerings. Persons who believe in the protective powers of food offerings would eat these offerings after such ceremonies. Species used for offerings were mostly cultivated crops (e.g. cowpea, *Vigna unguiculata*), but also included wild plants.

Similar to the preparation of herbal baths, ritual drinks were prepared by soaking or boiling plants in water. In Benin, bitter drinks prepared with palm wine were a common alternative to infusions. Ritual drinks made from plants were used to treat madness or possession by evil spirits, to attract love (e.g. *Pupalia lappacea*), to attain the favour of influential people, for good luck, or for spiritual purification. Many of the ritual drinks were used in protection against bewitchment, sorcery or evil spirits, in addition to treating Sakpata-related diseases. Protective drinks to enhance women's health either during or after pregnancy (e.g. *Pavetta corymbosa*), against infertility (e.g. *Omphalocarpum procerum*), and to protect children (e.g. *Senna siamea*) were also common.

The fact that extracts from the root bark of *Rauvolfia vomitoria* have a proven anticonvulsant activity (Siwe Noundou et al., 2014) provides an important insight to their use in the treatment of madness in Benin (Table 1). The symptoms of madness, which were described by our informants as "contortions caused by evil spirits who possess mad persons", were treated with a concoction of *R. vomitoria*. Likewise, the bark of *Monodora myristica*, which is prepared in a drink meant for spiritual purification, has demonstrated antibacterial effects when administered orally (Cimanga et al., 2002) (Table 1). When asked to elaborate about symptoms of evil spirit possession, our Beninese informants explained that these often manifested themselves as a disease or misfortune.

### 3.2.3. Other forms of direct contact

Burning, smoking and scarification were the least common routes of direct application of ritual species (Fig. 1b). Inhalation of smoke occurred when plant parts (usually the resin or bark of a tree, but also the roots or fruits of shrubs such as red pepper, *Capsicum annum*)

**Table 1**

Ritual uses for 24 commercially or otherwise important plant species in Benin and Gabon and their demonstrated biological activities reported in literature.

Plant species	Ritual use	Plant part; route of administration	Demonstrated biological activity	Plant part; route of administration	Reference
<i>Abrus precatorius</i>	Protection against evil spirits, sorcery, and enemies	Seeds; oral and amulet	Antibacterial, lethal toxicity	Seeds; oral	Bobbarala and Vadlapudi, 2009; Nelson et al., 2007
<i>Aframomum melegueta</i>	Enhancement of herbal treatments, stimulant	Seeds; oral	Analgesic	Seeds; injection	Umukoro and Ashorobi, 2007
<i>Alchornea floribunda</i>	Ceremonial stimulant	Roots; oral	Antibacterial, hallucinogenic	Roots, stems, leaves; in vitro	Siwe Noundou et al., 2014
<i>Aucoumea klaineana</i>	Spiritual purification	Bark, resin; baths, inhalation	Treatment of cutaneous infections and allergies	Resin; in vitro	Renimel and Patrice, 2004
<i>Caesalpinia bonduc</i>	Protection against skin diseases	Seeds; amulet	Immunomodulatory activity, antibacterial	Seeds; oral	Shukla et al., 2009; Saeed and Sabir, 2001
<i>Cymbopogon densiflorus</i>	Protection against evil spirits	Flowers; inhalation	Possible hallucinogenic effects	Flowers; inhalation	De Smet, 1998
<i>Dicoma tomentosa</i>	Spiritual purification	Whole plant; bath	Antiplasmodial	Whole plant; in vitro	Jansen et al., 2012
<i>Eclipta prostrata</i>	Protection against evil spirits and improving memory	Whole plant; scarification	Memory enhancer, anti-stress effect	Whole plant; oral	Thakur and Mengi, 2005
<i>Garcinia kola</i>	Ceremonial stimulant	Seeds; oral	Prevention of cellular DNA damage, antiviral, cytotoxic	Seeds; oral	Farombi et al., 2005
<i>Jatropha curcas</i> , <i>Jatropha multifida</i> , <i>Jatropha gossypifolia</i>	Protection against evil spirits, sorcery, and enemies	Whole plant; planted	Disinfectant, cytotoxic, lethal toxicity, strong laxative	Whole plant; oral, skin rub	Nelson et al., 2007; Thomas et al., 2008
<i>Lycopodiella cernua</i>	Protection against evil spirits	Whole plant; oral, bath	Prevents destruction of neurotransmitter acetylcholine	Whole plant; in vitro	Konrath et al., 2013
<i>Zanthoxylum zanthoxyloides</i>	Protection against diseases caused by witchcraft	Roots; bath	Treatment of skin diseases, particularly of Buruli ulcer	Roots; in vitro	Addo et al., 2007
<i>Monodora myristica</i>	Spiritual purification, stimulant	Seeds; oral, bath	Antibacterial	Seeds; in vitro	Cimanga et al., 2002
<i>Mucuna pruriens</i>	Supernatural (?) protection against snakes	Whole plant; planted	Antidote against snake venom	Leaves, seed, root; in vitro	Tan et al., 2009
<i>Ocimum americanum</i>	Protective baths against diseases of mystical origin	Leaves; bath	Larvicidal	Whole plant; in vitro	Cavalcanti et al., 2004
<i>Pancratium tenuifolium</i>	Protection against evil spirits	Roots; scarification	Hallucinogenic (?), cytotoxic, antiplasmodial	Roots; in vitro	De Smet, 1998; Sobiecki, 2002; Cedrón et al., 2010
<i>Pterocarpus soyauxii</i>	Ceremonial pigment	Wood; skin rub	Cytotoxic	Wood; in vitro	Su et al., 2013
<i>Rauvolfia vomitoria</i>	Treatment of madness	Root bark; oral	Anticonvulsant activity	Root bark; oral	Olatokunboh et al., 2009
<i>Sarcocephalus latifolius</i>	Bewitchment-induced malaria	Roots; baths	Antiplasmodial	Roots; in vitro	Abreu and Pereira, 2001
<i>Senna occidentalis</i>	Ritual treatment of nicotine addiction	Leaves; inhalation	Antianxiety	Leaves, oral	Rathod et al., 2010
<i>Tetrapleura tetraptera</i>	Insomnia caused by spirits	Fruits, bark; bath	Anticonvulsant and anti-inflammatory	Fruits; in vitro	Nwaiwu and Akah, 1986; Ojewole and Adewunmi, 2004
<i>Xylopia aethiopica</i>	Protection against evil spirits	Fruits; oral	Antimicrobial, cytotoxic	Fruits; in vitro	Asekun and Adeniyi, 2004

were burnt as incense. In total, 16 plant species were employed as such for the exclusive purpose to protect their users against evil spirits during ceremonies. In Gabon, two types of torches made from plants were burnt during ceremonies conducted in the context of Bwiti, Gabon's traditional religion. One was made from the bark of the *Xylopia aethiopica* and okume resin (*Aucoumea klaineana*), and the other one from the twigs of *Aframomum giganteum*. On the markets of both countries, ready-made incense mixtures were sold. These usually contained the resin of myrrh (*Commiphora* spp.) or copal (*Co-paifera* spp.) and the aromatic bulbs of sedges (*Cyperus esculentus*, *C. articulatus*, and *Kyllinga erecta*). Two *Senna* species (*S. occidentalis* and *Senna sophora*) were intentionally smoked in a cigarette, mixed with tobacco, to treat nicotine addiction. Here it is relevant to mention that studies in which *Senna tora* extracts have proven successful in the treatment of anxiety (Table 1) also indicate that *S. occidentalis* has the same properties (Konrath et al., 2013). As cigarette-smoking is often a coping strategy against anxiety (Kassel and Unrod, 2000), the smoking of *Senna* leaves suggests a biological activity.

Scarifications, as the term suggests, consisted of inflicting scars on the skin of users of ritual plants in order to apply herbal treatments. These “vaccinations”, as they were called by informants, were applied either in protection against enemies or sorcerers, or as a mark of

affiliation to a particular traditional faith. In Benin, the sharp ends of the cat's claw fruits (*Martynia annua*) were used in order to make incisions in the skin, and the macerated bulbs of *Panocratium tenuifolium* rubbed in scars in protection against evil spirits. Another member of the same genus, *P. trianthum*, has potential psychoactive effects (De Smet, 1998; Cedrón et al., 2010). The characteristic chemical constituents of a plant and/or its related constituents can also occur in other species, particularly in those of the same genus (Farnsworth, 1990). Moreover, since all species of the genus share the same alkaloids, it is likely that *P. tenuifolium* also has hallucinogenic properties, apart from the cytotoxic and antiplasmodial activity of all *Panocratium* species (Olatokunboh et al., 2009). In Gabon, the juice of *Eclipta prostrata*, *Centella asiatica* and *Hymenocoleus hirsutus* leaves were applied in skin incisions in protection against evil spirits. Here, it is important to highlight the relevance of this practice as an application of natural compounds directly into the blood stream. *E. prostrata*, for example, provides significant protection against stress induced alterations and works in the enhancement of memory (Thakur and Mengi, 2005) which corroborates exactly the purposes indicated by our informants in Gabon: to improve memory (Table 1 and Supplementary File 1).

### 3.3. Ritual plants with indirect contact to the human body

A small proportion (174) of the species used ritually did not come in direct contact with the human body. These plants were processed into amulets, represented taboo plant species, were mentioned during incantations (ritual enchantments), or served as sacred trees that were either intentionally planted or spared from felling – usually as protectors or as a dwelling place for spirits. Some ritual plant use implied the physical absence of plants (and therefore the lack of contact with the human body), either in manner of food taboos, ritual prohibitions (e.g. *Strophanthus gratus*), or incantations (e.g. naming the wild sage *Lantana camara* in a song to prevent the death of an ill child). Both food taboos and ritual restrictions were included in the category “incantations” (Fig. 1c).

Amulets were sometimes worn in clothes' pockets (e.g. the seeds of *Abrus precatorius*) or around the neck or waist (e.g. the seeds of *Caesalpinia bonduc*), but were more often kept around the homes of people, usually to ward off enemies, diseases, or sorcerers, or simply used in divination by traditional healers (e.g. the seeds of *Entada gigas* and *Cleistopholis patens*). Similarly, trees and vines were planted around homes (or spared from felling) in protection against evil spirits or snakes. Some of the species planted in protection against evil spirits include *Newbouldia laevis*, and three species of *Jatropha*. Apart from their seeds being poisonous (Nelson et al., 2007), *J. curcas*, *J. gossypifolia*, and *J. multifida* have disinfectant properties and are effective in combating skin infections (Thomas et al., 2008). The use of *A. precatorius* seeds as amulets and the planting of the *Jatropha* species in protection against sorcerers, evil spirits, and enemies, could be explained by these species' high toxicity (Nelson et al., 2007). Intentional poisoning of adversaries by *A. precatorius* and *J. curcas* was a common practice in Sub-Saharan Africa in the past (De Smet, 1998). Hence, their pharmacological importance, partly symbolic (as a relic of important past plant use) and, possibly, partly prophylactic (as disinfectant) is not to be underestimated. A similar example is the planting of *Mucuna pruriens* vines in protection against snakes (Table 1), a species whose seeds, leaves, and roots have proven to be an effective antidote against snake venom (Tan et al., 2009).

### 3.4. Salient ritual applications

Almost one-third (n=212) of the 667 ritual plants were used to seek supernatural protection. This type of ritual plant use was the commonest in both countries of study (Fig. 2). Under the category “other” we grouped ritual uses that were only mentioned once or twice in the interviews and included problem solving, finding lost objects, invisibility (to escape justice), unspecified spells (which although not admittedly performed by informants, were said to be used by sorcerers), food taboos and other restrictions (Fig. 2). Plants used for attaining success, a salient ritual use in Gabon, included finding a job, passing an exam, obtaining the favour of a person in a position of power, or simply attracting wealth. A notable percentage of plant species used in the prevention (10%) and the treatment (12%) of supernatural diseases were meant for the exclusive use of women, men, or children. In Gabon, we also recorded an ethnoveterinary treatment for dogs said to be possessed by evil spirits that involved the twigs of *Cognauxia podolaena*.

By using ritual plants, people sought to guard off evil spirits, sorcery, bewitchment or spells, enemies, weapons, theft, and snakes. Another important concern reflected by this type of use was to seek protection against diseases not recognised in biomedicine believed to be caused by either bewitchment or envy. Fig. 1 shows the type of

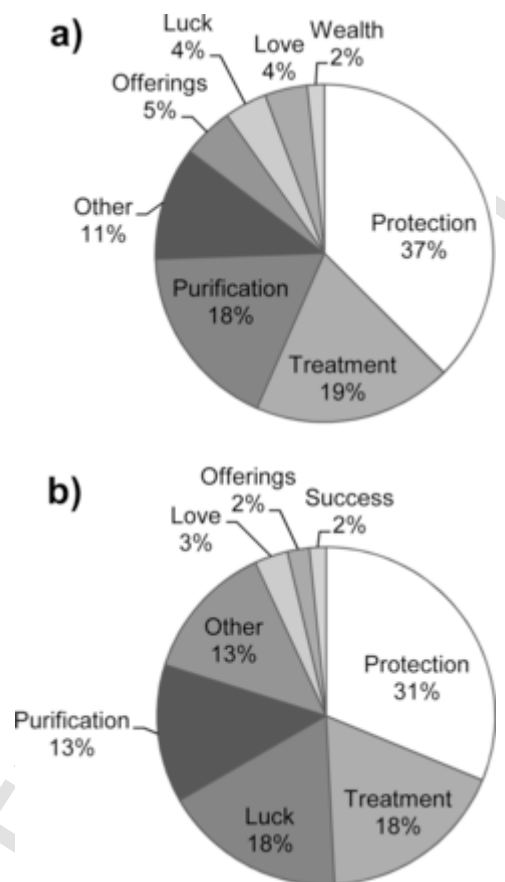


Fig. 2. Salient uses for ritual plants in (a) Benin and (b) Gabon.

diseases prevented and treated with ritual plants in Benin and Gabon. In Benin, people sought ritual protection and treatment of Sakpata-related ailments (a spirit that has no equivalent in Bwiti religion) and sexually transmitted diseases (STDs). Although health concerns differed in both countries, we found that several conditions recognised in biomedicine were the most salient ones. Malaria and conditions affecting women and children, which were salient ailments reported by our informants (Fig. 3b), have also been reported as important health concerns in other studies conducted in Benin and Gabon (Towns and van Andel, 2014).

### 3.5. Emic explanations to conditions treated with ritual plants

A common concept in Benin used by people in order to explain conditions treated with ritual plants was “tchakatou”. This term was elucidated by our informants as “bad luck” sent to one by envious enemies. Although terms such as “lancement” (figuratively, the act of tossing) or “envoûtement” (bewitchment) were used by some informants to explain the notion of tchakatou, it was more often agreed that the latter resulted in the eventual death of the victim, while “lancement” and bewitchment were only temporary states. Moreover, it was not uncommon to hear people refer to diseases recognised in biomedicine (e.g. malaria and skin infections) as “bizarre”, when stressing their attributed super-natural origin. Examples of such diseases were “le paludisme bizarre” (bizarre malaria) and “la fièvre bizarre” (bizarre fever). “La plaie incurable”, a chronic wound, was also attributed a supernatural origin.

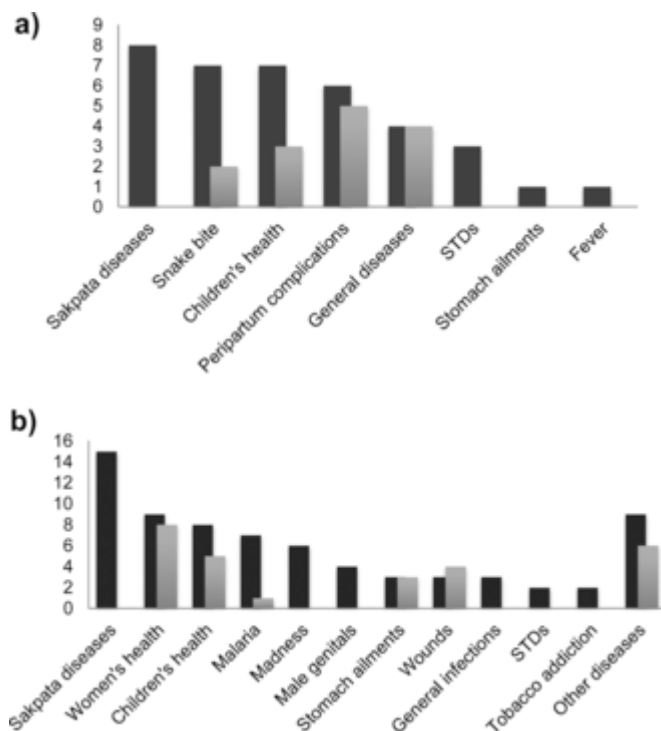


Fig. 3. Diseases (a) prevented and (b) treated with ritual plants in Benin (dark bars) and Gabon (light bars).

Likewise, Gabonese respondents alluded to the notion of “le vampire” (vampirism) as a state that could be reached by two means: possession by evil spirits or by another vampire. While the first was said to be manifested by the sudden evil doing of an otherwise good person; the second was visible in the ill health of the victim, which was believed to be “eaten” by his or her malefactor. Other salient conditions treated ritually in Gabon were those that were inflicted by sorcerers at night, such as “les fusils nocturnes” (the nighty guns), “le corps nocturnes” (the nighty bodies) and “le mari de nuit” (the night-time husband). The former two affected men and women alike and were characterised by wounds, pangs, and sores whose origin was not possible to explain by natural causes. The night-time husband was a group of conditions exclusively manifested in women and sometimes in their offspring, which caused female infertility, pregnancy and childbirth complications, such as miscarriage or the sudden death of a newborn. Indistinct from the sex of the victim, “les vers mystiques” (mystical worms) referred to infections, often gastro-intestinal ones, attributed to a supernatural origin. According to both our Beninese and Gabonese informants, these conditions had their causes in the ill will of enemies, or as a punishment from the spirits or ancestors for disobeying taboos, or simply by the loss of harmony in the natural environment or the human body characterised by the presence of “too much of a few elements”.

#### 4. Discussion

Our research highlights the potential pharmacological effect of ritual plants on their users, as reflected in the large proportion of treatments that involve direct contact with the human body (75%). Although we highlighted only a small fraction of the total number of ritual species and applications we encountered during our surveys, their documented biological activity was relevant to the ethnomedical claims made by our informants (Table 1). Moreover, as Allabi et al.,

(Allabi et al., 2011) stated, in order to substantiate the traditional medical knowledge behind frequently used medicinal plants, there is a need to promote phytochemical and pharmacological investigations of their use. Therefore, we are confident that our study can set a precedent for future research on the effects of ritually applied plants on the human body.

Both in Benin and Gabon, the majority of ritual plant use was to prevent and/or treat culture-bound syndromes (e.g. night guns), or ailments recognised in biomedicine but attributed a supernatural origin (e.g. “bizarre malaria”). Albeit less numerous, those uses that are characterised by the physical absence of plants (i.e. plants mentioned in incantations, food taboos, and restricted species) are also worthy of attention, as their ritual use might be a form of transmission of traditional medicinal knowledge (Cavalli-Sforza and Feldman, 1981). The explanations provided by our informants to the causes and symptoms of the conditions treated with ritual plants may help us understand why some plants, whose use at first seem to have no pharmacological effect, may after all prevent health ailments for which there are no equivalents in Western languages and experience (Warner, 1976). An example is the larvicidal properties of *Ocimum americanum* (Cavalcanti et al., 2004) and its use in protective baths against diseases of mystical origin that are manifested as infections. Moreover, it is appreciable from our results that diseases related to Sakpata, the god of smallpox, are still salient health concerns in Benin. Although smallpox has long been eradicated, the phenomena attributed to this god highlight not only important categories of past plant use but also emphasise historical events related to the social and economic outcomes of disease and epidemics (Kakpo, 2013).

Finally, two possible implications of ritual plant use for public health derive from our results. First, the possibly limited efficacy of ritual treatments in the control of epidemics – particularly, HIV/AIDS, which has its highest incidence rate in Sub-Saharan Africa (WHO, 2011). In our study, we found that people treat or believe to prevent STDs by using several ritual plants. We lack the data to ascertain the pharmacological effects of these plants on these diseases, as well as the preference of plant users to treat or prevent these diseases with plants or modern medicines. However, we must take into account that: (1) despite the progress achieved by governments and international medical organizations, the stigma around STDs (and specially HIV/AIDS) in Sub-Saharan Africa prevails (Sabapathy et al., 2012), and (2) about one-fifth of new infections in West Africa occur among people with multiple sexual partners and another one-third occurs in stable couples who do not currently self-report outside partners (UN-AIDS, 2010). Moreover, the stigma has direct relevance to health-seeking behaviours and the control and management of diseases such as STDs and HIV/AIDS (Dean and Fenton, 2010). Hence, the importance of documenting ritual plant use also allows addressing cultural practices that deter the prevention and control of epidemics.

A second implication of ritual plant use stems from the need to improve the ethical standards of the applications derived from pharmacological research. In her review of traditional knowledge systems, Reyes-García (2010) discusses the potential contribution of these systems for ethnopharmacological research, particularly in understanding how traditional knowledge is distributed in a society and who benefits from it. Species used by indigenous peoples for medicine have historically contributed to the discovery of herbal drugs, thereby assisting to improve the health of the industrialised world, but not that of the regions where this knowledge has been extracted (Kuper, 2005; Stephens et al., 2006; Reyes-García, 2010). However, the breach goes beyond that, as demonstrated by the manner in which ritual plant use is discredited by outsiders as being “a matter of belief” (thus, illustrating Reyes-García's claim). As mentioned earlier, there is



a clear tendency in science to draw a sharp line between medicine and spirituality or religion. Our results illustrate how users of ritual plants in Benin and Gabon do not share this view. As it appears, limiting the relevance of ritual practices and plant use in ethnopharmacology is evidence of the ignorance of the sceptic, rather than a demonstration of “the gullibility of the credulous”.

## 5. Conclusion

Returning to the hypothesis posed at the beginning of this study, it is now possible to state that ritual plant use reflects traditional knowledge concerning the biological activities of plant species, and that this knowledge is expressed even if plants are used in a symbolic way. The research has also shown that a large proportion (75%) of the ritual applications of plants implied direct contact with the human body. We also found one third of all ritual plants doubled as medicine for physical ailments. In contrast to previous research that explained the effectiveness of ritual plant use to be a matter of belief, our results hint at the potential medicinal properties of these plants. Finally, our results suggest that ritual plants have ethnopharmacological relevance because, regardless of whether diseases believed to have a supernatural origin are recognised in biomedicine or not, people use ritual plants to medicate themselves against these diseases.

## Acknowledgements

We wish to thank all our informants for kindly agreeing to share their knowledge and time. We are grateful for the botanical experts of the Naturalis herbarium who assisted in the identification of our specimens. Our research was funded by the Netherlands Organization for Scientific Research (NWO-ALW Vidi Grant no. 864.09.007) and the Alberta Mennega Foundation. We thank our institutional partners in Benin and Gabon for their crucial support. Dr. Gaby Schmelzer and two anonymous reviewers provided useful comments.

## Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jep.2016.05.006.

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