Drivers of Management of Spider Plant (*Gynandropsis gynandra*) Across Different Socio-linguistic Groups in Benin and Togo

E. O. Dêêdi Sogbohossou[*,1,2], Enoch G. Achigan-Dako[2], Tinde van Andel[1,3], and M. Eric Schranz[1]

[1]Biosystematics Group, Wageningen University, Wageningen, The Netherlands
[2]Laboratory of Genetics, Horticulture and Seed Sciences, Faculty of Agronomic Sciences, University of Abomey-Calavi, Abomey-Calavi, Republic of Benin
[3]Naturalis Biodiversity Center, Leiden, The Netherlands
*Corresponding author; e-mail: deedi.sogbohossou@wur.nl

We investigated the relationships between the cultural importance of spider plant (*Gynandropsis gynandra*), a neglected leafy vegetable in West Africa, and the different management regimes of the species among six socio-linguistic groups in Benin and one in Togo. Semi-structured interviews were conducted with 428 respondents. Cultural significance and management indices were used to quantify the importance of the species for each respondent. In addition to food uses, *G. gynandra* was used to cure 42 different diseases. A regression tree analysis revealed that the cultural importance and level of management of the species were strongly associated with ethnicity, gender, and to a lesser extent to age, education, income, and land tenure. Socio-linguistic groups with similar cultural background had convergent perceptions of the cultural importance of the species and described similar management practices. An analysis of farmers' willingness to change their current management practices revealed that migration, market opportunities, and external intervention might significantly affect future management decision-making processes. We discuss community-oriented approaches to upscale the species cultivation in the region. Our study highlights how cultural importance influences current and future management intensity and illustrates how ethnobotanical research can guide research for development strategies to enact positive changes in communities' management of traditional leafy vegetables.

Nous avons étudié les relations entre l'importance culturelle du Caya blanc (*Gynandropsis gynandra*), un légume-feuille négligé en Afrique de l'Ouest, et les différents régimes de gestion de l'espèce au sein de six groupes socio-linguistiques au Bénin et un au Togo. Des entretiens semi-structurés ont été menés auprès de 428 informants. Des indices d'importance culturelle et de gestion ont été utilisés pour quantifier l'importance de l'espèce pour chaque informant. En plus des utilisations alimentaires, *G. gynandra* a été utilisé pour soigner 42 maladies différentes. Une analyse par arbre de régression a révélé que l'importance culturelle de l'espèce était fortement associée à l'ethnicité et au genre, et dans une moindre mesure à l'âge, l'instruction, le niveau de revenu et le mode de faire-valoir de la terre. Les groupes sociolinguistiques culturellement proches ont eu des perceptions convergentes de l'importance culturelle de l'espèce et décrit des pratiques de gestion similaires. Une analyse de la volonté des agriculteurs de modifier leurs pratiques de gestion actuelles a montré que la migration, les opportunités de marché et l'intervention extérieure pourraient affecter les futurs processus décisionnels de gestion. Nous avons discuté des approches axées

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sur la communauté pour améliorer la production de l'espèce dans la région. La présente étude souligne comment l'importance culturelle influence l'intensité de la gestion actuelle et future et illustre comment la recherche ethnobotanique peut guider les stratégies de recherche pour le développement afin de favoriser des changements positifs dans la gestion de légumes-feuilles négligés par les communautés locales.

Key Words: Neglected and underutilized species, traditional knowledge, management, ethnicity, West Africa.

Mots Clés: Espèces négligées, connaissances traditionnelles, gestion, ethnicité, Afrique de l'Ouest.

Introduction

Wild edible plants constitute an essential food source used around the world and contribute to diet diversification and livelihoods in several communities (Ong and Kim 2017; Pawera et al. 2017). New trends in nutrition and the rising popularity of functional foods led to a regain of interest for these species and documentation of their utilization (Łuczaj et al. 2012; Romojaro et al. 2013). Some studies reported a decrease in the knowledge and consumption of wild edible plants associated with modernization of communities' lifestyles (Menendez-Baceta et al. 2017) and urbanization (Leal et al. 2018; Reyes-García et al. 2005). Among the Ati Negrito community in the Philippines, knowledge and use of wild edible plants was positively correlated with age, past experience of hunger, and household size but negatively affected by education and access to media and social services (Ong and Kim 2017). However, in some contexts, modernization and acculturation enriched plant knowledge and use through interaction with different communities and diversification of the sources of knowledge. Plant knowledge and use was rather greatly influenced by personal experiences, degree of interest for plants, age, and occupation (Mathez-Stiefel and Vandebroek 2012; Quinlan and Quinlan 2007; van den Boog et al. 2017). The participation in wild food collecting also differs regionally and may vary according to the income level, age, gender, opportunities to collect wild food, and cultural factors (Schulp et al. 2014). Cruz et al. (2013) found that while knowledge about wild edible plants was related to age, their current use was not associated with age, gender or occupation. Migration patterns also play an important role in the dynamics of plant knowledge and use and induced changes vary depending on differences in social, cultural, economic, institutional, and ecological contexts between migrants' home country/region and their host country/region (Medeiros et al. 2012). Knowledge exchange and significant cultural interactions may occur and migrant communities may adapt to the flora, knowledge, and traditions of the host country (Ceuterick et al. 2008; Volpato et al. 2009). This process is illustrated by the case of Tyrolean migrants and their descendants who migrated from Austria to Australia, Brazil, and Peru, 50, 80, and 150 years ago respectively. Investigation of their knowledge of medicinal plants revealed that in all three countries they abandoned specific medicinal plants and related practices from the original pharmacopeia when the plants were neither available nor cultivated in the country of arrival (Pirker et al. 2012). Migrants might also actively preserve the flora and knowledge from their home country or region as an attempt to conserve their cultural identity, as for example, the case of the Dominicans living in New York City (Vandebroek and Balick 2012) or the Surinamese in the Netherlands (van Andel and Westers 2010).

Associations between the body of knowledge developed by local communities and the harvesting strategies adopted have been increasingly investigated for informed conservation and management strategies of those useful plants. Typologies of plant management types take into account a gradient of complexity of practices and artificial selection (Vodouhè and Dansi 2012). González-Insuasti and Caballero (2007) described different management strategies including gathering from the wild, incipient non-selective management, incipient selective management, and occasional cultivation as a gradient of manipulation of plant resources. The intensity of management of a plant is determined not only by its biological characteristics but also by its cultural and/or economic importance and its availability (Blancas et al. 2013; González-Insuasti et al. 2008; N'Danikou et al. 2015). Many plant resources are managed in a variety of incipient forms and these forms may coexist for populations of the same species (Blancas et al. 2010; González-Insuasti and Caballero 2007). For example, local resources management decisions in the Raramuri community in Mexico were based on a culturally embedded

understanding of ecological processes. Different management regimes including selective harvesting, pruning, and favorable environmental modifications were applied to different groups of wild edible plants to ensure their sustainable use (LaRochelle and Berkes 2003). Human cultural values and traditional ecological knowledge of plant resources are therefore crucial for making management decisions in order to ensure or increase the availability and/or quality of desired plant resources (Blancas et al. 2013). However, despite extensive ethnoecological knowledge and awareness of sustainable harvesting practices, market forces might bring communities to abusive harvesting of wild plant resources to meet both market demand and their immediate economic needs (Ghimire et al. 2004; Sundriyal and Sundriyal 2004).

González-Insuasti et al. (2011) suggested a quantitative approach to investigate the determinants of management intensity tested for 20 edible plants under different management forms within a rural community of the Tehuacan Valley, Mexico. Management forms were influenced by socio-cultural variables such as age, education, and occupation as well as food preferences. The type of land tenure was also important, as commercially important species tended to be managed in communal areas whereas non-commercial food species were managed more intensely in private areas (González-Insuasti et al. 2011). Gender is also a decisive factor influencing management practices in communities where there is a gender differentiation of farm activities (Ekué et al. 2010; Vodouhè and Dansi 2012). Cruz et al. (2013) found that the degree of management of native wild edible plants in a local community in Brazil could be mainly explained by age and occupation. Younger respondents had lower motivation to tolerate wild edible plants than older ones. Farmers were also more inclined to manage the species than non-farmers. Blancas et al. (2013) developed an index to quantify management intensity of plant species based on 11 indicators related to energy invested, types of tools used, complexity of regulations and institutions, artificial selection intensity, and plant species biology. Investigation of management motives revealed that risk indicators on plant resources availability including life cycle, reproductive system, distribution, number of uses, and regulation of uses significantly influenced management intensity.

The existence of various human cultures, their distinct culinary costumes, the variable range of socio-economic situations, the differential availability, and forms of access to resources, help to understand that management of plant resources at each location depends on multiple factors that need to be analyzed particularly for species and communitarian contexts (Arellanes et al. 2013). Cross-cultural studies of plant use and management described different scenarios with emphasis on the interconnections between socio-cultural and ecological systems. Traditional communities with a strong connection with their environment and who depend on natural resources for livelihood had deeper plant knowledge and frequently used these species compared with urban communities (Monteiro et al. 2006; Soares et al. 2017). Communities sharing the same cultural background are also likely to have convergent patterns of plant knowledge and use. Exceptions arise when communities of the same socio-cultural background live in contrasting phytogeographical areas (Achigan-Dako et al. 2011). Migrant communities are obliged to adapt their management practices to the flora of their new environment and domestication may become a strategy to ensure availability of the culturally important species (Kujawska and Pardo-de-Santayana 2015; Segnon and Achigan-Dako 2014). Likewise, communities with different cultural backgrounds may share the same uses of wild food plants when living in the same environment (Ghorbani et al. 2012). The way complex interactions between local context, cultural values, and traditional knowledge might affect wild edible plant resources management in the future has been given less attention. Moreover, drivers of such change need to be carefully investigated to determine leverage actions and enhance sustainable utilization. A comparison of records of wild edible plants uses in Belarus between the 19th and the 21th centuries revealed a conservation of edible fruits use but a decrease in the knowledge and use of wild edible vegetables (Łuczaj et al. 2013). Taste appreciation is likely to have played a crucial role in the preservation of some wild vegetables over time (Łuczaj et al. 2013; Ong and Kim 2017). Urbanization coupled with increased knowledge exchange between different communities (Georgian and Emshwiller 2013), communities' migration and adaptation to new environments, market opportunities (Arellanes et al. 2013; Reyes-Garcia et al. 2005), education, and patterns of knowledge transmission within communities (van den Boog et al. 2017) are all factors which can affect decision-making processes related to wild edible plants management.

The current management spectrum of spider plant (*Gynandropsis gynandra* (L.) Briq.), a neglected

leafy vegetable in Benin and Togo (West Africa), offers a good example to study current management intensity of the species and understand how its management and use could change in different communities to inform strategies for sustainable utilization and conservation. Spider plant is cultivated in some communities in East and West Africa (Abasse et al. 2007; Oluoch et al. 2009) as well as Asia (Arora 2014). The species is rather found wild or feral in other parts of Africa (Dovie et al. 2007; Kidane et al. 2015; Segnon and Achigan-Dako 2014). Initiatives for promoting the species in commercial farming systems are rapidly emerging, especially in East Africa (Onyango et al. 2013) as a result of increased recognition of its multiple nutritional and health benefits (Omondi et al. 2017).

The present study aims at documenting the current management practices on *Gynandropsis gynandra* in local communities of Benin and Togo to explore drivers for future positive change. Using quantitative ethnobotanical data, we (1) examined the variation in the traditional knowledge and management practices of *G. gynandra*; (2) identified factors that influenced such traditional knowledge and management practices; and (3) analyzed farmers' willingness to improve their current management practices, i.e., collectively moving the current practices to a higher management level in the process of domesticating *G. gynandra*. We hypothesized that (1) current management practices are shaped by factors including ethnicity, economic and cultural values of the species, and existence of local market-oriented vegetable production systems and (2) willingness to improve the species' management in the future is influenced by ethnicity and cultural importance of the species.

Materials and Methods

Study Area and Sampling Strategy

Based on information available on *G. gynandra* distribution and use in literature (Achigan-Dako et al. 2010; Akoègninou et al. 2006) and preliminary observations made during germplasm collection missions conducted from April to June 2015 in Benin and Togo (Cleome Consortium 2016), six socio-linguistic groups were selected in Benin: the Fon (17.6% of the country's population), Adja (8.7%), and Holli (1.4%) in southern Benin and Waama (1%), Gourmantche (0.5%), and Zerma (0.1%) in the north (Fig. 1). These six socio-linguistic groups use *G. gynandra* as a food plant and were chosen to represent the different management regimes. The Ewe, Adja, and Fon are the three most important communities of the Gbe language group (Hounkpati 1991) while the Holli belong to the Ede language group (CENALA 2003). Both Gbe and Ede linguistic groups form the Kwa language family (CENALA 2003). The Waama and the Gourmantche belong to the Gur language family (CENALA 2003). The Zerma living in Northern Benin are migrants from Southern Niger (Dosso, Tillaberi), engaged in the trade of cereals and manufactured products (Walther 2014). The Zerma belong to the Songhay language group that is considered to be unrelated to any other known language or language group (Muhammad 2016). Ewe farmers in Togo cultivate *G. gynandra* for commercial purposes. Thus, the Ewe community was selected as a reference group for the comparison of management practices in Benin.

From July to August 2016, semi-structured interviews were conducted with 57 to 68 respondents per socio-linguistic group, using purposive sampling (Albuquerque et al. 2014; Tongco 2007). This sampling method allowed us to select respondents who knew the species and consumed it or used to consume it in each socio-linguistic group and to obtain a reasonable compromise between sample size and available resources to conduct our study. Although our sampling was not representative of the whole community, this method was proved to be the most adequate for ethnobotanical studies that require respondents with specific qualifications for hypothesis testing (Albuquerque et al. 2014; Tongco 2007). The surveyed localities were chosen with the help of extension services agents in each municipality, while the local authorities at each site helped us establish the first contact with consumers of the species. We shared full disclosure on the nature of the research, received authorization from local authorities in each locality in Benin and Togo, explained the objectives of the study and requested prior informed consent from all participants, and ensured participants' confidentiality by anonymizing their identities in databases and publications.

Interviews

Our questionnaire (Appendix 1, Electronic Supplementary Material, ESM) contained general socio-demographic characteristics (age, gender,

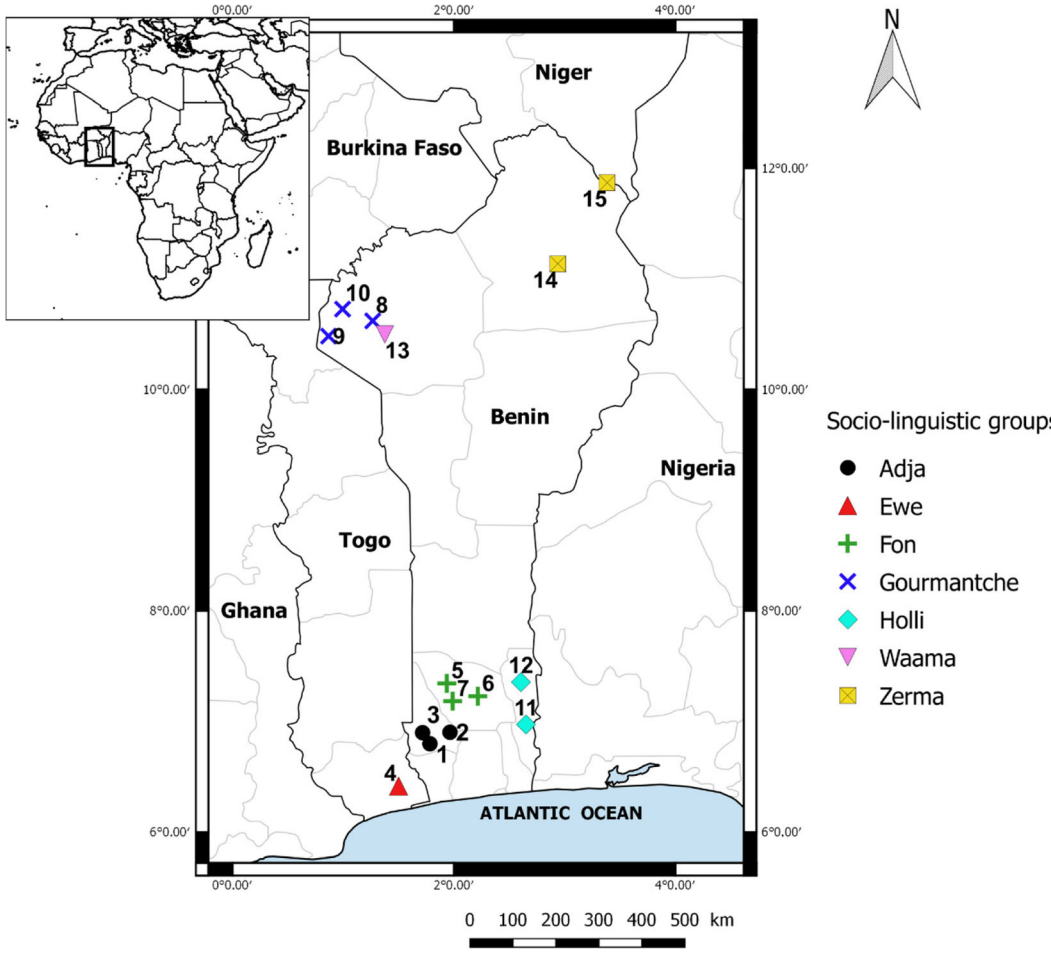

Fig. 1. Map of the surveyed districts and socio-linguistic groups interviewed in Benin and Togo. 1, Dogbo; 2, Lalo; 3, Djakotomey; 4, Vogan; 5, Djidja; 6, Za-Kpota; 7, Agbangnizoun; 8, Tanguieta; 9, Materi; 10, Cobly; 11, Pobe; 12, Ketou; 13, Toucountouna; 14, Kandi; 15, Malanville.

ethnic group, education level, occupation, number of years of local residency, area of origin (if migrant), monthly income, land ownership). Other questions were related to the economic importance of *G. gynandra*. In areas where the vegetable was sold on local markets, informants were asked about its market price. A contingent valuation was used when the species was not commercialized. Respondents were asked how much a given amount of *G. gynandra* would be worth in the market or for how much they would be willing to sell it. Local measurement units such as baskets and bunches were weighed to determine the average price of *G. gynandra* leaves per kilogram.

Cultural Importance of the Species

We modified the cultural significance indices (CSI) (Blancas et al. 2013; Pieroni 2001) to quantify the cultural importance of *G. gynandra*. The CSI was calculated based on 11 variables (Table 1) according the following formula:

$$\mathrm{CSI} = \mathrm{RU} \times \mathrm{S} \times \mathrm{AI} \times \mathrm{FU} \times \mathrm{LC} \times \mathrm{PPU} \times \mathrm{FP} \times \mathrm{TA} \times \mathrm{H} \times \mathrm{C} \times \mathrm{MV} \times 10^{-4}$$

The CSI was considered as a quantitative measure of the knowledge and use of *G. gynandra*. The

TABLE 1. VARIABLES AND STATES CONSIDERED TO COMPUTE THE CULTURAL SIGNIFICANCE INDEX (CSI).

Variables	Modalities (scores)	Explanation
Number of reported uses (RU)	Absolute number	Number of uses cited for the species by each informant. We included this variable as suggested by Blancas et al. (2013). Reyes-García et al. (2006) previously quantified the cultural value of a species based on the number of uses reported, the proportion of informants who mentioned the species as useful, and the proportion of informants who mentioned each use of the species. In our case, the proportions of informants are irrelevant as we computed the values per respondent.
Source of knowledge (S)	Parents (4); other community members (3); people from different community (2); mass media (1)	The source of knowledge (S) indicates patterns of transmission of plant knowledge. We considered the transmission from parents to children and from other members of the same community as the best indicators of the cultural dimension of such knowledge as previously reported in literature (Lozada et al. 2006; Reyes-García et al. 2009). When several sources of knowledge were cited, the average score was considered.
Perceived availability of the species (AI)	Very abundant (5); abundant (4); moderately abundant (3); rare (2); very rare (1)	Perceived availability is an important factor explaining the cultural importance of edible plants (Cruz et al. 2013; Pieroni 2001) and depends on the demand in the species. Available useful plant species tend to be more widely used than rarer ones (Albuquerque 2006; Hart et al. 2017) and their decreasing availability might trigger the domestication process if the demand cannot be satisfied (Vodouhè and Dansi 2012). In our case, the perceived availability of the species may contribute to explain patterns of knowledge and use.
Frequency of uses (FU)	More than once a week (5); more than once a month but less than once a week (4); once a month (3); more than once a year but less than once a month (2); once a year (1); not used during the past 3 years (0.5)	Frequency of uses (FU) and last day of consumption (LC) indicate how often the respondent uses the species and how important it is in the daily diet. LC illustrates the actual use of the species and as such, complements the number of uses which only reflects informant's knowledge (de Lucena et al. 2007).
Last day of consumption (LC)	More than 3 years ago (0.5); more than 1 year ago (1); less than 1 year ago (2); less than 6 months ago (3); within the last month (4); within the last week (5)	
Plant parts used (PPU)	Leaves (1); flower buds (1); leaves and stems (1); young pods (1); seeds (1)	The plant parts used (PPU) (Pieroni 2001) were summed up for the respondents who used multiple organs of the species.
Food preparation (FP)	Processed food (1.5); single in sauce or stew (1); condiment (1); raw (1); mixed with other vegetables (1)	Cooking and processing practices are part of the cultural identity of local communities (Sansanelli et al. 2017). We attributed a higher score to processing of the species as it indicates a value addition to the plant (e.g., drying and grinding leaves for long-term storage).
Taste appreciation (TA)	Very poor (1); poor (2); fair (3); good (4); very good (5)	The taste appreciation (Pieroni 2001) is in our case specific to each respondent and was considered as an indicator of how palatable the species is for the respondent.

TABLE 1. (CONTINUED).

Variables	Modalities (scores)	Explanation
Harvest type (H)	Opportunistic (1); dedicated (2)	Harvesting mode was also considered an indicator of importance: harvesting exclusively suggests a higher cultural importance while harvesting the species only when it is found while conducting other activities indicates that the species is not important enough to plan specific harvest sessions (Blancas et al. 2013).
Commercialization possibilities (C)	None (0.5); existing but not exploited (1); leaves sold/bought on local markets (2); leaves and seeds sold/bought on local markets (3)	We included commercialization possibilities (González-Insuasti et al. 2008) to investigate whether or not some respondents considered selling the species or if it was already bought and sold in the surveyed areas in response to a high market demand. Modalities were modified to take into account various situations described by respondents.
Medicinal value (MV)	Not medicinal (1); healthy food without therapeutic specification (3); medicinal (5)	The medicinal value was used to take into account the gradients of perceived "health-promoting" properties.

11 variables were multiplied to amplify eventual variations (Pieroni 2001). Higher CSI values indicated a greater cultural importance of the species.

Current Management Practices

The management practices were described and categorized based on a management intensity index modified from Blancas et al. (2013) and González-Insuasti et al. (2011). Indicators used to compute the management index are presented in Table 2. When several modalities of a variable were adopted by the same informant, the scores were summed. Individual management indices were summed to calculate the management index:

$$MI = ML + AS + RH + PC + MF$$

Farmers' Intention to Improve Current Management Forms

In order to assess farmers' intention to improve current management practices through higher investment of energy, intensive artificial selection, and land allocation (Blancas et al. 2013; González-Insuasti et al. 2008), the interview included the following questions: are you satisfied with your current level of exploitation of *G. gynandra*? If not, what would you like to improve and how? What are the perceived constraints related to the implementation of your decisions? These questions allowed better understanding of the motivation underlying farmers' intentions to modify their management schemes in the future. In order to avoid the willingness to please biasing farmers' responses, it was well explained to them that we would not provide a reward in kind or in cash in response to their motivation to cultivate the species. Social desirability bias may lead to a tendency to provide positive answers to environmental questions, especially in studies related to behavioral intention (Floress et al. 2018). Information provided by farmers was used to compute an expected management scheme based on management forms typology adapted from González-Insuasti et al. (2008). Five steps were identified including: simple collection with no selection (1); tolerance, protection, or promotion without selection (2); transplantation of selected spontaneous individuals (3); rain-fed cultivation (4); and intensive irrigated cultivation all year round (5).

DATA ANALYSIS

The seven socio-linguistic groups were compared for their number of reported uses and the frequencies of uses of the species based on Kruskal-Wallis

TABLE 2. VARIABLES USED TO ESTIMATE THE MANAGEMENT INTENSITY INDEX.

Variables	Categories (scores)	Explanation
Maintenance labors (ML)	Cleaning or weeding (1); grooves water penetration (1); soil tillage (1); removing dead or diseased plants (1); fertilization (1); irrigation (1); fumigation with pesticides (1); fences (1); other dissuasive measures (1)	Maintenance practices on managed plots as suggested by Blancas et al. (2013). Only the modalities cited by our respondents are listed here.
Artificial selection (AS)	Odor (1); leaf form (1); leaf color (1); stem color (1); leaf size (1); phenological differences (1); texture (1)	Criteria mentioned for selection of particular variants on managed plots for leaf/seed harvesting and propagation.
Reaction to harvest without permission (RH)	No reaction (0); yes, admonition applies (1); yes, applies monetary penalty (2); yes, complaints to authorities (3)	Indicates how important the managed plots are for respondents. Adapted from the variable "collective regulation" (Blancas et al. 2013) to assess the rules and agreements for accessing and protecting plant resources. The modalities we used are the ones cited by the respondents.
Proximity to collection/-cultivation sites (PC)	More than 5 km (1); up to 5 km (2); up to 1 km (3); less than 100 m (4)	Distance from the respondent's house to collection/cultivation site provides an indication of the importance of the resource (Blancas et al. 2013) and an indication of management intensity. We gave a higher value to closer sites as most respondents explained that spider plant is a seasonal vegetable that grows better on fertile plots near houses and can be more easily managed and harvested. The species requires intensive management over a short period of time and could also become invasive if grown in the fields.
Management forms (MF)	Simple collection from the wild with no particular selection (1); tolerance, protection or promotion of wild plants without selection (2); transplantation of selected wild individuals to gardens (3); rain-fed cultivation (4); intensive irrigated cultivation all year round (5)	Adapted from González-Insuasti et al. (2008) and Blancas et al. (2013) to reflect the different situations observed in the case of spider plant in the surveyed areas.

tests. A regression tree analysis was performed using the R packages "tree" (Ripley 2016) and "maptree" (White and Gramacy 2012) to predict the variation in cultural significance index based on both quantitative and qualitative socio-demographic variables. The most significant variables among the dependent variables gender, age, education level, ethnicity, land tenure, land area, and level of income were selected. A generalized linear model with Poisson distribution allowed us to investigate the socio-demographic factors influencing the management intensity in each community. The deviance explained by the model (D^2) was determined using the R package "modEvA" (Barbosa et al. 2016). As ethnicity was the main factor explaining the variation in the CSI and the management intensity, a principal component analysis was performed using the components of the CSI, the management intensity, and the economic value of the species to better describe the characteristics of the socio-linguistic groups. The Kendall's rank correlation (τ) was used to test the association between current and expected management regimes. To model the projected changes in management practices according to time (current and expected management forms) and socio-linguistic groups, a generalized estimating equation was fitted to the management forms [simple collection with no selection (1); tolerance, protection, or promotion without selection (2); transplantation of selected spontaneous individuals (3); rain-fed cultivation (4); and intensive irrigated cultivation all year round (5)]. Generalized estimating equations are commonly used in epidemiology and social sciences for multivariate logistic regression of

ordinal longitudinal outcome variables (Nooraee et al. 2014; Parsons et al. 2009).

Results

Characteristics of Respondents

Women represented 72.0% of the respondents and were dominant across all socio-linguistic groups except for the Ewe, of which 73.0% of respondents were male (Table 3). *G. gynandra* users were between 14 and 90 years old, with an average age of 44.9 ± 15.7 years. A high proportion of the Beninese respondents were illiterate (73.0%), while for the Ewe ethnic group in Togo, this was only 33.0%. Literate male producers dominated the *G. gynandra* production system in the Ewe community, while female illiterate producers were more involved in wild harvesting and home gardening. The main occupation of all respondents was farming and/or trading agricultural products. Landowners represented 66.0% of the respondents, except in the Ewe group, where most of the market gardeners leased their land (62.0%).

Knowledge and Diversity of Uses of *G. gynandra*

Gynandropsis gynandra was used by all socio-linguistic groups as food (100.0% of respondents). Medicinal uses were mentioned by 50.7% of respondents including 80% of the Adja and Zerma, 56% of the Fon, 34% of the Gourmantche, 25% of the Holli and Ewe, and 15% of the Waama. Spiritual uses of the species were mentioned by less than 5.0% of respondents in all groups, except for the Gourmantche and Waama communities who did not mention these uses at all. The number of reported uses varied significantly among the groups (Kruskal-Wallis $\chi^2 = 124.6$, df = 6, $p < 0.001$). The highest number of uses was reported by Zerma respondents (3.2 ± 1.5). The Ewe (1.7 ± 0.8), Gourmantche (1.5 ± 0.8), Holli (1.4 ± 0.6) and Waama (1.3 ± 0.7) stated the lowest number of uses.

In addition to food, *G. gynandra* was used to cure 42 different diseases, classified in 12 disease categories according to the International Classification of Diseases and related health problems (WHO 2016) (Appendix 2, ESM). General symptoms and signs not elsewhere classified were grouped in "general health" category. Most of the Adja (81.0%) and

Table 3. Socio-demographical characteristics of respondents from seven socio-linguistic groups of Benin and Togo.

Variables	Modalities	Adja ($N = 62$) *n* (%)	Ewe (N = 60) *n* (%)	Fon ($N = 57$) *n* (%)	Gourmantche ($N = 61$) *n* (%)	Holli ($N = 60$) *n* (%)	Waama ($N = 60$) *n* (%)	Zerma ($N = 68$) *n* (%)	Total ($N = 428$) *n* (%)
Age	Mean ± sd	44.5 ± 12.4	41.4 ± 15.0	48.0 ± 16.2	45.4 ± 18.7	43.8 ± 14.8	43.9 ± 13.8	47.2 ± 17.5	44.9 ± 15.7
Gender	Male	10 (16)	44 (73)	11 (19)	11 (18)	19 (32)	14 (23)	11 (16)	119 (28)
	Female	52 (84)	16 (27)	46 (81)	50 (82)	41 (68)	46 (77)	57 (84)	309 (72)
Instruction level	Illiterate	52 (83.8)	20 (33.3)	47 (82.4)	41 (67.2)	51 (85)	44 (73.4)	56 (82.3)	311 (73.4)
	Primary	–	23 (38.4)	6 (10.5)	5 (8.2)	6 (10)	8 (13.3)	9 (13.2)	57 (13.6)
	Secondary	7 (11.3)	15 (25)	3 (5.3)	15 (25.6)	3 (5)	8 (13.3)	3 (4.5)	54 (13.3)
	University	–	2 (3.3)	1 (1.8)	–	–	–	–	3 (1)
	Literate (local language)	3 (4.9)	–	–	–	–	–	–	3 (1)
Land ownership	No land	3 (4.8)	1 (1.7)	6 (10.5)	13 (21.4)	6 (10.2)	1 (1.7)	13 (19.1)	43 (10.1)
	Purchase	9 (14.5)	–	8 (14)	1 (1.6)	2 (3.4)	–	3 (4.4)	23 (5.4)
	Lease	11 (17.7)	37 (61.6)	1 (1.8)	–	14 (23.7)	–	6 (8.8)	69 (16.2)
	Loan	2 (3.2)	1 (1.7)	4 (7)	1 (1.6)	1 (1.7)	–	7 (10.3)	16 (3.7)
	Gift	2 (3.2)	1 (1.7)	5 (8.8)	–	0 (0)	2 (3.3)	5 (7.4)	15 (3.5)
	Inheritance	35 (56.5)	20 (33.3)	33 (57.9)	46 (75.4)	37 (61)	57 (95)	34 (50)	262 (61.1)

Zerma (81.0%) respondents were aware of the medicinal uses of the species followed by the Fon (56.0%). Only 9.0% of the Waama reported medicinal uses for the species. The most cited diseases treated with *G. gynandra* included malaria, headache, earache, anemia, stomachache, and malnutrition. The citation frequency of medicinal uses per disease category and socio-linguistic group are presented in Fig. 2. The categories of diseases cured and their relative importance varied across the communities. Most respondents (88%) obtained their knowledge on *G. gynandra* uses from their parents, 7% from community members other than their parents, and 5% from people from other communities. Among the Fon respondents, 61% received their knowledge from their parents, 28% from community members other than their parents, and 10% from people from other communities.

Factors Influencing Cultural Importance of *Gynandropsis gynandra*

The regression tree of the cultural significance index based on the respondents' socio-economic characteristics explained 37.1% of deviance in the cultural significance index and revealed that ethnicity was the main factor explaining the cultural importance attributed to the species (19.3% of deviance) (Fig. 3). The splits based on other variables resulted in much lower deviance (< 4%) and therefore poorly contributed to explaining the variation in the index. The socio-linguistic groups were split into two categories: the Adja and Ewe who gave a higher cultural importance to the species were in the first category and other socio-linguistic groups in the second.

Among the Adja and Ewe, the species had a higher cultural importance for older respondents (≥ 57 years) than younger respondents (< 57 years). Moreover, the older Ewe respondents had a CSI twice lower than their Adja counterparts. Among younger Adja and Ewe respondents, land tenure, education, and income were also important factors of differentiation (Fig. 3). Respondents who inherited family land or had no access to land gave a higher cultural importance to *G. gynandra* than those who bought or leased the land (mostly Ewe market gardeners). Non-schooled respondents and those who only attended primary school had also a higher CSI than respondents with higher education levels. In this latter category, respondents with low monthly incomes (less than 50 USD) had a higher CSI than those with higher monthly income.

Among the other socio-linguistic groups, most of the respondents (85.0%) had low monthly income (less than 140 USD) and fell into one category with a low CSI. Among respondents with higher income (only 15.0%), older respondents (> 41 years) had a higher CSI than younger ones. The older Fon, Gourmantche, and Holli respondents had a lower CSI than their Waama and Zerma counterparts.

Variation in the Management Intensity, Cultural and Economic Importance of *G. gynandra*

Four management regimes of *G. gynandra* were observed during the survey: (1) wild collection with no selection; (2) tolerance, protection, or promotion of plants around houses; (3) rain-fed cultivation in home gardens; and (4) intensive irrigated cultivation all year round. The significant factors explaining the variation in management intensity were ethnicity (D^2 = 65.9%, $p < 0.001$) and land tenure (D^2 = 17.6%, $p < 0.05$).

The species was intensively cultivated by Ewe market gardeners in southern Togo (96.0% of Ewe respondents; management intensity index (MI), 14.9 ± 1.4) (Fig. 4), where the price of the leaves varied between 0.25 USD per kilogram in the rainy season and 1.1 USD/kg in the dry season (1 USD = 590 F CFA on average, July 2016). Seeds were also sold on local markets; prices varied from 5 to 16.7 USD/kg, depending on the season. Rain-fed cultivation in home gardens was common among the Adja (93.0% of respondents; MI, 11.0 ± 2.7). Leaves were sold in bunches with a price that varied between 0.2 and 0.5 USD/kg. Seeds were occasionally sold but most of the farmers spared some of their own plants to harvest the seeds. The Gourmantche (90.2%; MI, 4.2 ± 1.3) and the Fon (80.7%; MI, 4.1 ± 3.1) mainly harvested the plant in the wild at the beginning of the rainy season along roadsides or in fallow lands. Among Waama people, simple collection (46.7%) and tolerance or protection of spontaneous populations (48.3%) were the most common management practices (MI, 5.7 ± 2.5). Simple collection in the wild (63.3%) and rain-fed cultivation (23.3%) were the dominant management practices among the Holli (MI, 4.8 ± 2.9). Our Zerma respondents pointed out that as they recently migrated from Niger to Northern Benin, they had limited access to agricultural land. They said that *G. gynandra* was not popular among the other socio-linguistic groups living near them in northern Benin. Therefore,

Fig. 2. Frequency of citations of categories of diseases treated with *Gynandropsis gynandra* in each socio-linguistic group.

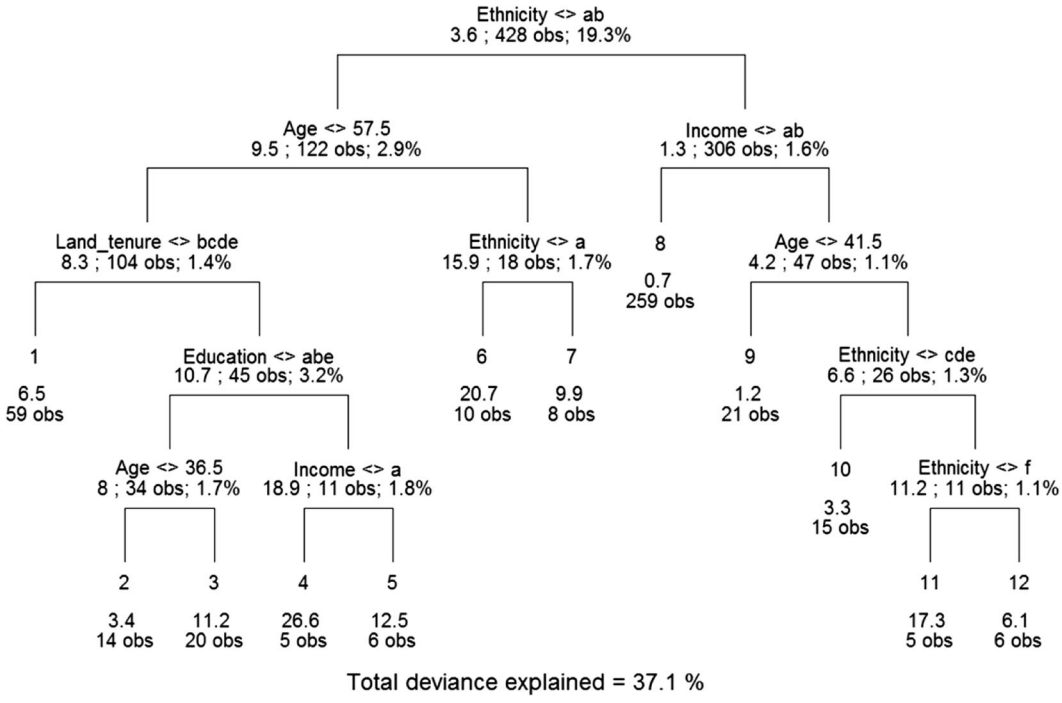

Fig. 3. Regression tree of cultural significance index as a function of demographic variables for use of *Gynandropsis gynandra*. Terminal nodes display from top to bottom: terminal node number, average CSI for the subsample, and the number of observations in the subsample. Categorical predictors include: ethnicity (a = Adja; b = Ewe; c = Fon; d = Gourmantche; e = Holli; e = Waama; f = Zerma); income (a = < 50 USD; b = 50–170 USD; c = 170–330 USD; d = > 330 USD; 1 USD = 590 F CFA on average, July 2016); land tenure (a = no access; b = purchase; c = lease; d = loan; e = gift; f = heritage); education (a = illiterate; b = primary school; c = secondary school; d = university; e = literate (local language).

54.0% of our Zerma informants harvested the plant in the wild and only 20.0% cultivated it in home gardens (MI, 5.0 ± 2.7). Land tenure had a significant influence on the MI (D^2 = 17.6%, $p < 0.05$) with the highest average value observed for lease (11.3 ± 4.8) mainly adopted by Ewe (61.6%) respondents. Other land tenure regimes including purchase (7.0 ± 4.9), inheritance (6.6 ± 4.1), loan (6.1 ± 3.5), and gift (4.6 ± 3.2) were associated with lower MI scores. People with no land had the lowest MI (4.6 ± 3.0).

A significant variation was noticed in the perceived availability of the species across sociolinguistic groups (Kruskal-Wallis χ^2 = 194.3, df = 6, $p < 0.001$). While in Fon, Adja, Ewe, Gourmantche, and Waama communities, *G. gynandra* was regarded as a common species, the Holli and Zerma noticed that it was becoming rare in their region. The reasons cited to explain this rarity included (1) increasing urbanization, intensive crop production, and use of herbicides, which reduced the natural habitat of the species (34.0% of respondents); (2) lack of knowledge about the reproductive biology (33.0%); (3) erosion of knowledge (10.0%); (4) low economic value (8.5%); (5) low germination ability of the seeds (8.0%); and (6) grazing by goats, pigs, and other animals (7.0%). No selection of phenotypes was reported for the species.

The principal component analysis revealed that the variables related to the use of the species, the economic importance, and the management intensity were correlated with the first principal component (33.2% of variation explained) while the number of reported uses and the medicinal value of the species were correlated with the second principal component (12.9% of variation explained) (Table 4). The frequency of uses and the last day of consumption were also significantly correlated with the third principal component, which explained 10.0% of the variation.

Fig. 4. Ewe woman harvesting spider plant leaves (*Gynandropsis gynandra*) in a market garden in Vogan County (Togo).

The projection of the respondents on dimensions 1, 2, and 3 (Fig. 5) supported the differences in knowledge, uses, and management of *G. gynandra* among socio-linguistic groups. The species had both high cultural and economic importance for the Adja and Ewe, which presented positive coordinates on the first dimension. The difference between both groups lies in the fact that the Adja also had a strong knowledge on the uses of the species (positive coordinates on dimension 2), while for the Ewe the species was mostly a vegetable. For all other groups, the species was both culturally and economically less important, apart from the Zerma, who showed a significant knowledge on the vegetable that they brought with them during their migration from Niger to Benin.

Willingness to Improve Current Management Practices

A significant and positive correlation was found between current and projected management regimes of *G. gynandra* ($\tau = 0.52$, $p < 0.001$). Among the Adja, who cultivated the species in home gardens, 73% were willing to shift from rain-fed cultivation to intensive year-round cultivation. The Ewe would not significantly change their practices over time as they already intensively cultivated the species. In all the other socio-linguistic groups, rain-fed cultivation was considered as an interesting option for the future. The variation in management forms across socio-linguistic groups is depicted in Fig. 6.

The generalized estimating equation computed on the management forms used as repeated measures revealed a significant variation across socio-linguistic groups and across time as well as for the [time × socio-linguistic groups] interaction (Table 5 and Fig. 7).

The significant negative regression coefficient (Z value = – 8.1, $p < 0.001$) for the projected management practices suggested that the level of these practices would overall increase compared with the current management practices. The Adja

TABLE 4. SCORES OF 14 VARIABLES RELATED TO CULTURAL IMPORTANCE, MANAGEMENT INTENSITY, AND ECONOMIC IMPORTANCE ON THREE FIRST PRINCIPAL COMPONENTS FOR USE OF *GYNANDROPSIS GYNANDRA*. SIGNIFICANT SCORES ARE IN ITALICS.

	Dim1	Dim2	Dim3
Cultural importance indicators			
Commercialization possibilities	*0.85*	– 0.02	– 0.17
Harvest type	*0.68*	0.04	– 0.11
Frequency of uses	*0.61*	0.01	*0.64*
Last day of consumption	*0.61*	0.03	*0.58*
Perceived availability	*0.60*	– 0.18	0.20
Plant parts used	0.37	0.03	– 0.36
Taste appreciation	0.37	0.23	0.28
Source of knowledge	0.20	0.09	0.09
Medicinal value	– 0.01	*0.90*	– 0.07
Number of reported uses	– 0.01	*0.93*	– 0.06
Food preparation	– 0.18	0.18	0.44
Management index	*0.85*	0.05	– 0.24
Economic value of leaves	*0.83*	– 0.04	– 0.27
Economic value of seeds	*0.78*	0.01	– 0.21
% of variance explained	33.16	12.96	10.04
Cumulative % of variance	33.16	46.12	56.16

were used a reference for comparison with other socio-linguistic groups. The interaction between time and socio-linguistic groups suggests that the Ewe (Z value = 8.1, $p < 0.001$) would show significantly less change in management practices over time than the Adja. The negative interaction regression coefficients for the Fon, Gourmantche, and Holli suggested significantly higher rate of change in these groups compared to the Adja respondents. The non-significant interaction for the Zerma (Z value = 0.6, $p = 0.537$) and Waama (Z value = – 1.5, $p = 0.136$) indicated that the management practices in these groups would not significantly change in the future compared to the Adja. However, the model suggested a higher change rate for the Waama than the Adja and a lower change rate for the Zerma than the Adja.

Discussion

FACTORS INFLUENCING THE USE AND MANAGEMENT OF *G. GYNANDRA*

We hypothesized that the variation in use and management of the species would be influenced by ethnicity, cultural and economic importance as well as the presence of market-oriented vegetable production. Our results indeed demonstrated strong ethnicity-driven patterns of knowledge, use, and valuation of spider plant. Ethnicity was also raised as an important factor in previous studies investigating variation in indigenous plant species knowledge (Ekué et al. 2010; Kidane et al. 2015). We observed that the cultural and economic importance varied across socio-linguistic groups and could be also explained by ethnicity.

The economic importance of the species was high among Adja and Ewe socio-linguistic groups. Both socio-linguistic groups are closely related and sometimes considered as the same ethnic community (Landoh et al. 2016) which may explain these similarities. While in the Ewe community, the species was only found among market gardeners who cultivate a wide diversity of vegetables, in the case of the Adja, the species was cultivated in rain-fed home gardens in pure stands and sold on local markets. We can therefore speculate that even in the absence of market-oriented vegetable production, local communities would domesticate the vegetable as soon as it becomes a popular and valued species. The differences noticed between both socio-linguistic groups in terms of cultural importance of the species suggested that urbanization could have resulted in less attention for the medicinal and cultural value of the species. Urbanization may jeopardize, increase, or have no effect on traditional knowledge transmission and conservation (Gaoue et al. 2017; Júnior et al. 2016). In our case, further comparison of

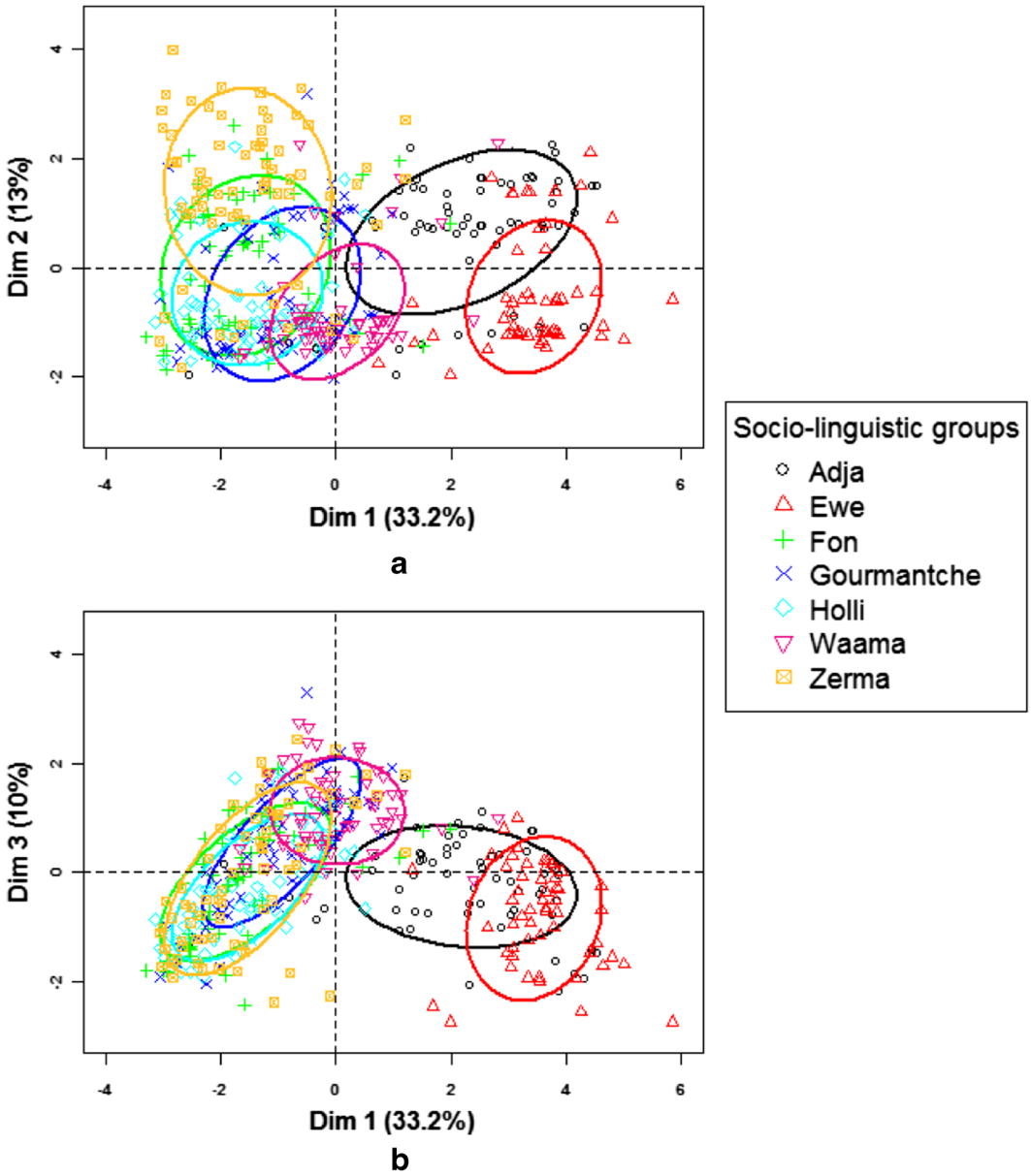

Fig. 5. PCA scores plot of 428 respondents from the different socio-linguistic groups based on knowledge and use and economic importance of *Gynandropsis gynandra*. (A) Projection on principal components 1 and 2. (B) Projection on principal components 1 and 3.

traditional plant knowledge among urban and rural Ewe farmers would be required to test how urbanization affected their knowledge of the species.

Even though spider plant was perceived as abundant among the Fon, Gourmantche, and Waama groups—with strong awareness of usefulness—these communities did not consider the species as economically important and would only harvest it when needed for consumption or medicinal uses. The differences observed between knowledge and use among the different communities could be explained by discrepancies between

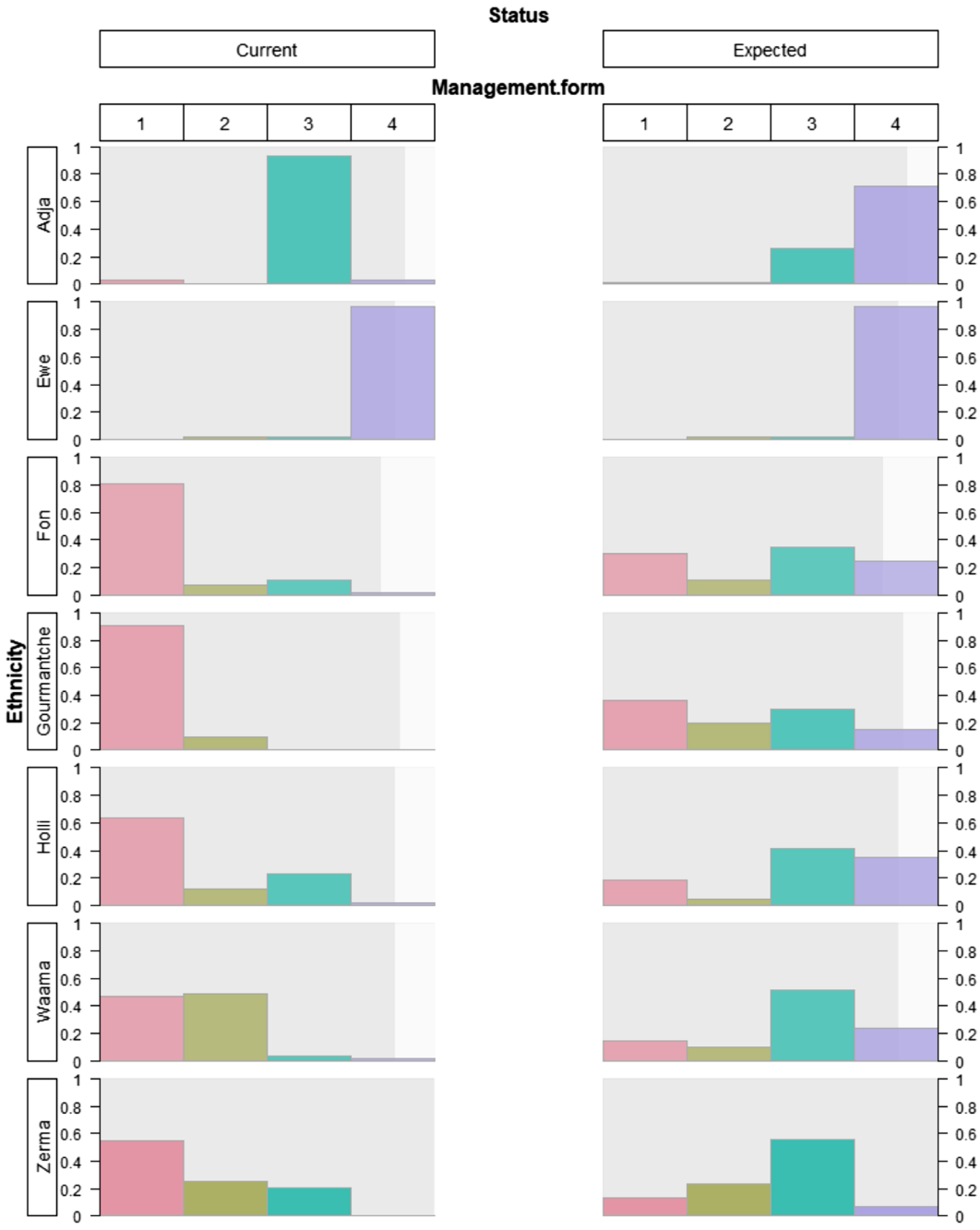

Fig. 6. Frequencies for current and expected management forms in each socio-linguistic group for use of *Gynandropsis gynandra*. Management forms: (1) wild collection with no particular selection; (2) tolerance, protection, or promotion of plants around houses; (3) rain-fed cultivation in home gardens; and (4) intensive irrigated cultivation all year round.

their ethnobotanical knowledge and their practical uses of the species (Godoy et al. 2009; Reyes-García et al. 2006). Albuquerque (2006) distinguished the notions of "mass knowledge" and "stock

TABLE 5. ASSOCIATION BETWEEN CURRENT AND FUTURE MANAGEMENT SCHEMES ACROSS SOCIO-LINGUISTIC GROUPS.

	Estimates	Standard error	Odd ratios	95% CI	*Z* value	$p > \|Z\|$
β1	− 2.17	0.16	0.11	0.08–0.15	− 13.85	< 2e−16***
β2	− 1.20	0.12	0.30	0.24–0.38	− 9.98	< 2e−16***
β3	1.19	0.11	3.29	2.66–4.06	11.08	< 2e−16***
Current (reference)						
Future	− 1.87	0.23	0.15	0.10–0.24	− 8.11	< 2e−16***
Adja (reference)						
Ewe	− 4.60	0.74	0.01	0.01–0.04	− 6.23	< 2e−16***
Fon	3.73	0.41	41.53	18.46–93.44	9.01	< 2e−16***
Gourmantche	4.65	0.52	104.99	37.52–293.78	8.86	< 2e−16***
Holli	2.65	0.30	14.18	7.85–25.60	8.79	< 2e−16***
Waama	2.44	0.23	11.49	7.33–18.03	10.63	< 2e−16***
Zerma	2.40	0.26	10.97	6.63–18.15	9.33	< 2e−16***
Future: Adja (reference)						
Future: Ewe	1.87	0.23	6.51	4.14–10.23	8.11	< 2e−16***
Future: Fon	− 1.18	0.46	0.31	0.13–0.76	− 2.55	0.013*
Future: Gourmantche	− 1.44	0.62	0.24	0.07–0.79	− 2.33	0.019*
Future: Holli	− 1.05	0.39	0.35	0.16–0.75	− 2.69	0.007**
Future: Waama	− 0.54	0.36	0.58	0.29–1.18	− 1.49	0.136^{ns}
Future: Zerma	0.20	0.32	1.22	0.65–2.28	0.62	0.537^{ns}

CI confidence interval, *ns* non-significant
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

knowledge" which refer respectively to the total number of useful plants known by a community and the species actually used by them. In other words, some communities have a good knowledge of the species but would only use it as a last resort and prefer using other species with similar functions (e.g., food, medicine). This situation might change if there is an increasing market demand for the species. Other communities have a high preference for the species which, in the case of the Ewe and Adja, led to its cultivation and commercialization probably due to an increasing demand on the market. As previously reported by N'Danikou et al. (2011), the market importance of wild edible plants is also a main incentive for species' use and conservation. For example, our Zerma respondents, who originate from Niger, where the species is used and cultivated, cited the highest number of uses compared with any other socio-linguistic group. However, because of the low popularity and the lack of marketing opportunities for spider plant in Northern Benin, they used the species less frequently than the others and were less interested in its cultivation. Similar trends were observed for *Artemisia absinthium*, a plant species cultivated in Haiti for food, medicinal, and spiritual uses and with a high economic value. The species lost popularity over time among migrant Haitians in Cuba and its cultivation in home gardens declined substantially. Moreover, the species which was the main ingredient of the *Tifey*, a local beverage used for multiple purposes, was progressively replaced by other species more abundant in the host country (Volpato et al. 2009).

In the case of the Holli, the species was overall considered as rare and this community subsequently also had a low number of reported uses as well as frequency of uses and overall cultural importance. The link between species availability, knowledge, and actual use is therefore not straightforward but rather context-specific. In our case, the availability of the species was evaluated by the respondents based on how they perceive the balance between their demand and the abundance of the species in their community. To better account for the complexity of the concept of species availability, Gaoue et al. (2017) suggested a multi-dimensional index incorporating ecological, socio-cultural, economic, and political aspects and drivers of availability.

Patterns of plant uses and management often arise from complementarity between socio-cultural

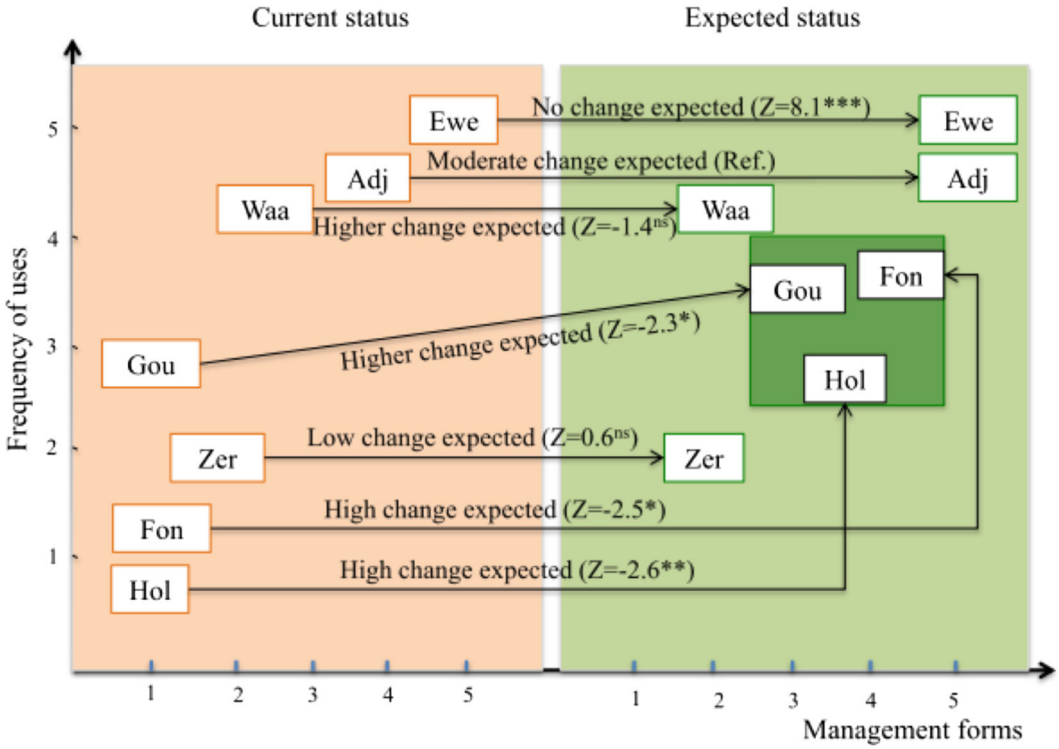

Fig. 7. Current and expected future management intensity ($\tau = 0.52$, $p < 0.001$) of *G. gynandra* by socio-linguistic groups as main drivers ($D^2 = 65.9\%$) in Benin and Togo. Ewe: Ewe community, Adj: Adja community, Waa: Waama community, Gou: Gourmantche community, Zer: Zerma community, Fon: Fon community, Hol: Holly community. The greener area is where the leverage activities should be intensified.

attributes and biogeographical factors. Communities sharing the same environment but with different cultural backgrounds may have convergent plant uses (Segnon and Achigan-Dako 2014; van Andel et al. 2015). We observed patterns of convergence in use and management between communities sharing a same cultural background and living in the same geographical area. For the Gourmantche and the Waama who belong to the Gur language family (CENALA 2003) and live in the Sudanian semi-arid region, the species has a lower cultural importance and is less intensively managed compared with the Adja and Ewe who belong to the Kwa language family and live in the Guineo-Congolian humid region. Although our data supports the hypothesis that management and uses are shaped by ethnicity and geographical proximity, an exception is that among the Fon who also belong to the Kwa language family and are geographically close to the Adja and Ewe (CENALA 2003), the species is much less popular as a vegetable, but more as a medicinal plant, and thus managed less intensively. The name of the species is also the same among the Ewe and Adja, suggesting strong cultural affinities, but different for the Fon who are more culturally distant from those socio-linguistic groups. Wartena (2006) explained that the Fon and the Adja shared their climate, geological conditions, trade opportunities, and cultural origins of their populations. However, divergences between the two socio-linguistic groups was traced back to pre-colonial times, first in trade and culture contacts with neighbors and then in the socio-economic and cultural practices of the slave raiding and trading Fon on the one hand and the agrarian Adja hiding from slave raiders on the other. The author also described in details the current differences in the traditional beliefs, agricultural practices, and food preferences between these communities.

A commonality between all the surveyed socio-linguistic groups is the knowledge about the medicinal uses of the species. The use of spider plant to cure malaria and anemia respectively by the Fon and the Mahi were previously reported in southern

Benin (Allabi et al. 2011; Yetein et al. 2013). Medicinal uses of the species were also reported in other parts of the world including India (Bala et al. 2010; Shanmugam et al. 2012), Uganda (Oryema et al. 2010), and Kenya (Jeruto et al. 2008). The use of the species as a medicinal plant across several socio-linguistic groups in Benin suggests its proven efficacy. Its occurrence in anthropogenic areas as an herb that grows at the onset of the rainy season makes it easily available when needed. Such characteristics are in accordance with the "availability" and the "ecological apparency" hypotheses commonly used to explain the predominance of weeds in medicinal flora. The availability hypothesis states that accessible or locally abundant plants are more likely to be used as medicinal plants. The ecological apparency hypothesis speculates that species with short lifespan (non-apparent species) develop "inexpensive" qualitative defense compounds against herbivores (secondary metabolites) (Albuquerque 2006; Gaoue et al. 2017). Those compounds also have beneficial health-promoting properties. Spider plant leaves are indeed rich in glucosinolates and flavonoids which are involved in response against environmental stresses (Omondi et al. 2017), but also have pharmacological properties (Bala et al. 2014; Moyo et al. 2013).

During our sampling, we noticed that the management of the species was gender-specific. Most of our respondents were female. However, in the Ewe community, with a high economic orientation to the cultivation of spider plant, producers were predominantly males. In the other socio-linguistic groups, women managed the species for household consumption and in rain-fed cultivation in home gardens and sold it occasionally on local markets. In Benin, it was reported that women are typically involved in the domestication of leafy vegetables and medicinal plants while fruit domestication is controlled by men (Vodouhè and Dansi 2012). The predominance of males in commercial production is explained by the fact that commercial vegetable production requires important financial resources for land lease, irrigation, and purchase of various inputs. For male Ewe respondents, vegetable production was a full-time job. Only few women were encountered during our survey in Togo and they were much more involved as hired laborers and vegetable traders. Several studies conducted in urban areas of West Africa reported the male dominance in vegetable production, while women lead vegetable marketing (Drechsel et al. 2013; Gockowski et al. 2003). However, peri-urban and rural vegetable production is often dominated by women who mainly grow African leafy vegetables as these require lower amounts of external inputs and financial resources than non-indigenous vegetables (Dinssa et al. 2016). Adja women who lived in peri-urban and rural areas were considered by their male counterparts as more knowledgeable about the uses and growth of the species. The same behavior was noticed for all the other socio-linguistic groups in Benin, where male farmers considered that "only women manage the species for culinary purposes". These trends suggest an increasing interest from men when the species becomes economically important. Research for development initiatives aiming at promoting African leafy vegetables should therefore put an emphasis on ensuring women's access to key agricultural production factors including land, labor, and financial asset.

In the Adja community, we observed a strong willingness to shift towards intensive year-round cultivation of the species, which would require higher investment of resources from women. The commercial cultivation of the species by the Ewe in Togo is a unique opportunity to identify and address the main constraints related to agronomy of the species. Rain-fed cultivation of the species in home gardens was considered as an attractive option among the Fon, Holli, Gourmantche, and Waama. These groups have access to land, but external factors including farmers' training on adequate cultivation practices and leverage activities should also be taken into account to support their efforts. Strategies for integration of wild edible plants in the market should take into account the issues of production, storage and processing, organization of wild edible plants supply chains, and negative perceptions of their consumption, often associated with poverty and low social status (Leal et al. 2018). The promotion of *Moringa oleifera* in several African countries is an example of successful diffusion of innovation consistent with existing social and cultural practices (Thurber and Fahey 2009). Intensive cultivation of the species year-round in the surveyed communities would require interventions to create public awareness about the nutritional and health benefits of the species and other wild leafy vegetables. Potential consumers including women, youths, and elite class citizens with high income in urban and peri-urban areas should be targeted in order to increase the demand in the vegetable. Participatory breeding efforts to provide farmers with high-yielding and nutritious varieties as well as investigation on optimal seed storage and

conservation are also necessary to sustain the species cultivation.

Limitations of Our Study

The purposive sampling method in ethnobotany has been often criticized as the results cannot be generalized to the whole community (Tongco 2007). In our study, however, this method was the most convenient as we needed to identify people who knew the species and were willing to participate in the study. Another unavoidable bias in our study was the gender skewness of our sample. In most households we visited, men directed us to women who were in charge of collecting or cultivating vegetables for cooking and commercialization. Because of the subjective character of some of the variables collected, repeated interviews in time would allow better triangulation of our data. However, this approach would be time-consuming and costly.

The cultural significance index and the management index were both adapted to the context of our study. The choice of the cultural significance index was guided by the need to analyze the perceptions of the respondents. Other cultural importance indices developed in literature were used to compare species and were restricted to the comparison between the number of respondents who mentioned some uses of a species in defined use-categories (Tardío and Pardo-de-Santayana 2008). However, we do not pretend to have exhaustively taken into account all the aspects to consider when evaluating the cultural significance or the management intensity of a plant species. For example, determining the relative cultural importance of spider plant compared with other leafy vegetables in the surveyed communities would have allowed to better assess the species availability, use, and management. Such information coupled with a discrete choice experiment (Espinosa-Goded et al. 2010; Schulz et al. 2014) and an analysis of market opportunities could also improve our evaluation of respondents' willingness to integrate the species in their home gardens.

Conclusion

Our study provides insight in the knowledge, use, and management of *Gynandropsis gynandra* in seven socio-linguistic groups in Benin and Togo. Communities had a good knowledge of the nutritional and medicinal value of the species. However, cultural importance of the species and management practices across these communities were diverse and strongly influenced by ethnicity and gender and to a lesser extent by age, education, and access to land. We observed overall a convergence of knowledge and management practices between communities with similar socio-cultural and ecological contexts. Migration and available market opportunities also significantly influenced the management practices adopted by our respondents. In areas where *G. gynandra* is still harvested from the wild, promotion of the species among consumers and farmers' training, especially women, are expected to trigger the species' cultivation. Efficient selection of neglected plant species to promote in a given region for successful commercial cultivation should take into account not only their nutritional value and pharmacological properties but also communities' willingness to intensify management of these species with a particular emphasis on potential socio-cultural and economic constraints which could arise during such an intensification process.

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