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Indigenous ecological knowledge, conservation status, and spatial distribution of Sterculia setigera in Togo

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Indigenous knowledge of plant resources is very useful for their sustainable management. The present study aimed at understanding the indigenous knowledge for sustainable management of *Sterculia setigera* in Togo. In particular, it collected information on the ethno-ecological knowledge of *S. setigera*, its habitat, population dynamics, traditional management and spatial distribution in Togo. Data were collected through semi-structured individual and focus group interviews with 376 informants (almost all Togolese ethnic groups: 29), coupled with direct field observations. A total of 553 occurrences were recorded during the field observations. The results showed that knowledge of the species' habitat and population dynamics varied by geographical area, while management was sometimes influenced by socio-cultural considerations and use values. Human activities were identified as a major threat affecting the population dynamics of the species. The projection of these on the Togolese eco-floristic map showed that eco-floristic zones I and III were identified as areas with a high occurrence of *S. setigera*, while the species is almost absent in the semi-deciduous forest zone (eco-floristic zone IV). Further research on how climate change affects the species' habitat, propagation and planting should be encouraged.

Keywords: *Sterculia setigera*, ethno-ecology, distribution, Togo

INTRODUCTION

Indigenous people have a great deal of knowledge about their environment, accumulated over time. This knowledge, which differs from basic science, is based on secular wise observations, resource use and management practices, experiences and beliefs accumulated over a lifetime and sometimes transmitted from ascendant to descendant. Traditional ecological knowledge (TEK) is dynamic and adapted to the natural, social and historical conditions of each society (Becker et Ghimire, 2003; Saynes-Vásquez et al., 2013; Koteswara Rao, 2024). Scientists have been interested in TEK because they can contribute to the sustainable use and management of natural resources. Although TEK have been recognised as useful and sustainable (Wala et al., 2009; Birhan et al., 2011; Gwali et al., 2011; Gakuubi et Wycliffe, 2012; LaRiviere et Crawford, 2013), obviously not all traditional practices and knowledge were ecologically adaptive from the beginning. Most of them that were previously useful become maladaptive over time (Berkes et al., 2000), as the natural environment is constantly changing.

In West Africa, some tree species play a reliable role in the livelihoods of people, especially in rural

communities. This importance justified numerous studies dedicated to their sustainable management (Diop et al., 2005; Tanyanyiwa et Chikwanha, 2011; Venter et Witkowski, 2011; Samarou et al., 2021). In spite of these studies, the sustainable management of plant resources stills a great challenge facing effects of climate change, human population growth, and urbanization (Salako et al., 2019; Dimobe et al., 2020; Ehlui et al., 2024). Therefore, understanding the local knowledge on these plants will be helpful for their sustainable management. According to Ayantunde et al. (2008), failure of many natural resources management and conservation projects can be partly attributed to the lack such understanding.

S. setigera is one of the tree species native to sub-Saharan Africa, known for its medicinal, cosmetic and dietary uses. Its leaves, bark and roots are widely used in folk medicine (Lawal et al., 2010; Musa et al., 2011; Atakpama et al., 2015). Its seeds, leaves, and gum, are used for dietary, food and cosmetic purposes (Idu et al., 2008; Atakpama et al., 2015). Supporting studies have provided evidence for the use of S. setigera as an antimicrobial and anti-inflammatory agent in traditional medicine (Tor-Anyiin et al., 2011; Babalola et Adelakun, 2013; Ouédraogo et al., 2013; Ahlidja et al., 2024). The gum is also used in the preparation of various pharmaceutical products (Elkhalifa et Hassan, 2010). In Senegal in particular, the trade in S. setigera gum contributes to increasing the income of rural households (Jonhson et al., 2005).

In Togo, S. setigera is widely distributed and commonly used for pharmacopoeial, dietary, magical and cosmetic purposes (Atakpama et al., 2012; Atakpama et al., 2015). The identification of this species as gum tree species justified the recent studies. These studies revealed that the species is threatened in its natural habitat (Atakpama et al., 2014a; Atakpama et al., 2014b) due to its organs harvesting, especially for medicinal purposes, socio-cultural considerations (fetish tree or home of evil spirits) and lack of knowledge of the economic value of its gum (Atakpama et al., 2015; Atakpama et al., 2018). Information such as habitat suitability, dynamics and impacts of land use patterns are also known (Atakpama et al., 2016). Despite these studies, ethno-ecological knowledge is needed to develop sustainable management, implement domestication strategy and promote S. setigera gum in Togo.

S. setigera sometimes grow on hilly, rocky, poor and shallow soils (Sacandé et Sanon, 2007). Therefore, its valorisation, is one of the objectives of sustainable development and one of the main causes of the degradation of plant resources, could contribute to the exploitation of some lands unsuitable for agriculture, increase the income of indigenous households and, consequently, reduce poverty. The present study aims to collect information on the ethno-ecological knowledge of S. setigera: its habitat, local perceptions on population dynamics and management in Togo.

MATERIAL AND METHODS

Study area

Togo is a small country in West Africa, located between 6°06’N and 11°08’N latitude and 0°09 W and 1°49 longitude with a total area of 56,600 Km2. It is bordered by Burkina Faso to the north, the Atlantic Ocean to the south, Benin to the east and Ghana to the west. The population is made up of about 38 cultural groups, divided into three main ethnic groups: Adja-Ewe, Para-Gourma and Kabye-Tem (Kuevi, 1981). The population is approximately 6.191.155 inhabitants (INSEED, 2022).

Based on geo-climatic factors, the country is subdivided into 5 eco-floristic zones (Ern, 1979): I, II, II, IV, and V. In zone I, the vegetation is a mosaic of the Sudan dry savanna of the northern plains. This vegetation is modified by agroforestry parklands. These parklands are composed of different agroforestry species: Parkia biglobosa, Vitellaria padoxa, Tamarindus indica, Borassus aethiopum, Sterculia setigera, Lannea microcarpa, … (Folega et al., 2019; Atakpama et al., 2022a; Samarou et al., 2023). Zones II and IV correspond respectively to the northern and southern Togolese mountains. Zone II is a mosaic of Sudanese savannah, open forest and dry dense forest (Wala et al.,

2012; Atsri et al., 2018; Djideal et al., 2024). Parkia biglobosa and Vitellaria paradoxa dominated the agroforestry parklands (Padakale et al., 2015). Zone III or the central plain is the domain of Guinean savannahs, open and dry dense forests (Kokou et al., 2006; Pereki et al., 2013). Zone IV is characterised by semi-deciduous forests (Akpagana, 1989) and guinen savannahs (Guelly, 1994). These stands of native vegetation are being replaced by agroforests planted with coffee, cocoa and a variety of fruit trees (Koda et al., 2016; Djiwa et al., 2020). The coastal plain, zone V, is a mosaic of small relict sacred forests, savannahs, thickets and meadows (Kokou et Sokpon, 2006).

Data collection

Information was collected through semi-structured individual and focus group interviews (Atakpama et al., 2012). Informant consent was obtained by explaining the purpose of the study, first to local authorities to obtain their permission to conduct the survey, and then to randomly selected respondents. Only those who had lived in the municipality for at least five years were included in the survey. The questionnaires were preceded by the presentation of pictures of S. setigera and samples of fresh leaves, fruits and seeds (Atakpama et al., 2015). The fieldwork was conducted between 12 December 2012 and 30 March 2013. The people were first asked to identify the species and give a description. They were then asked to describe the habitat of the species (vegetation type, topography and soil type) and to give the vernacular or local name and its meaning, if any.

Local perceptions regarding the dynamics of S. setigera over time, the causes of these dynamics, the impact of harvesting on the survival and regeneration of the plant, as well as local management practices were also collected. Regarding the dynamics of the species, each respondent was asked to choose only one answer among four propositions: The species is abundant (1), less abundant (2), becoming scarce (3), very scarce (almost absent) (4). According to these propositions, informants were asked to use the following scale from 1 to 10: (1) within a number of 10 stem observations, the missing number was less than 3 stems, (2) between]3-5] stems, (3) between]5-7] stems and (4) means ≥ 8 stems. Therefore, the number of respondents within a given ethnic group represents those who recognised S. setigera, responded according to its habitat and dynamics, and stayed in the study area for at least 5 years.

Interviews were combined with field observations. Geographical coordinates (longitude, latitude and altitude) of species occurrences were recorded using Global Positioning System (GPS Garmin) in order to map their distribution on a country scale. To obtain a good estimate of the distribution, the sampled localities were separated by at least 5 km.

A total of 376 respondents with mean age 51.5 ± 14.3 years belong to 29 ethnic groups were investigated. The woman/man ratio was disproportionate: 14.4 % of women against 85.6 % of men. Almost half of respondents were illiterates (48.1 %). Those who recognize and give responses according to the aim of the study were sometimes rural people, especially peasants (56.6 %) and traditional healers (15.4 %). Civil servants were less represented (1.8 %).

Data analysis

The consensus value was used to weight people’s knowledge about the habitat and dynamics of S. setigera in the five eco-floristic zones. The consensus value (CV) was calculated using the following formula: $CV = Fx/Ft$, in where Fx is the number of times a given answer was reported, and Ft is the total number of citations. A matrix constructed according to the frequency of each threat recorded in each eco-floristic zone was subjected to Principal Component Analysis (PCA) using the Community Analysis Package software (CAP 2.15), in order to identify the driving forces affecting the dynamics of S. setigera. The occurrence data collected during the fieldwork were projected onto an eco-floristic map of Togo using ArcGIS 9.3 software. These data were coupled with the spatial elevation data of the study area downloaded from the database www.diva-gis.com.

RESULTS

Vernacular names of S. setigera

The local names of S. setigera vary according to the ethnic group (Table 1). Some of them have a clear explanation, while others are not defined by the respondents. Sometimes, the meaning refers to a specific plant part of the species, its habitat or local perception. There are three main criteria for naming the species: shape and colour of plant parts, habitat of the species, and cultural uses and beliefs (Table 2).

S. setigera is locally known as “Lowankantole” in the Bassar ethnic group. This means testis. This name refers to the shape of the fruits (Figure 1a). The Moba people call it “Nafoufoulgou”, which means tree with holes. This name is a reference to the porosity of the wood, which is less lignified. It is this characteristic that limits its use as fuel wood by the local communities.

Due to the shape of the leaves, which look like cotton leaves, the Ewe people called it “Zogbedeti” or “Adewudeti”, meaning wild cotton or warriors’ cotton respectively. It is called “wild cotton” (Figure 1b) because it is a spontaneous, non-planted tree found far from settlements with leaves similar to those of cotton (Gossypium hirsutum). Elsewhere, in ancient times, its bark decoction was used by traditional Ewe warriors/royal guards, in particular machetes, as a dye and thickener for their clothes.

The nomination of the species within the Kabye, Lamba, Ouatchi and another Ewe name ‘Zogbedjido’ refers to baobab (Table 2, Figure 1c), due to the trunk aspect, similar to that of the baobab (Adansonia digitata L.). The name “Alewatelou”, which means devil’s baobab by the Kabye ethnic group, can be explained by the fact that the species is considered to be the devil’s house. It is defended for people to have this species near or inside their houses. The same socio-cultural consideration is met within the Moba, Gourma, Bissa and Fon ethnic groups.

Some local names refer to the habitat of the species. The Kotocoli ethnic group called the species “Poudelou”, meaning “mountain baobab”, because the species is sometimes found on hills or mountains in their area. The species is also found on farmland. This justifies the local names “Fotelou” and “Fodatelou”, meaning “baobab of the farm” in the Kotocoli and Kabyè ethnic groups respectively.

Indigenous knowledge about S. setigera population dynamics and habitat

The consensus values showed that the species were generally becoming scarce (CV = 0,33). However, the species was reported to be still abundant in eco-floristic zone II, corresponding to the northern mountainous region (Figure 2). Throughout this area, the species was frequently found in a variety of habitats: savannahs, hillsides/mountain slopes, fields and the garden of the slot (Figure 3). In general, throughout the country, the species is reported to be found in shrubby and woody savannahs (45.1% of cases) and fields (36.7%). The consideration of the species as a god by the Lamba, Bassar and Temberma ethnic groups (Figure 4) justifies its frequency in garden slots and houses within eco-floristic zones I, II and III.

Dynamic driving forces

The dynamic of S. setigera were affected by different driving forces. These driving forces were categorized into four major types: species use value, species regeneration, environmental threats, and human activities. Human activities were pointed out as the main cause (52.4 %) that reduces the abundance of the species. It is followed by the use value (24.6 %), species regeneration capacity (7.5%), and environmental threats (1.98 %). Added to these threats, ethno-cultural considerations (13.5 % of cases) were noted as another factor, which influences the management of the species

within eco-floristic zone I, II, and III. The main human activities are bushfire, agricultural practices, and organs harvesting. Bushfire was reported to destroy seeds and seedling. Adult trees bark and other organs are harvested for medicinal, culinary and pastoral purposes. Environmental threats reported are climatic fluctuations and violent winds. Violent winds induce stems and branches breaking while climatic fluctuations especially seasonal variations and uneven rainfall reduce the regeneration capacity of the species, since the species was reported to regenerate mostly by seeds.

Some causes are shared through the overall study area (Figure 5). These causes are bushfire, ageing population, regeneration by seeds, uses and plant parts harvesting, especially barks used in pharmacopeia (Figure 6). Threats are more diversified in eco-floristic zone I (Figure 5). Within this area, mainly Moba and Gourma ethnic groups do not appreciate the species near habitations or farms. These people think it could induce several unpleasant events. Hence, because of this myth it was cut down during habitation and field settlements. S. setigera is less appreciated as agroforestry tree and seedlings are uprooted during plowing time. Therefore, socio-cultural considerations affect population management.

Table 3 summarises the test performed on the significant canonical dimension. Therefore, the first test evaluates whether all the considered dimensions are significant (they are, F = 17.2), the next test tests whether dimensions 2, 3 and 4 combined are significant (they are, F = 3.54). The third test tests whether dimensions 3 and 4 are significant. They are not. Dimensions 1 and 2 are statistically significant at the 0.05 level, while dimensions 3 and 4 are not. Dimension 1 had a canonical correlation of 0.41 between the set of variables, while for dimension 2 the canonical correlation was much lower at 0.16.

Table 4 shows the standardised canonical coefficients for the first two dimensions for both sets of parameters. For the regeneration variables, the first canonical dimension is most influenced by natural regeneration (0.64) and for the second dimension by seed regeneration (-0.49). For the environmental threats variables, climate variability and wind have the highest value on the second dimension axis (-0.69 and 0.65 respectively). Concerning the anthropogenic variables, the highest value on the second dimension was observed for bushfire (-0.82), while harvesting and cutting have a significant value on the first dimension (-0.77 and 0.56, respectively).

Occurrence of S. setigera

Direct observations showed that the species is more abundant within eco-floristic zone I (in savannas, mostly on hilly and gravelly soils), followed by eco-floristic zone III, which corresponds to the central plain at altitudes between 0 and 500 m (Figure 7). The species is less widespread in eco-floristic zone II, which corresponds to the northern mountains. The species is almost absent in the southern mountain zone (eco-floristic zone IV). The last two zones (zones II and IV) are the highest parts of the country. The occurrence of the species is low in the less elevated part of the country (zone V) and is mainly located in the southern part of this zone.

DISCUSSION

The variation in the meaning of local names of S. setigera reported in this study demonstrates the intrinsic links between indigenous people and their environment. Socio-cultural perceptions, daily resource use and observation are transmitted from ascendants to descendants and acquired through experience. This finding is similar to that reported by Gouwakinnou et al. (2011) for Sclerocarya birrea (A. Rich) Hochst. Respondents reported that the species' trunk is similar to that of baobab, an agroforestry tree sometimes conserved by indigenous people in slot gardens for its multiple uses (Diop et al., 2005). This similarity with baobab, as perceived by indigenous people, is very relevant. In contrast, S. setigera is a spontaneous and non-planted tree that sometimes grows in farmland. This finding shows that local names are wisely chosen in relation to a deep knowledge of the biology of this plant resource and its habitat.

Even if the traditional knowledge appears to be wise, the lack of knowledge of the name of the plant or its explanation in some ethnic groups could be due to the decline of traditional knowledge due to the disappearance of traditional education, rural depopulation and changes in beliefs. The monotheistic religions has been pointed out as the main cause of the degradation of sacred forests and groves in Togo (Kokou et al., 2005; Atakpama et al., 2021; Atakpama et al., 2022b). Recognising S. setigera as a totemic species (Noundja et al., 2023), helping to regenerate the species is increasingly being ignored. The relationship between human populations and their environment has been profoundly altered by modern education and the rise of monotheistic religions in Africa. Furthermore, rural societies adopting urban tastes and values and losing local languages (Saynes-Vásquez et al., 2013) lead to the loss of traditional knowledge.

The virtual absence of target species in eco-floristic IV could be due to climate type and land cover. The climate is of the Guinean tropical type and the vegetation consists of semi-deciduous forest. The southern part of Togo has experienced rapid population growth and urbanisation in recent years compared to the Sudanese zone, which remains the slowest (DGSCN, 2011; INSEED, 2022). As a result, natural habitats (savannas and forests) have been degraded by field settlements and reduced by construction. The uncultivated areas are sometimes small remnants of sacred forests (Kokou et al., 2005), fallow land and groves. Moreover, this zone is less elevated and the climate is Guinean in contrast to the northern part of the country where the climate is Sudanese. The type of soil is another reason for the distribution of species. According to Sacandé et Sanon (2007), the species grows in savanna-type vegetation on poor and shallow soils and on hilly/stony sites. This type of soil and vegetation corresponds to the habitat where the species was found abundant in the Sudanese zone (savannas, hilly and gravelly soils) and could justify the high occurrence of the species in this area.

According to Atakpama et al. (2015), ethnic groups living in this zone mostly use the plant parts, mainly barks for medicinal purposes. The harvesting of barks and roots has been described as very detrimental to the survival of the plant species (Maroyi et al., 2013). The knowledge of the use of the plant parts of the species argues in favour of their conservation in the fields, especially among the Kotocoli ethnic group, located in eco-floristic zone II. On the other hand, the lower usefulness of the species by eco-floristic zone V does not allow its conservation, since the conservation of a species, especially within agroforestry systems, was guided by its use knowledge. People preferred to preserve and establish edible fruit and economic tree species on their farmland. Although the uses of the species were well known in the Sudanese zone, the overharvesting of plant parts and the myth, added to the total ignorance of the economic value of it gum, do not argue in favour of its conservation. In addition, this zone is still experiencing harsh climatic conditions in recent years (Badjana et al., 2012), which induced diversity degradation: biodiversity loss and land cover degradation (Diwediga et al., 2012).

CONCLUSION

The present study showed that S. setigera is well known and widespread throughout the Togolese territory, especially in eco-floristic zones I, II, III and V. It occurs mainly in eco-floristic zones I and III, which correspond to the middle elevated areas of the country. There are several names of the species in each ethnic group. The popular nomination is based on its habitat, beliefs, organ colour and forms. The management of the species is influenced by human activities and socio-cultural considerations. However there is no traditional management or conservation practices for the species in its natural stands. T The lack of economic knowledge of the species does not argue for its conservation. Its valorisation is crucial for its conservation.

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