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RESEARCH ARTICLE

# Galactogenic plant diversity, phenology and local in situ conservation practices in agro-ecological zones of Benin Republic

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**Abstract** Benin has a high-value plant resources among which galactogenic plants are neglected. This paper aimed at assessing the diversity and indigenous practices associated with in situ conservation of galactogenic plants in the agro-ecological areas of Benin. An ethnobotanical study was carried out involving 310 informants in five sociolinguistic groups. The relative frequency of citation and fidelity index were used to assess the galactogenic value of each species. A principal component analysis and correspondence analysis were performed respectively to depict the relationships between the use of galactogenic plants and the sociolinguistic groups and appreciate the relationships between sociolinguistic groups and local practices for in situ conservation of galactogenic plants. A total of 69 galactogenic species belonging to 57 genera and 25 families were identified. Results also showed that predominant species were Fabaceae (18.8%), Poaceae (11.6%), Euphorbiaceae (10.1%), Caesalpiniaceae, Combretaceae and Apocynaceae (7.2%). The most represented genera were Euphorbia (5.9%) and Ficus (4.5%). According to the informants, *Afzelia africana* Sm. ex Pers., *Euphorbia balsamifera* Aiton, *Bobgunnia madagascariensis* (Desv.) J.H.Kirkbr. & Wiersema, *Vigna unguiculata* (L.) Walp. and *Arachis hypogaea* L. are the most effective galactogenic species for milk production with cow. Knowledge about galactogenic plants varied significantly across sociolinguistic groups, but not across agro-ecological zones and socio-professional profiles. Results also indicated that informants had poor knowledge of phenological time-axis of plant species, including *A. africana*, *Pterocarpus erinaceus* Poir. and *Khaya senegalensis* (Desr.) A. Juss. Local in situ conservation practices identified were protection of seedlings, preservation of the species in the fields and habitation, and plantation. Phenological studies of the most important galactogenic species are necessary to define appropriate strategies for their rational use and conservation.

**Keywords** Galactogenic plants · Indigenous knowledge · Milk production · Relative frequency of citation · Sociolinguistic groups · Benin Republic

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## Introduction

African flora is characterized by an important diversity of plant species that are valuable resources for the population, especially for people living in rural areas (Adoukonou-Sagbadja et al. 2007). In many regions of Africa, rural communities rely on indigenous knowledge to harness plant resources to address daily health and nutritional challenges (Fandohan et al. 2015; Shrestha et al. 2016; Chingwaru et al. 2019a). Plants are also used as wood energy (e.g. coal making), in construction and in craft (Sèwadé et al. 2018; Lokonon et al. 2019; Naah, 2020). Others plants are used to control plant pests (Stevenson et al. 2010; Roy et al. 2016; Stevenson et al. 2017). Galactogenic effect of plants has been reported by several authors in different countries, for example in South Africa (Simelane et al. 2012), in Iran (Hosseinzadeh et al. 2013) and in India (Badgujar and Bandivdekar 2015; Sahoo et al. 2016). In Benin, many studies have highlighed the medicinal use of plants to stimulate, improve or increase milk production in women that have low production of breast milk. For example, Akouedegni et al. (2012) and Déléké Koko et al. (2009, 2011) identified 22 and 57 medicinal plants respectively. These plants were used to stimulate milk production and to treat breastfeeding and menstrual pain problems. Furthermore, 55 plant species were identified in North Benin by Dassou et al. (2014) for their potential to stimulate milk production. Among those species, six, i.e. *Balanites aegyptiaca* (L.) Delile, *V. unguiculata, Swartzia madagascariensis* Desv., *Lagenaria siceraria* (Molina) Standl., *Sorghum bicolor* (L.) Moench, *Adenium obesum* (Forssk.) Roem. & Schult. were highly used by local communities for their galactogenic properties. There is mounting interest in the use of some of the above-mentioned species by livestock farmers for food (Sèwadé et al. 2016, 2018), veterinary care (Upadhyay et al. 2011; Sidi et al. 2017) and for improving zootechnical performance (i.e. average daily gain, live weight and milk production) of goats and cattle (Price 2007; Hêdji et al. 2014). Likewise, in Benin, 41 plant species were identified by Salifou et al. (2017) as species used by livestock farmers to improve milk production in cows.

The undeniable use of galactogenic species in Benin places high pressure on those plants. Such pressure is reinforced by the lack of control over the phenology of the species (Adomou et al. 2018). Therefore, there is an essential need not only for galactogenic species conservation, but also for designing strategies for their sustainable exploitation (Sinasson Sanni et al. 2017). An important step to reach this goal is to deepen knowledge not only on the phenological time axis of the galactogenic plant species, but also on local knowledge around those species. Pilgrim et al. (2007) and Rai (2007) argued that indigenous knowledge are an essential component of biodiversity conservation. Indigeneous knowledge are also considered as critical in decision making for resource management (Campos and Ehringhaus 2003; Mavhura and Mushure 2019). Despite the interests of some authors on galactogenic plants in Benin (Déléké Koko et al. 2009, 2011; Salifou et al. 2017), knowledge on the diversity of galactogenic species and related conservation methods in the main cattle breeding areas in this country remain limited. Previous studies only focussed on cooking mode of galactogenic plants and state of conservation of those plants in limited areas, such as the cynegetics zone of Pendjari (Benin).

The present study aimed at assessing the diversity and the indigenous practices of in situ conservation of galactogenic plants in the agro-ecological zones of Benin. Specifically, this study (i) describes the diversity of the galactogenic plants used by livestock farmers and agro-pastoralists; (ii) identifies the most important galactogenic plants for milk production in cows, (iii) describes local knowledge on plant phenology and, (iv) investigates indigenous practices of in situ conservation of galactogenic plants by livestock farmers and agro-pastoralists in the study area.

## Materials and methods

### Study area

This study was conducted in Benin's main agropastoral areas that hold over 76% of the national cattle herd (FAOSTAT 2018), and covering four agroecological zones (AZ) such as AZ-II, AZ-III, AZ-IV and AZ V (Fig. 1). Data were collected in various municipalities within each agroecological zone (AZ) including Banikoara, Gogounou (AZ II); Kalalé, Kouandé, Nikki (AZ-III); Tanguiéta (AZ-IV); Dassa, Savalou and Tchaourou (AZ-V).

The selection of the municipalities was based on the (i) size of cattle population, (ii) high number of

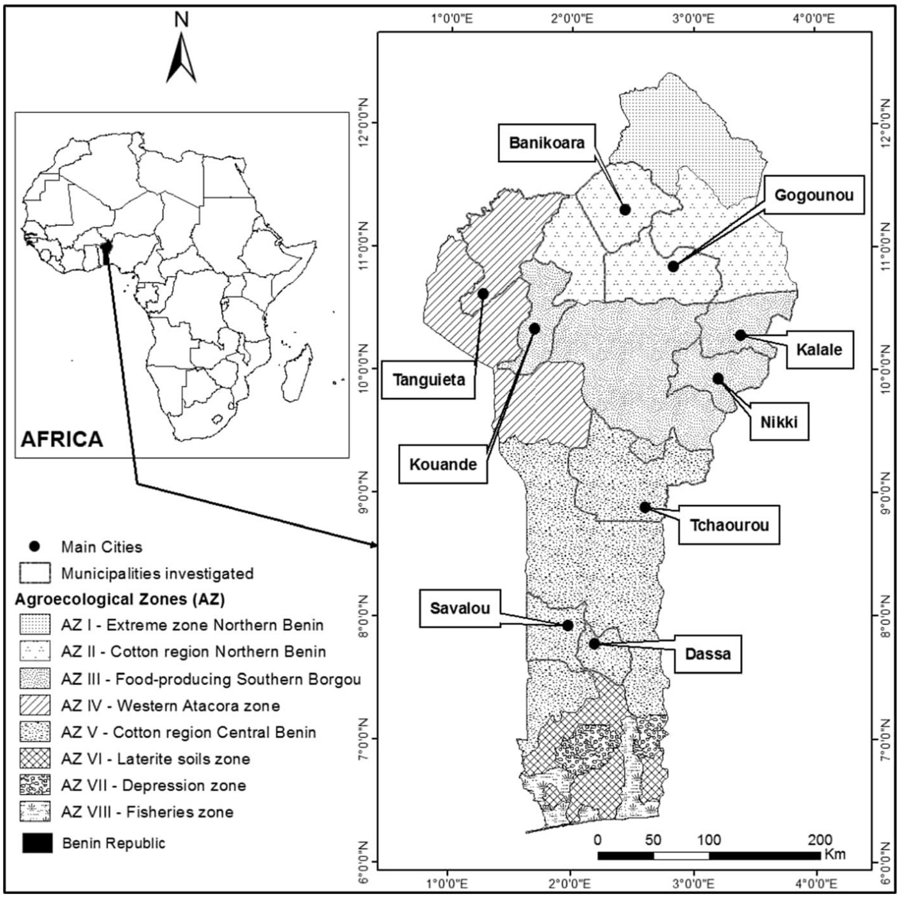


**Fig. 1** Survey areas in Benin agroecological zones

livestock farmers and agro pastoralists (INSAE 2016), and (iii) their characteristics as transhumant area. Banikoara has the largest livestock in Benin (FAOSTAT 2018) while Kalalé, Nikki and Tchaourou hold the greatest community of Fulani: 74.3%, 44.7% and 25.5% respectively (INSAE 2016). In addition, Tchaourou was reported to be one of the favorite zones of transhumance (Sèwadé et al. 2016). Dassa, Savalou, Tchaourou and Nikki are located in the Sudano-Guinean zone (7°30′–9°45′ N) and characterized by ferruginous soils and vegetation dominated by moist woodland and savannas (Gandji et al. 2019). Rainfall is unimodal, from May to October with annual total rainfall varying between 900 mm and 1110 mm. In contrast, Banikoara, Gogounou, Kalale, Kouandé and Tanguiéta are in the Sudanian zone (9°45′–12°25′ N) and characterized by ferruginous soils, with savanna and dry woodlands. The average annual precipitation is around 1000 mm (Houessou et al. 2019).

## Sampling

A total of 310 informants were surveyed across 26 villages. Informants were randomly sampled in each agro-ecological zone for an exploratory study. Selection criteria were mainly based on membership in sociolinguistic groups (Fulani, Gando), socio professional (livestock farmers, agro-pastoralists, farmers, traditional healers) and age (at least 25 years old). The rationale behind those criteria was to take into account only people who already have some experiences in the use of plants based on their galactogenic properties. Key informants in the municipalities and veterinary capacity building structures were involved in villages' selection within each municipality. Selection criteria included the presence of high number of livestock farmers and the presence of targeted sociolinguistic and socio professional groups.

### Survey and data collection

The survey was based on structured interviews, focus group discussions and field visits. The structured interviews were conducted using a questionnaire, while interview guide was used during the focus group discussions involving an average of 10 informants, and mostly men. The KoboCollect version 1.25.1 (http://www.kobotoolbox.org/) was used for data collection. Questionnaires were administered in local languages of the study areas (i.e. Fulani, Bariba, Dendi, Nago). Data collected were related to informants knowledge on galactogenic species and plants organs used, the preparation mode, the abundance of these plants, the causes of low abundance of some species, phenological phases (leaf emergence period, leaf fall period, flowering period, generative phase duration) and in situ conservation practices of species.

Scientific names of collected species were identified using reference documents (Akoègninou et al. 2006; de Souza 2008). The identification of collected species were authenticated by botanist from National Herbarium of University of Abomey-Calavi and scientific names confirmed or updated using the PROTA database website (http://www.prota4u.org/).

### Data analysis

Distribution of informants in age group followed that of Assogbadjo et al. (2008) while distribution according to the socio-professional groups livestock farmers, agro-pastoralists and farmers was inspired from Vall et al. (2017).

Data were analysed using descriptive statistics which aimed at getting an overview of families, genera and species, plants organs used, and preparation mode of galactogenic plants.

The importance of each galactogenic plant species was appreciated using the relative frequency of citation (RFC) and fidelity index (FI).

$$\mathrm{RFC} = \frac{\mathrm{n}}{\mathrm{N}}$$

where n is the number of informants who mentioned the plant as a galactogenic species, N is the total number of informants (Lawin et al. 2019). Thus, the species with the highest RFC are the most important. The fidelity index (FI) helps to assess the intensity of the relationship that informants establish between a plant and the role(s) for which the plant is mentioned. This index is used in this study to assess the level of use of galactogenic plant species. It is calculated with the following formula used by Shalukoma et al. (2015) and Olou et al. (2018).

$$\mathrm{FI} = \frac{\mathrm{Nu}}{\mathrm{Nc}}$$

where Nu is the number of informants who used the given species as galactogen; Nc is the total number of informants citing the same species.

Relative frequency of citations (RFC) and fidelity index (FI) were used to identify the most important galactogenic plants (most cited and used) in each agrecological zone. These index have been used in several ethnobotanical studies to assess the relative importance of plant resources for local communities (Olou et al. 2018; Lawin et al. 2019) and to assess the pastoral priority of ligneous fodder species (Sèwadé et al. 2016). High values of the relative frequency of citations for a specific species/use generally reflect a consensus for that species/use within the community.

A principal component analysis (PCA) was performed to depict the relationships between the galactogenic plants and the sociolinguistic groups. The eigenvalue criterion was used to select the number of components (Wold et al. 1987). Eigenvalues accounting for more than 50% of the total variance as stated and used by Peres-Neto et al. (2005) were used to select the number of components. Only species with a RFC $\geq$ 5% were considered to better refine the results (Fandohan et al. 2017). A correspondence analysis (CA) was performed to assess the practices adopted by the various sociolinguistic groups for the in situ conservation of galactogenic plant species.

Factors influencing the level of knowledge regarding the use of species for galactogenic purpose have been identified using the generalized linear model model (GLM) with Poisson error distribution based on the response variable (number of species mentioned) which is a count data (Candy 1997; St-Pierre et al. 2018). Thus, sociolinguistic group, age, level of education, occupation and agroecological zone were all included as explanatory variables. The effect of each factor was tested using simple models with one factor. To test the simultaneously effect of all the

**Table 1** Number and characteristics of informants

| Characteristics | | Sociolinguistics groups | | | |
|---|---|---|---|---|---|
| | | Fulani ($N^a$ = 232) | Gando (N = 52) | Others sociolinguistics groups[b] (N = 26) | Total (N = 310) |
| Age (years) | Young (age ≤ 30) | 23 | 8 | 6 | 37 |
| | Adults (30 < age < 60) | 124 | 36 | 14 | 174 |
| | Aged (age ≥ 60) | 85 | 8 | 6 | 99 |
| Occupation | Agro Pastoral Farmers (10 < head of beef ≤ 30) | 30 | 26 | 5 | 61 |
| | Livestock farmers (head of beef > 30) | 178 | 16 | 12 | 206 |
| | Other occupations[c] | 24 | 10 | 9 | 43 |
| Instruction level | Not educated | 212 | 46 | 16 | 274 |
| | Educated | 20 | 6 | 10 | 36 |
| Agroecological Zone (AZ) | AZ-II | 39 | 13 | 20 | 72 |
| | AZ-III | 102 | 39 | 1 | 142 |
| | AZ-IV & V | 91 | 0 | 5 | 96 |

[a]N: Number of informants

[b]Bariba, Dendi and Nago

[c]Healer, Pastoralists and Veterinary agents

factors and appreciate the relationship among factors, a multiple model incorporating the main effects and the possible second order interactions was constructed. The least important terms of the model were then removed with the stepwise method using at each stage of the procedure, a selection based on the Akaike Information Criterion (AIC) (Rashid et al. 2018). The statistical tests were performed using R 3.5.1 software (R Core Team 2018) at 5% threshold.

In situ conservation practices were identified by establishing a preliminary list from survey data.

Leaf emergence, leaf fall and flowering periods of the various species were identified by establishing a preliminary list from survey data.

## Results

### Characteriscs of informants

Results indicated that informants belong to five sociolonguistic groups: Fulani, Gando, Bariba, Dendi and Nago. The sociolinguistic groups Bariba, Dendi and Nago as well as the agroecological zones IV and V were respectively merged due to their low representativeness in the sample which could biais the estimates. Fulani was the most represented (232 informants) followed by Gando (52 informants). Most of the informants were livestock farmers with no formal education and aged between 30 and 60 (Table 1). The informants were mostly from the agroecological zone III.

### Diversity of galactogenic plants

A total of 69 galactogenic plants species belonging to 57 genera and 25 families were collected (Table 2). Fabaceae were the most dominant family with 13 species followed by Poaceae (eight species), Euphorbiaceae (seven species), Caesalpiniaceae (five species), Combretaceae (five species), and Apocynaceae (five species) (Fig. 2). *Euphorbia* and *Ficus* had four and three species respectively, and were the most represented genera (Fig. 2, Table 2).

Plant parts mostly used were leaves, stems, fruits, roots, bark, panicles and tubers. Fodder consumption, decoction and maceration were the most frequent modes of preparation (Table 2).

Galactogenic species mainly used were *A. africana* (RFC = 0.32), *Pterocarpus erinaceus* Poir. (RFC = 0.17), *E. balsamifera* (RFC = 0.17), *V. unguiculata* (RFC = 0.17), *A. hypogaea* (RFC = 0.14), *B.*

**Table 2** Families, scientific and local names, parts used and mode of preparation of galactogenic plants

| Family | Scientific name | Local name | Part used | Mode of preparation | RFC |
|---|---|---|---|---|---|
| Anacardiaceae | *Anacardium occidentale* L. | Caju (n[a]) | Leaf, Bark | Decoction | |
| Apocynaceae | *Saba comorensis* (Bojer) Pichon | Bernahi (p[b]) | Root, Bark | Maceration, Decoction | 0.05 |
| | *Calotropis procera* (Aiton) W.T.Aiton, 1811 | Bambambi (p) | Leaf | Decoction of Crushed leaf | 0.01 |
| | *Thevetia peruviana* (Pers.) K.Schum | Wagnan (d[c]) | Stem, Leaf | Infusion | |
| | *Raphionacme brownii* Scott-Elliot | Dahiyohi (p) | Tuber + (panicle of sorghum + Bark of *Acacia macrostachya*); Tuber + red salt | Decoction Maceration | 0.01 |
| | *Leptadenia hastata* (Pers.) Decne. | Sokpotoro (p) | Leaf | Fodder | |
| Bignoniaceae | *Kigelia africana* (Lam.) Benth | Djiledjalè (p) | Fruit, Leaf | Maceration, Decoction | 0.03 |
| Bombacaceae | *Bombax costatum* Pellegr. & Vuillet | Kuruhi (p), Leaf + potasse | Fruit | Decoction | 0.01 |
| Caesalpiniaceae | *Bobgunnia madagascariensis* (Desv.) J.H.Kirkbr. & Wiersema | Cocobi, Gô sanhi (p) | Bark | Pound and macerate | 0.08 |
| | *Piliostigma thonningii* (Schumach.) Milne-Redh | Barkehi (p) Eguikpanoumon (n) | Fruit, Leaf | Direct use | 0.01 |
| | *Burkea africana* Hook. | Yéridjanbi (p), Atakpaèyo (n), Kohi (p) | Bark | Decoction | |
| | *Afzelia africana* Sm. ex Pers. | Warayangne (p), Gbébou (b); Akpaka (n) | Leaf | Fodder | 0.32 |
| | *Daniellia oliveri* (Rolfe) Hutch. & Dalziel | Karlaye (p), Iya (n) | Leaf | Fodder | 0.07 |
| Caricaceae | *Carica papaya* L. | Calabossi (p) | Leaf | Pound + water: drink | 0.01 |
| Combretaceae | *Combretum ghasalense* Engl. & Diels | Bourohi (p) | Dry leaf + hedgehog skin + shea butter | Powder to pass on the breasts | 0.02 |
| | *Terminalia schimperiana* Hochst. | Bouri, Bori ou Bouhiri (p) | Leaf | Fodder | 0.01 |
| | *Anogeissus leiocarpa* (DC.) Guill. & Perr. | Kojiol (p) | Leaf | Fodder | 0.01 |
| | *Combretum adenogonium* Steud. ex A.Rich. | Buyki Soto (p) | Young branch | Maceration | 0.01 |
| | *Combretum molle* R.Br. ex G.Don | Tchintchingoui (p) | Fruit | Direct use | |
| Convolvulaceae | *Ipomoea batatas* (L.) Lam. | Patate douce (f[d]) | Tuber | Make leather and pound + hedgehog skin: pass on the nipples | |

**Table 2** continued

| Family | Scientific name | Local name | Part used | Mode of preparation | RFC |
|---|---|---|---|---|---|
| Cucurbitaceae | *Cucurbita maxima* Duchesne | Pampalo (p) | Fruit, fruit + Panicle (Sorghum) | Cut and eat (Fruit), Decoction | 0.07 |
| | *Lagenaria siceraria* (Molina) Standl. | Bessanahi (p) | Leaf | Fodder | |
| | *Cucurbita pepo* L. | Boro (p) | Fruit | Cut and eat, Decoction | 0.01 |
| Cyperaceae | *Cyperus esculentus* L. | Ayadjê (p) | Seed + Seed (peanut) | Decoction | 0.01 |
| Dioscoreaceae | *Dioscorea spp.* | Sakatarè (p) | Tuber (peel) | Direct use | 0.01 |
| Euphorbiaceae | *Euphorbia hirta* L. | Elendè (p) | Whole plant | Pound and macerate | |
| | *Euphorbia balsamifera* Aiton | Tcholouwi (p) Bèdè (b[e]) | Stem, Leaf | Decoction | 0.17 |
| | *Jatropha gossypiifolia* L. | Okpokpo kpoukpa (n) | Leaf | Decoction | |
| | *Euphorbia convolvuloides* Hochst. ex Benth. | Hindabougali (p) | Whole plant | Decoction | 0.01 |
| | *Euphorbia heterophylla* L. | Ehindé (p) | Leaf | Fodder | 0.01 |
| | *Manihot esculenta* Crantz | Kpakihi (p) | Peeled tuber + Seed (peanut) | Decoction | 0.02 |
| | *Hymenocardia acida* Tul. | Alafitahi (p) | Leaf | Fodder | 0.02 |
| Fabaceae | *Prosopis africana* (Guill. & Perr.) Taub. | Guinsoba (p) Wondoyi (p) ou Tchinguéléhi (p) | Fruit, Leaf | Fodder | 0.03 |
| | *Acacia sieberiana* DC. | Aluki (p) | Leaf | Fodder | 0.04 |
| | *Acacia macrostachya* Rchb. ex DC. | Patouki/shidi (p) | Bark + (Tuber of *Raphionacme brownii* + Panicle of Sorghum) | Decoction | 0.02 |
| | *Acacia seyal* Delile | Guihei (p) | Leaf; Bark | Fodder (Leaf); Decoction (Bark) | 0.04 |
| | *Pseudarthria hookeri* Wight & Arn. | Tchètè (p) | Tuber peelings | Direct use | 0.01 |
| | *Philenoptera laxiflora* (Guill. & Perr.) Roberty | Babroussahi (p) | Leaf | Fodder | 0.03 |
| | *Vigna subterranea* (L.) Verdc. | | Seed | Grill + water: make the animal drink | 0.01 |
| | *Arachis hypogaea* L. | Biriiji (p) | Seed, Dry leaf after grains harvesting | Direct use | 0.14 |
| | *Xeroderris stuhlmannii* (Taub.) Mendonça & E.C.Sousa | Dadanehi (p) | Leaf | Fodder | 0.04 |
| | *Glycine max* (L.) Merr. | Soja | Bran + salt | Direct use | |
| | *Vigna unguiculata* (L.) Walp. | Yèbè (p) | Dry leaf after grains harvesting, Seed | Eat raw (Fane), Pound and macerate in the fermented water of akassa (Seed) | 0.17 |
| | *Tamarindus indica* L. | Djabi (p) | Root | Pound and macerate | |
| | *Pterocarpus erinaceus* Poir. | Banouhi (p), Tona (b), Ara akpékpé (n) | Leaf | Fodder | 0.17 |
| Malvaceae | *Gossypium hirsutum* L. | Hotolo (p), Wensu (b) | Leaf; Seed | Fodder (Leaf), Direct use (Seed) | 0.04 |

**Table 2** continued

| Family | Scientific name | Local name | Part used | Mode of preparation | RFC |
|---|---|---|---|---|---|
| Meliaceae | *Khaya senegalensis* (Desr.) A.Juss. | Kahi (p), Gbirou (b) | Leaf | Fodder | 0.08 |
| Moraceae | *Ficus glumosa* Delile | Kéikéi, Limatabaché (p) | Leaf; Bark; fruit | Fodder (Leaf), Decoction (Bark and fuit) | |
| | *Trichilia emetica* Vahl | Pirsahi (p) | Bark + Seed (*Vigna unguiculata*) | Pound and filter to make animal drinks | |
| | *Ficus sur* Forssk. | Gayayaru (b) | Leaf | Fodder | 0.02 |
| | *Ficus vallis-choudae* Delile | Ibi (p) | Leaf | Fodder | |
| Myrtaceae | *Eucalyptus camaldulensis* Dehnh. | Lekon/lekko (p) | Leaf | Fodder | 0.01 |
| Olacaceae | *Ximenia americana* L. | Tchapoulé/Capoli (p) | Stem + panicle (Sorghum) | Decoction | |
| Poaceae | *Sorghum bicolor* (L.) Moench | Dobi (p) | Panicle + fruit (*Cucurbita maxima*) | Decoction | 0.03 |
| | *Bambusa vulgaris* Schrad. ex J.C.Wendl. | Kéwé (p), Bangou (b) | Leaf | Fodder | 0.02 |
| | *Zea mays* L. | Maïs (f) | Bran | Direct use | 0.02 |
| | *Pennisetum glaucum* (L.) R.Br. | Mil (f) | Seed + sugar | Pound (Lapping powder) | 0.01 |
| | *Andropogon gayanus* Kunth | Sènonrè (p) | Leaf | Fodder | 0.03 |
| | *Andropogon tectorum* Schumach. & Thonn. | Falofalo (p) ou Selselnin (p) | Leaf | Fodder | 0.03 |
| | *Paspalum polystachyum* R.Br. | Gaéri (p) | Leaf | Fodder | |
| | *Rottboellia cochinchinensis* (Lour.) Clayton | Garssamari (p) | Leaf | Fodder | 0.01 |
| Rhamnaceae | *Ziziphus mauritiana* Lam. | Gouloudjabi (p) | Root | Infusion | 0.01 |
| Rubiaceae | *Gardenia erubescens* Stapf & Hutch. | Bossojè, Dihanli, Dingalel-gorel (p) | Leaf, Bark, Root | Fodder (Leaf) | 0.01 |
| | *Sarcocephalus latifolius* (Sm.) E.A.Bruce | Dekadé (b) | Leaf | Decoction | 0.02 |
| | *Mitragyna inermis* (Willd.) Kuntze | Kouri/Kuli (p) | Leaf | Fodder | 0.01 |
| Rutaceae | *Citrus limon* (L.) Burm.f. | Citronnier | Leaf | Decoction | 0.01 |
| Sapotaceae | *Vitellaria paradoxa* C.F.Gaertn. | Karehi (p) | Young Leaf; Bark | Pound and Macerate | 0.02 |
| Verbenaceae | *Vitex doniana* Sweet | Goumé (p), Kounongou (b) | Fruit | Direct use | 0.01 |
| Zygophylaceae | *Balanites aegyptiaca* (L.) Delile | Tani (p), Kpanrou (b) | Leaf; Bark + fermented maize grains water | Fodder (Leaf); Maceration or Decoction | 0.03 |

[a]n: Nago

[b]p: Fulani

[c]d: Dendi

[d]f: Français

[e]b: Bariba

*madagascariens* (RFC = 0.08), *Khaya senegalensis* (Desr.) A.Juss. (RFC = 0.08), *Daniellia oliveri* (Rolfe) Hutch. & Dalziel and *Cucurbita maxima* Duchesne (RFC = 0.07), and *Saba comorensis* (Bojer) Pichon (RFC = 0.05) (Table 2).

Galactogenic importance of inventoried plants per agroecological zone

In AZ II (Fig. 3a), *E. balsamifiera* (RFC = 0.49), *A. africana* (RFC = 0.29) and *P. erineceus* (RFC = 0.22) had the highest values of relative frequencies of citiation among the ten most cited species of galactogenic plants. In terms of fidelity index, *A. africana* (FI = 0.60), *E. balsamifera* (FI = 0.59) and *B. madagascariensis* (FI = 0.50) were the species with the highest fidelity indices (Fig. 3a). They appear to be the most used to stimulate milk production.

In AZ III (Fig. 3b), *A. Africana* (RFC = 0.66), *V. unguiculata* (RFC = 0.30) and *A. hypogaea* (RFC = 0.27) presented the highest values of relative frequencies of citiation among the ten species mentioned mainly by the informants. But like in AZ II, *A. Africana* (FI = 0.58), *E. balsamifera* (FI = 0.53) and *B. madagascariensis* (FI = 0.49) are species with the highest fidelity indices (Fig. 3b).

In AZ IV&V (Fig. 3c), *P. erinaceus* (RFC = 0.22), *A. africana* (RFC = 0.20), *A. hypogaea* (RFC = 0.17) and *V. unguiculata* (RFC = 0.14) showed the highest relative frequencies of citation among the ten species mostly mentioned by informants as galactogenic plants. In terms of fidelity index, *V. unguiculata* (FI = 0.36); *A. hypogaea* (FI = 0.29), *A. africana* (FI = 0.28) and *E. balsamifera* (FI = 0.25) were species with the highest indices (Fig. 3c).

On the other hand, some important (highly cited and used) galactogenic plant species in one agroecological zone were absent from the list of the ten most cited species in another agro-ecological zone (Fig. 3). However, species such as *B. madagascariensis, V. unguiculata, A. africana, K. senegalensis* and *E. balsamifera* were also cited and used in all agroecological zones of the study (Fig. 3).

Cultural importance of galactogenic plants

Galactogenic plants were used by all sociolinguistic groups in traditional medicine, as food, wood, wood energy, construction and veterinary care, but at different degrees (Fig. 4). Sociolinguistic groups such as Fulani and other sociolinguistic groups (i.e. Bariba, Nago and Dendi) used more galactogenic plants for veterinary care as compared to Gando. In addition, all informants of the other sociolinguistic groups used these plants mainly for construction and as energy wood than Fulani and Gando.

Social factors influencing the level of knowledge of the use of galactogenic plants

The level of knowledge of the use of galactogenic plants is sociolinguistic group dependent (Table 3). Thus, the Gando had a greater knowledge of the galactogenic use of plants ($P = 0.024$; Table 3) than those of other sociolinguistic groups. In contrast, Fulani, Bariba, Nago and Dendi sociolinguistic groups had more or less the same level of knowledge about the use of galactogenic plants ($P = 0.652$; Table 3). The agroecological zone and the occupation of the informants did not have a significant effect on individual knowledge related to the use of galactogenic plants in improving milk production in cows in Benin ($p > 0.05$; Table 3).

Use of the most important galactogenic plants by various sociolinguistic groups

The Principal Component Analysis (PCA) performed on the most important galactogenic plant species data (RFC $\geq$ 5%) showed that the first two PCAs account for 65.70% of the total variance (Table 4). *A. africana, V. unguiculata, B. madagascariensi, K. senegalensis, D. oliveri* and *S. comorensis* were strongly correlated ($|\text{correlation}| > 0.5$) with the first PCA; *E. balsamifera, A. hypogaea* and *C. maxima* were strongly correlated with the second PCA (Table 4). On the other hand, *P. erinaceus* is strongly correlated ($|\text{correlation}| = 0.92$) with the third PCA.

Correspondences of the projection of various sociolinguistic groups and galactogenic plant species on the PCA systems (Fig. 5) showed that, *E. balsamifera* and *C. maxima* were the most used galactogenic plants by young Gando and adults from other sociolinguistic groups. *A. africana, V. unguiculata, B. madagascariensis, D. oliveri, K. senegalensis* and *S. comorensis* were the most used by Gando (adults as well as the aged) to stimuate milk production in cows. *A. hypogaea* was also most used by Gando adults as

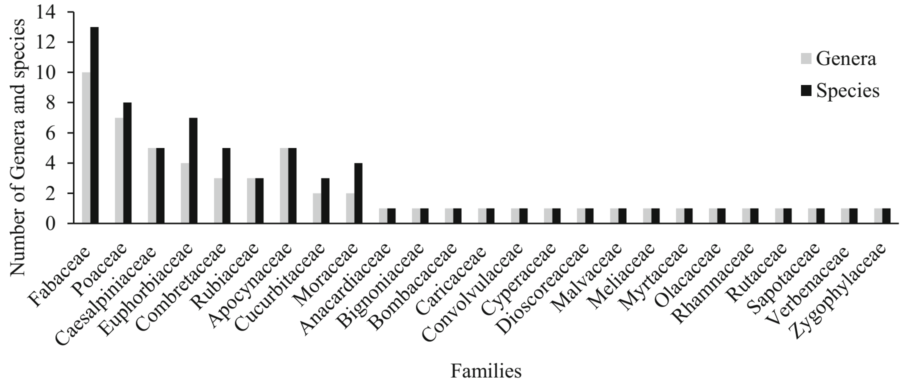


**Fig. 2** Number of genera and species within each family of galactogenic plant

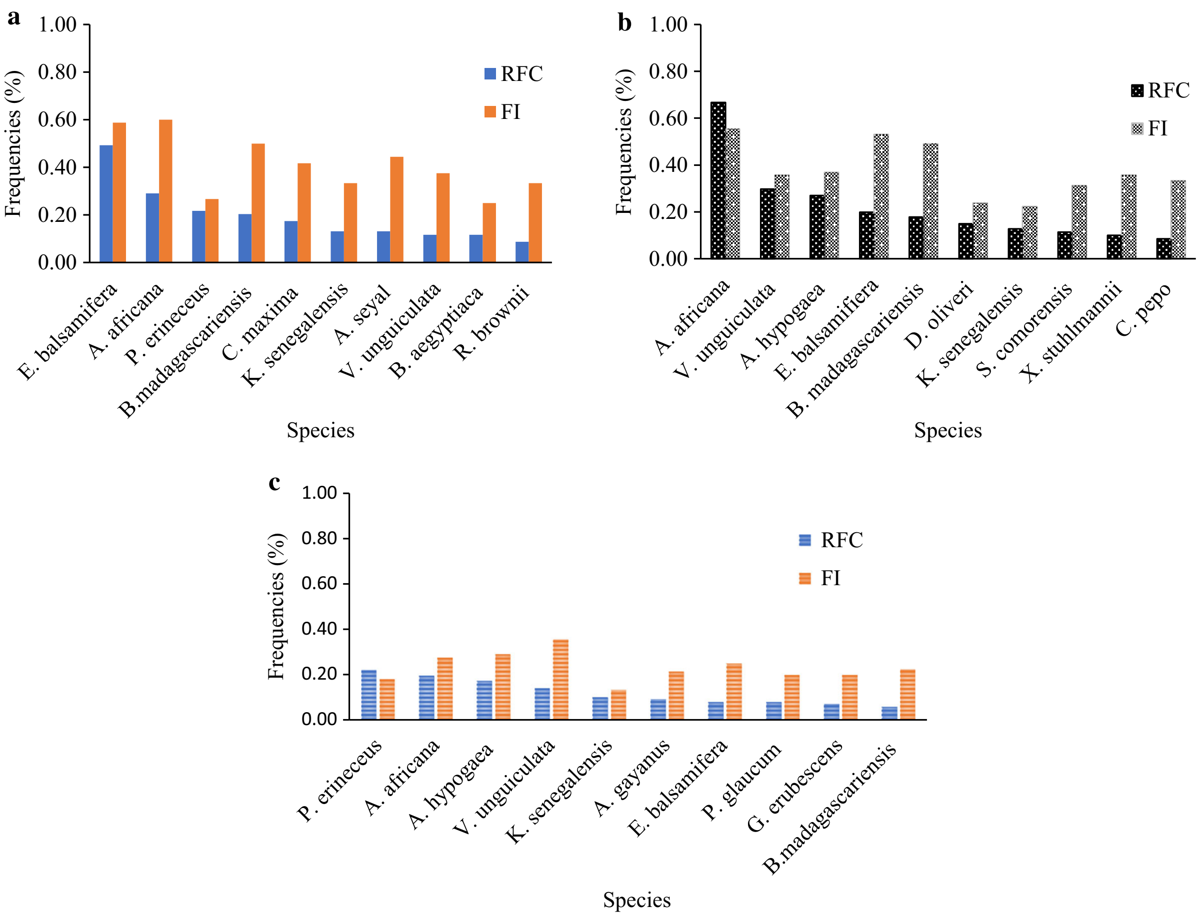


**Fig. 3** Most important galactogenic plants by agroecological zones, **a** = AZ II, **b** = AZ III and **c** = AZ IV&V, based on relative frequency of citations (RFC) and fidelity index (FI)

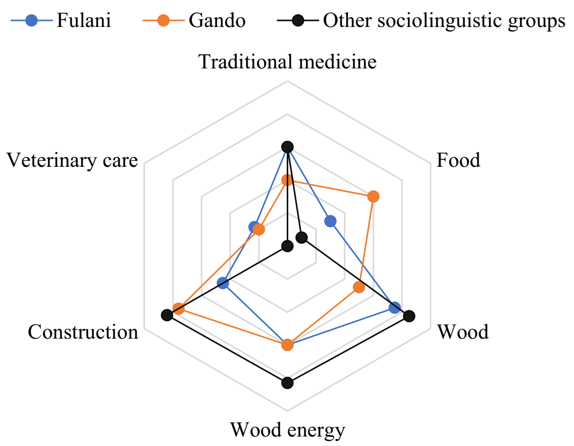


**Fig. 4** Cultural importance of galactogenic plants according to sociolinguistic groups

galactogenic plant. However, *P. erinaceus* was most used by young, adults and aged Fulani as a galactogenic plant.

## Local practices for the in situ conservation of galactogenic plants

The Correspondence Analysis (CA) performed on data on sociolinguistic groups and galactogenic plant conservation practices showed that 95.95% of the correlation between these two variables is explained by the first two axes (Fig. 6a). This means that in situ conservation practices for galactogenic plants is sociolinguistic group dependent.

The correspondences resulting from the projection of the various conservation practices of galactogenic plants and sociolinguistic groups in the CA axis systems, showed that the aged and adult members of other sociolinguistic groups (i.e. Bariba, Dendi and Nago) would accommodate certain galactogenic plant species in their surroundings. The Fulani and Gando, regardless of their age, kept plants and trees in the fields and around the houses as strategies of conservation of galactogenic plants. In contrast, young people from other sociolinguistic groups did not adopt any practice of conservation of those plants (Fig. 6a).

Species such as *A. africana, K. senegalensis, P. erinaceus, V paradoxa, B. aegyptiaca* and *V. doniana* were the main plant species that benefited mainly from the protection of young plants, as well as the preservation of trees present in fields and around houses (Fig. 6b). On the other hand, species of the genus Ficus and *B. madagascariensis* benefited much more from preservation. Species such as *C. maxima, C. pepo, E. balsamifera, A. hypogea, V. unguiculata, M. esculenta, S. bicolor, Dioscorea spp.* were much more planted. These species, apart from *E. balsamifera*, are all annual crops and were grown for human consumption (Fig. 6b).

**Table 3** Estimates of the effect of socio-demographic factors (sociolinguistic group, occupations, agroecological zone) on the level of knowledge of the galactogenic use of plants

| Variation sources | Estimate | STD error | Z value | Pr (> \|z\|) |
|---|---|---|---|---|
| Intercept | 1.008 | 0.168 | 6.005 | 0.000*** |
| Gando | 0.352 | 0.155 | 2.265 | 0.024* |
| Fulani | − 0.065 | 0.144 | − 0.451 | $0.652^{ns}$ |
| Other occupations | − 0.144 | 0.132 | − 1.095 | $0.274^{ns}$ |
| Livestock farmers | − 0.079 | 0.090 | − 0.884 | $0.377^{ns}$ |
| AZ II[a] | 0.062 | 0.105 | 0.591 | $0.555^{ns}$ |
| AZ III[b] | 0.121 | 0.087 | 1.379 | $0.168^{ns}$ |

[a]AZ II: Agroecological zone II

[b]AZ III: Agroecological zone III

***Statistically significant at $p < 0.001$; **: statistically significant at $0.001 \leq p < 0.01$; *Statistically significant at $0.01 \leq p \leq 0.05$; ns: statistically significant at $p > 0.05$

Estimated dispersion parameter equals 1; deviation = 204.57 out of 307 degrees of freedom; model deviation or residual deviation = 166.83 out of 301 degrees of freedom; AIC = 1051

**Table 4** Correlations between the first and two axes and galactogenic plants

| Galactogenic plants | PCA 1 | PCA 2 |
|---|---|---|
| *Afzelia africana* | 0.88 | 0.16 |
| *Pterocarpus erinaceus* | − 0.28 | 0.11 |
| *Euphorbia balsamifera* | 0.52 | − 0.59 |
| *Vigna unguiculata* | 0.93 | − 0.15 |
| *Arachis hypogea* | 0.54 | 0.76 |
| *Boggumia madagascarensis* | 0.74 | − 0.12 |
| *Khaya senegalensis* | 0.74 | − 0.22 |
| *Daniella oliveri* | 0.71 | 0.65 |
| *Cucurbita maxima* | 0.60 | − 0.68 |
| *Saba comorensis* | 0.58 | 0.22 |
| *PCA eigenvalues and proportions* | | |
| Variance | 4.58 | 1.99 |
| % of var | 45.80 | 19.90 |

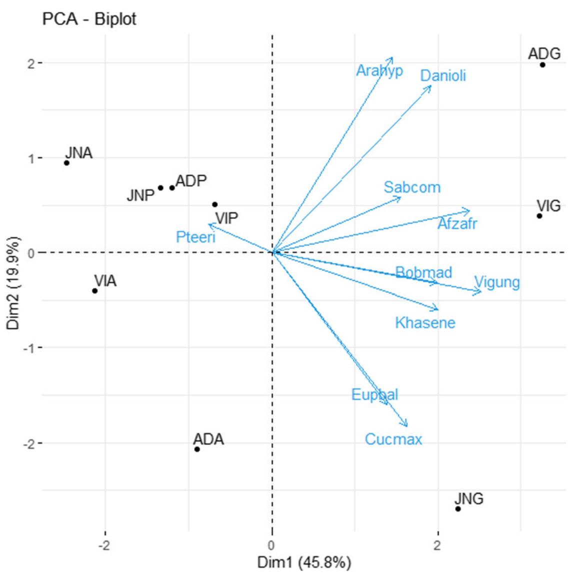


**Fig. 5** Projection of various sociolinguistic groups and species in the system of PCA 1 and 2. JNP: Youngs Fulani, ADP: Adults Fulani, VIP: Aged Fulani, JNG: Youngs Gando, ADG: Adults Gando, VIG: Aged Gando, JNA: Youngs other sociolinguistic groups, ADA: Adults other sociolinguistic groups and VIA: Aged inforamnts in other sociolinguistic groups, *Vigung*: *V.unguiculata, Arahyp*: *A. hypogaea, Eupbal*: *E. balsamifiera, Bobmad*: *B.madagascariensis, Afzafri*: *A. africana, Danoli*: *D. oliveri, Khasene*: *K. senegalensis, Sabcom*: *S. comorensis, Pteeri*: *P. erinaceus* and *C. maxima*

### Local perceptions on the phenological stages of galactogenic plant species

According to the informants, galactogenic plant species varied according to their phenological phases (leaf emergence, leaf fall, flowering period (reproductive phase), vegetative phase duration, and generative phase duration (flowering to fruit maturity) (Table 5). However, their knowledge on the phenological phases of the galactogenic plant species was limited. In fact, informants were able to provide information on less than half of the species recorded during this study (Table 5). Some informants were able to provide information on the phenology of galactogenic species. For example, some informants were able to provide information on the flowering time, leafing and leaf fall periods of species such as *A. africana*, *E. balsamifera, K. senegalensis* and *P. erinaceus*. However, no informant was able to comment on the phenological stages of *B. madagascariensis*, one of the most cited and used species.

The average time for the perennial galactogenic plants to initiate the flowering ranged from 2.5 ± 0.5 years (*A. occidentale*) to 32.5 ± 0.5 years (*P. erinaceus*) and the average duration of the generative phase (flowering-fruit maturity) ranged from 1.8 ± 0.4 months (*A. occidentale*) to 9.7 ± 1.6 months (*A. africana*) (Table 5). In annual species, the mean productive age ranged from 2.4 ± 0.0 months (*Z. mays*) to 6.0 ± 0.0 months (*Dioscorea spp.*) while the average duration of the generative phase ranged from 1.3 ± 0.3 months (*V. unguiculata*) to 3.0 ± 0.8 months *G. hirsutum* (Table 5).

## Discussion

### Diversity and importance of galactogenic plants

Tropical areas are sources and potential reservoir of valuable plant resources. The objective of our study was to inventory the diversity and the traditional practices of in situ conservation of galactogenic plants in the agro-ecological zones of Benin. In total, 69 galactogenic plant species were identified in the surveyed areas, representing approximately 2.4% of Benin's flora estimated at 2807 species (Akoègninou et al. 2006). This number is far above that reported by

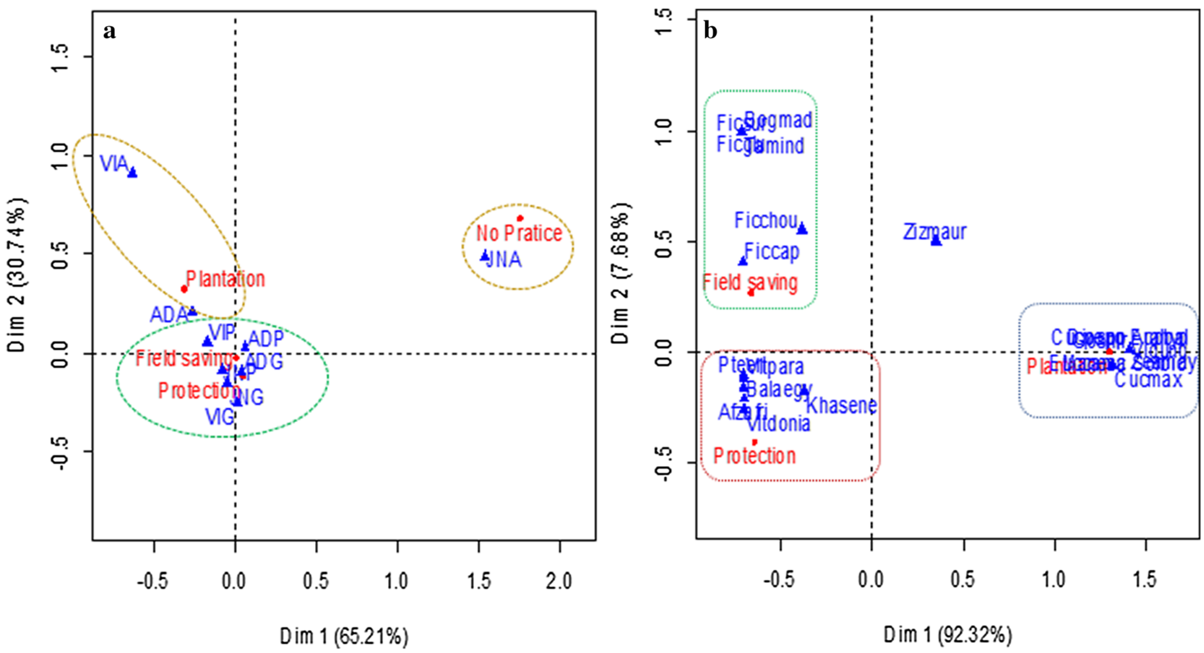


**Fig. 6** Projection of the various sociolinguistic groups (**a**) and local in situ conservation practices (**a**, **b**) in the axis 1 and 2 system. VIA: Aged informants in other sociolinguistic groups, ADA: Adults other sociolinguistic groups, JNA: Youngs other sociolinguistic groups, JNP: Youngs Fulani, ADP: Adults Fulani, VIP: Aged Fulani, JNG: Youngs Gando, ADG: Adults Gando, VIG: Aged Gando. Afzafri: *A. africana*, Arahyp: *A. hypogaea*, Balaegy: *B. aegypiaca,* Bogmad: *B. madagascariensis*, Cucmax: *C. maxima*, Cucpepo: *C. pepo*, Diospp: *Dioscorea* spp, Euccama: *E. camaldulensis*, Eupbal: *E. balsamifera*, Ficcap: *F. capensis*, Ficglu: *F. glumosa*, Ficsur: *F. sur*, Ficchou: *F. vallis-choudae*, Goshir: *G. hirsutum*, Khasene: *K. senegalensis*, Manesc: *M. esculenta*, Pteeri: *P. erinaceus*, Sorbic: *S. bicolor*, Tamind: *T. indica*, Vitdonia: *V. doniana*, Vitpara: *V. paradoxa*, Vigung: *V. unguiculate*, Zeamay: *Z. mays*, Zizmaur: *Z. mauritiana*

Salifou et al. (2017) who inventoried 41 galactogenic plants species used by herders in four departments (Alibori, Borgou, Collines and Mono) in Benin. Such difference in the number of galoctogenic plants species can be explained by (i) the large sample size of 310 informants in the current study versus 142 informants in the study by Salifou et al. (2017), (ii) the diversity of the sociolinguistic groups considered in the current study and the (iii) municipality selection criteria with majority of informants dominated by livestock farmers and transhumant in the current study. The diversity in galactogenic plants was greater than that obtained by Déléké Koko et al. (2011) who worked on the galactogenic plants in the Pendjari hunting area in Benin (57 species) and Maya et al. (2018) in the Cascades Region of Burkina Faso (25 species). Several factors such as climatic, edaphic, topographical and anthropogenic variations can explain these variations (Moumouni et al. 2017; Agbanou et al. 2018).

Fabaceae is by far dominant in the list of galactogenic plants identified. Similar observations were made by Sèwadé et al. (2016) and Akouehou et al. (2017) in Benin. In Burkina Faso, Maya et al. (2018) and in Guinea-Bissau, Catarino et al. (2016) obtained similar results in their study in the Cascades region and in different regions of Guinea-Bissau respectively. Akodewou et al. (2014) and Wembou et al. (2014) also obtained similar results in the Lama depression and sub-humid zone respectively in Togo.

The result showed that *E. balsamifiera, A. africana* and *B. madagascariensis* in the agro-ecological zones II and III; *A. africana*, *A. hypogaea*, *V. unguiculata* and *E. balsamifiera* in the agro-ecological zone IV&V were the most cited and used as galactogenic plants. This variation in the species across agro-ecological zones could be linked to the availibility of species in the area (i.e. their geographical distribution) or level of knowledge of respective local populations. Species such as *A. africana, A. hypogaea, E. balsamifera, B. madagascariensis* and *V. unguiculata* have been

**Table 5** Phenological stages of some galactogenic plant species in Benin

| Species | Leaf emergence | | | | | | | | | | | | | Leaf fall | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | [a]$P_{\%}$ | J | F | M | A | M | J | J | A | S | O | N | D | $P_{\%}$ |
| *A. africana* | | + | + | + | | | | | | | | | 41 | + | + | | | | | | | | | ++ | + | 44 |
| *P. erinaceus* | | + | + | | | | | | | | | | 57 | | | | | | | | | | | + | + | 40 |
| *K. senegalensis* | + | + | + | | | | | | | | | | 75 | | | | | | | | | | + | + | + | 38 |
| *G. hirsutum* | | | | | | | | | | | | | – | | | | | | | | | | + | | | |
| *F. sur* | | | + | + | | | | | | | | | 50 | + | + | | | | | | | | | + | | 67 |
| *X. americana* | | | | | | | | | | | | | – | | | | | | | | + | | | | | 100 |
| *V. unguiculata* | | | | | | | | | | | | | – | | | | | | | | | | | | | |
| *P. glaucum* | | | | | | | | | | | | | – | | | | | | | | | | | | | |
| *B. aegyptiaca* | | + | + | + | | | | | | | | | 40 | + | | | | | | | | | | + | + | 60 |
| *C. limon* | | | | | | | | | | | | | – | | | | | | | | | | | | | |
| *A. sieberiana* | | | | | | | | | | | | | – | | | | | | | | | | | | | |
| *E. balsamifera* | | | | | + | + | | | | | | | 75 | + | + | | | | | | | | | | + | 100 |
| *C. pepo* | APL[c] | | | | | | | | | | | | 100 | | | | | | | | | | + | | | |
| *C. maxima* | | | | | | | | | | | | | – | AMF[d] (O, N) | | | | | | | | | | | | – |
| *I. batatas* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *B. costatum* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *B. africana* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *A. leiocarpa* | + | + | | | | | | | | | | | 100 | | | | | | | | | | | + | + | 100 |
| *P. laxiflora* | | | | + | | | | | | | | | – | + | | | | | | | | | | + | + | 67 |
| *V. paradoxa* | | | + | + | | | | | | | | | 33 | + | + | | | | | | | | | | | 67 |
| *V. doniana* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *A. tectorum* | RS[e] | | | | | | | | | | | | 100 | DS[f] | | | | | | | | | | | | 100 |
| *P. polystachyum* | RS | | | | | | | | | | | | 100 | DS | | | | | | | | | | | | 100 |
| *A. gayanus* | RS | | | | | | | | | | | | 100 | DS | | | | | | | | | | | | 100 |
| *F. glumosa* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *A. occidentale* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *Dioscorea spp.* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *S. bicolor* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |
| *Z. mays* | | | | | | | | | | | | | – | | | | | | | | | | | | | – |

| Species | Flowering | | | | | | | | | | | | | Duration generative phase (month) | Production age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | $P_{\%}$ | | |
| *A. africana* | | | + | + | | | | | | | | + | 65 | 9.7±1.6 | 17.2±1.1 years |
| *P. erinaceus* | | | | + | + | | | | | | | | 33 | 9.1±1.9 | 32.5±0.5 years |
| *K. senegalensis* | | + | + | + | | | | | | | | | 50 | 8.6±0.9 | 18.5±6.5 years |
| *G. hirsutum* | 1.42 ±0.14 MAS[b] | | | | | | | | | | | | – | 3.0±0.8 | 2.4±1.2 months |
| *F. sur* | | | | | | + | + | + | + | | | | 33 | 2.0±0.0 | 3.8±0.3 years |
| *X. americana* | | | | | | + | + | + | + | | | | 100 | 4.0±0.0 | 3.50±0.5 years |
| *V. unguiculata* | 1.87±0.85 MAS | | | | | | | | | | | | 20 | 1.3±0.3 | 3.6±0.0 months |
| *P. glaucum* | 3.5±0.71 MAS | | | | | | | | | | | | – | 2.0±0.0 | 4.8±0.0 months |
| *B. aegyptiaca* | | | + | + | | | | | | | | | – | 7.5±0.7 | – |
| *C. limon* | | | | | | | | | | | | | – | – | 3.5±0.5 years |
| *A. sieberiana* | | | | | | | | | | | | | – | – | 3.5±0.3 years |
| *E. balsamifera* | | | | | | | | | | | | | – | – | – |
| *C. pepo* | 3.13±1.18 MAS | | | | | | | | | | | | – | 2.0±0.0 | 3.6±0.0 months |
| *C. maxima* | 3.25±0.50 MAS | | | | | | | | | | | | – | 19±0.4 | 4.8±0.0 months |
| *I. batatas* | | | | | | | | | | | | | – | – | 4.8±0.0 months |
| *B. costatum* | + | | | | | | | | | + | + | + | 33 | – | – |

**Table 5** continued

| Species | Flowering | | | | | | | | | | | | | Duration generative phase (month) | Production age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | P% | | |
| *B. africana* | | | | | | | | | | | | | – | – | 22.5±2.5 years |
| *A. leiocarpa* | | | | | | | | | | | | | – | – | – |
| *P. laxiflora* | | | | | | | | | | | | | – | – | – |
| *V. paradoxa* | | | + | + | | | | | | | | | 67 | 2.8±0.8 | 21.7±1.7 years |
| *V. doniana* | | | | | | | | | | | | | – | – | 25.0±0.0 years |
| *A. tectorum* | RS | | | | | | | | | | | | 100 | – | – |
| *P. polystachyum* | RS | | | | | | | | | | | | 100 | – | – |
| *A. gayanus* | RS | | | | | | | | | | | | 100 | – | – |
| *F. glumosa* | | | | | | | | | | | | | – | | 4.8±0.3 years |
| *A. occidentale* | | | | | | | | | | | + | + | – | 1.8±0.4 | 2.5±0.5 years |
| *Dioscorea spp.* | | | | | | | | | | | | | – | – | 6.0±0.0 months |
| *S. bicolor* | | | | | | | | | | | | | – | – | 3.6±0.0 months |
| *Z. mays* | | | | | | | | | | | | | – | – | 2.4±0.0 months |

[a]P: percentage of informants, [b]MAS: month after sowing, [c]APL: after lifting, [d]AMF after fruit ripening, [e]RS: rainy season, [f]DS: dry season

regularly cited and used in almost all agro-ecological zones. This could be explained by their effectiveness in stimulating milk production in cows. This observation is aligned with the results of Salifou et al. (2017) who reported that *V. unguiculata, E. balsamifera, B. madagascariensis* and *A. hypogaea* were the most used species by livestock farmers as recipes to stimulate or increase milk production in cows. The ability of these species to stimulate milk production in cows could be due to some secondary metabolites such as alkaloids, flavonoids, polyphenols, polyterpenes, saponosides, quinonic derivatives, steroids, terpenes, cardiotonic heterosides and catechic tannins that can induce milk secretion. Oketch Rabah (1998), Goyal et al. (2003), Déléké Koko et al. (2011), Akouèdégni et al. (2012), have reported some compounds such as terpenes, steroids and cardiotonic derivatives which characterised the galactogenic plants. Phytochemical screening of the *E. balasamifera* showed that the leaves, stems and root were rich in steroids, tanins, flavonoids, saponins and alkaloids (Kamba and Hassan 2010). Manekeng et al. (2018) reported that leaves and stem of *A. hypogaea* contain alcaloids, saponins and steroids. Chingwaru et al. (2019b) also mentioned the presence of saponins, flavonoids and tannins in bark of *B. madagascariensis.* Results of the studies by Obayomi et al. (2019) and Olorunmaiye et al. (2019) showed that the seeds of *A. africana* are rich in alkaloids, tannins, saponins, flavonoids, and terpenoids. The galactogenic potential of these plants could therefore be supported by the presence of these compounds.

This study also showed that the fact that informants belonged to sociolinguistic groups was determinant in the level of knowledge of galactogenic plants. Similar results have been reported in ethnobotanical studies in Benin (Ahoyo et al. 2018; Savi et al., 2018) and in Niger (Garba et al. 2019) where the sociolinguistic group factor was a determinant in ethnobotanical and ethnoveterinary knowledge of plant resources. In this current study, Gando sociolinguistic group had a greater knowledge of galactogenic plants than the Fulani, Bariba, Dendi and Nago sociolinguistic groups. This contradicts the study by Ahoyo et al. (2018) who argued that the Fulani had a deeper knowledge of plant resources.

### Local practices for in situ conservation of galactogenic plants

This study revealed that only 24 out of the 69 galactogenic plants recorded have been subject to conservation practices including planting, keeping of young plants and trees in the fields, and around houses in the study area. Similar results were obtained in the work by Lawin et al. (2016) on the vulnerability and indigenous strategies of conserving plants for the treatment of diabetes in Central Benin. These authors had indicated that the indigenous conservation strategies of the population are field conservation and conservation in home gardens. Such galactogenic species provide goods and services such as food (*C. maxima, C. pepo, A. hypogea, V. unguiculata, M. esculenta, Z. mays, S. bicolor* and *D. spp., T. indica*), veterinary care, timber, fuelwood, construction and pharmacopoeia (*V. paradoxa, species of the genus Ficus, A. africana, K. senegalensis, P. erinaceus, V. paradoxa, V. doniana E. convolvuloide, Z. mauritiana, B. aegyptiaca* and *E. balsamifera*).

It appears that among the ten top galactogenic species, *A. africana, P. erinaceus, B. madagascariensis* and *K. senegalensis* were under heavy pressure due to logging and extensive agriculture currently on going in the geographical of this study. These observations were consistent with that of Déléké Koko et al. (2014) who concluded that a reduction in anthropogenic pressures would make it possible to better conserve certain species e.g. *K. senegalensis* in their natural habitats. In fact, as mentioned by some authors such as Fandohan et al. (2017), Akobi et al. (2018) and Biaou et al. (2019), human activities represent potential threats to the survival of plant species. It is thus necessary to develop appropriate measures to prevent their extinction. Concerted strategy would be welcomed, as in the case of the Reunion Island, where many recommendations came out through multistakeholders platforms. The adopted stakeholder platform adopted strategies that conserve plants species such as in situ plantations in the natural or semi-natural environment after restoration, creation of ex situ collections of threatened species, planting of indigenous species in public gardens, schools and private homes (Baret et al. 2012). The above strategies support the works of Hazarika et al. (2015) who proposed the implementation of in situ conservation strategies such as on farm conservation and creation of natural reserves for sustainable use, protection and rehabilitation of these threatened species.

### Phenology of galactogenic plants

Our results indicated that only 89 informants (28.71%) had knowledge of the phenological stages of the identified galatogenic plant species. Informants were aware of the phenological stages of only 29 species out of the 69 galactogenic plant species identified. These information are similar to those of Diallo et al. (2016) in Senegal, who reported variation between phenological stages of five woody species.

According to informants, *A. africana* flowers in the months of March to April. Such a result is in agreement with the findings of Ahouangonou and Bris (1995) and Donkpegan et al. (2014) who indicated that in Benin, *A. africana* normally flowers from March to April. However, the level of knowledge of plant phenological phases by informants remains low, probably because the surveyed community may not have been interested in the multiplication or domestication of these perennial species. The same observation was made on *Newbouldia laevis* (P. Beauv.) Seem.in southern Benin by Adomou et al. (2018) who reported that most community members have limited knowledge on the reproductive phase of this species.

### Strength and limitations of the data collection method

The survey method used for the data collection for this study was based on individual interviews and focus groups, using questionnaires and interview guides. It provided information on the biodiversity of galactogenic plant species in the study area, the most important species, in situ conservation methods, and the level of knowledge of the phenological stages of some species. Since this method relies on the informants' memory, it could lead to biases related to the informants' personal appreciation (Dossou et al. 2012; Wédjangnon et al. 2016). The importance of the use of the species is given by individuals who, in addition to their experience, take into account their personal appreciation, which often refers to their preference. Notwithstanding these few biases, this method has been used in several ethnobotanical and diversity studies by many authors in Benin (Lawin et al. 2019) with sound results that advance science and improve the definition of rational use strategies for these resources.

## Conclusion

This study assessed the diversity of galactogenic plant species and has contributed enormously to enrich knowledge on the biodiversity of galactogenic plants in Benin. It also highlights the fact that livestock farmers used plant resources to stimulate or increase milk production in cows, especially those belonging to Caesalpiniaceae, Euphorbiaceae, Fabaceae families. Within these families, *V. unguiculata, A. hypogaea, E. balsamifera and B. madagascariensis* came out to be the most effective. Due to the fact that the first two species have been already integrated to human food system, they can be easily cultivated as fodder to feed livestock. However, this raises the issue of competition with regard to food security for human beings and may lead to design better way to promote *E. balsamifera* and *B. madagascariensis* which were not under high human pressure. The great awareness of the extinction of some of the galactogenic species by local communities led to the adoption of in situ conservation, including the in field protection of young plants, the preservation of trees of some of the species, and planting. Such indigenous knowledge and practices will set the ground for further research in order to draw scientific knowledge out of the outcomes of this study. It also came out that Gando community was more knowledgeable in this study than Bariba, Dendi and even the Fulani meaning that further research could use Gando as an entry point for species valorization. However, the fact that very few informants had little knowledge with regard to the phenological stages of some species represent a huge gap to fill by establishing participatory training programme covering modules on recognition of development stages, as well as issues related to in situ conservation and practices.

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**Author's contributions** All authors contributed to the conception and design of this study. Lucien Imorou conducted the survey. Lucien Imorou, Euloge C. Togbé and Nicodeme V. Fassinou Hotegni analysed the data. All authors wrote the manuscript. Alexander T. K. Nuer, Hubert Adoukonou-Sagbadja and Léonard E. Ahoton contributed to critical revision of the manuscript. All authors read and approved the final manuscript.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethics approval** Not applicable.

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