Breeders’ knowledge on cattle fodder species preference in rangelands of Benin

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Abstract

Background

We undertook ethnobotanical and ecological studies on fodder plants grazed by cattle across Benin national area. The study aims to ascertain the top priority fodder plants in order to catalogue the indigenous knowledge regarding their use.

Methods

Data were collected through semi-structured interviews and covered 690 breeders and 40 days of pasture walk. These were analysed using similarity index of Jaccard (IS), relative frequency citation (RFC) and fodder value during pasture walk (FVPW).

Results

We documented a total of 257 fodder plant species, of which 116 recorded during ethnobotanical investigations and 195 during pasture walk. These species belong to 181 genera and 54 families. Both methods shared 52 species. Leaves (58%) and leafy stem (28%) were the most grazed parts of plant. The most common species used as fodder included Andropogon gayanus, Panicum maximum, Pterocarpus erinaceus and Flueggea virosa. The top species with a highest FVPW were Panicum maximum and Pterocarpus erinaceus. A total of 16 species were considered as top fodder plants in Benin.
Conclusions

The wide diversity of plants reported indicates that there is a number of promising fodder species in the flora of Benin. The insight gained in this study relating to bovine feeds could guide in the selection and introduction of feed innovations that could improve livestock production.

Keywords

- Cattle fodder species
- Indigenous knowledge
- Pasture walk
- Top priority
- Benin

Background

Worldwide, indigenous knowledge about the uses of plants as fodder or medicine played an important role in animal breeding development. Animal breeding is an ancient practice that represents an important subsistence source for low-income households worldwide [1]. In Benin, this activity plays an important role in the local economy and contributes to maintaining rural areas’ activity, their involvement in environment’s quality and poverty alleviation [2]. The considerable headway made in the field during recent decades, in particular the respect of schedules of vaccination campaigns becoming more and more rigorous, breeder awareness and their training on alimentation and the sanitary security of their cattle, and the increase of the credits allocated to them, have led to the steady growth of livestock production. From 1994 to 2013, livestock inventory in Benin increased by 39.18% for cattle and 35.40% for sheep and goats according to the FAOSTAT official database (http://www.fao.org/faostat/en/#home). Unfortunately, livestock sub-sector is still confronted by feeding problems [3], related to the availability and the quality of fodder resources. Indeed, natural pastures constitute the basis and, in most cases, the total food resources of ruminants. These pastures are in the majority dominated by annual plant species, characterised by a short development cycle that entirely unrolls in rain season. In this period, pasture contributes to ensure feed of cattle, but during the dry season, the longest season, it exists only the straws which are qualitatively poor and quantitatively deficient [4]. Although Benin is characterised by a vegetation type diversity [5], environmental pressures and strong influence of climatic seasonality limit the productive and nutritional potential of the fodder resources and hinder to maintain flocks, especially during drought periods. So, many breeders devote oneself to the ligneous that dispose leaves and fruits with high protein contents.

To face the unfavourable situation to the breeding development, it is important to capitalise traditional knowledge about fodders. Understanding traditional knowledge of people will result in four major outputs: the database creation of fodder plants consumed by cattle, identification of their properties and optimisation of their uses. To these, we can add the selection of fodders with top priority in stock farming based on their use value. According to Nunes et al. [6], a combination of traditional and scientific knowledges could allow to optimise the selection of useful fodder plants.
Ethnobotanical investigations about ruminants fodder plants have been developed in African countries such as Ethiopia, Nigeria, Ghana and Uganda [7, 8, 9, 10], and elsewhere in Asia, India and Mexico [6, 11, 12, 13]. In Benin, there is no overall documentation about the relative importance of these feeds to farmers, although some researchers reported on tree fodders or medicinal tree fodders browsed by ruminants on natural pasture in northern Benin [14, 15, 16]. This study aims to (i) document fodder plants of natural pastures and state farms in Benin, (ii) assess the local knowledge regarding their use and (iii) select the most important fodder plants. The results of this study will be used to provide a checklist of fodder resources for further anatomical investigation and a possible improvement of food diet in controlled stock farming in Benin.

**Methods**

**Study area**

Study was conducted across national area of the Republic of Benin (Fig. 1), located in West Africa between the latitudes 6° 10’ N and 12° 25’ N and longitudes 0° 45’ E and 3° 55’ E. It is bordered by Togo in the west, Nigeria in the east, Atlantic Ocean in the south and Burkina Faso and Niger in the north. The fieldwork was carried out in 23 localities (Fig. 1) and 4 state farms described in Table 1.
Fig. 1

Location map of Benin with localities and farms covered by this study

Table 1
Description of the state farms

| State farms | Area (ha) | Climate zone     | Annual rainfall (mm of rain) | Temp.  | Soil                        | Vegetation                           | Breed type                  |
|-------------|-----------|------------------|------------------------------|--------|-----------------------------|--------------------------------------|-----------------------------|
| FEK         | 380       | Guinean          | 900–1100                     | 29 °C  | Ferralitic, clay-gravel     | Small islands of forest, savannah    | Girolando                   |
| FES         | 3600      | Guinean          | 1123                         | 27.6 °C| Clay                        | Savannah, forage plots               | Lagunaire, Métis Azawak-lagunaire, Borgou |
| FEB         | 11,127    | Sudano-guinean   | 900–1100                     | 25 °C  | Poorly evolved, ferruginous hydromorphic | Savannah, woodland, forest gallery | Borgou                      |
| FEO         | 33,000    | Sudanian         | 1125                         | 27 °C  | Sandy, loamy                | Woodland, savannah                   | Borgou, Girolando, Azawak   |

Source: MAEP [3]

Temp. temperature, FEK state farm of Kpinnou, FES state farm of Samiondji, FEB state farm of Bétécoucou, FEO state farm of Okpara

The study zone is submitted to three climate types (subequatorial in the southern zone, transition between subequatorial and tropical in the centre zone and tropical climate in the northern zone). The mean annual rainfall fluctuates from 900 to 1400 mm. The vegetation grows under three climate zones. According to Adomou [17], the southern zone consists of savannah, grassland, farmland and fallow intermingled with small islands of closed forest (semi-deciduous and swamp forests). In the centre and northern zones, the natural vegetation is essentially made of a patchwork of woodlands and savannahs with belts of riparian forest along rivers.

The national area contains 2807 plants species belonging to 1130 genera and 185 families [18]. The population of the country was estimated at 9,983,884 inhabitants with the majority involved in agriculture and breeding [19]. The livestock are mainly cattle (2,005,000), sheep and goats (2,413,000), pigs (293,200) and birds (15,900,000) [20]. The cattle production is concentrated at 85% in north of the country and largely dominates those of other animals [21]. The composition
of cattle herds is characterised by a predominance of cows which expresses the dairy and breeding vocation that breeders give them. There are two general types of traditional cattle production in Benin: sedentary production in the Guinean region, which accounts for about 20% of the national herd, and transhumant production, which accounts for the other 80%. The exploitation of cattle is based on natural pastures and crop residues [22]. The Peulh own 95% of the national cattle herd and are thus the essential actors for the supply of animal proteins from the country [23].

Data collection

We coupled ethnobotanical study and pasture walk for the data collection. During ethnobotanical investigations, 690 livestock owners were identified with the assistance of specialised animal production technicians for their experience in traditional breeding. Between February 2016 and May 2017, we conducted semi-structured individual interviews using 30 questionnaire slips per locality. The topics covered by the interview were socioeconomic parameters (ethnic group, sex, age, education level, profession, breeding type, size of livestock and source of knowledge) and fodder plants consumed by cattle (wild or crop, preference, parts of plants, collect modes and season of use).

In this paper, we use the term “fodder” to indicate plants grazed by the animals directly on pasture lands and those cut and carried to them. It includes grasses, cereal crops, legumes, shrubs and trees.

The pasture walk was authorised by the Coordinator of PAFILAV (Programme d’Appui aux Filières Lait et Viande) that ensures the management of state farms. It was conducted on the 4 state farms, and the data were recorded following the season (Table 2). On each farm, one herd and one animal were randomly selected by specialised animal production technician regarding state health of cattle. The pasture walk consisted of following the herd in natural vegetation neighbouring the farm between 9:00 am and 5:00 pm and to record plant species consumed by the targeted animal. The observations were repeated during 5 days.

Table 2

| State farm | Dry months in 2016 | Rainy months in 2017 | Breed type |
|------------|-------------------|---------------------|------------|
| Kpinnou    | January           | June                | Girolando  |
| Samiondji  | February          | July                | Lagunaire  |
| Bétécoucou | March             | September           | Borgou     |
| Okpara     | April             | June                | Borgou     |

Data analysis

Assessment of the taxonomical diversity
The data were organised, summarised and analysed using Excel spreadsheets. All species cited by informants and those recorded during pasture walk were identified using the Analytic Flora of Benin [18] and at the National Herbarium of Benin by comparing with already identified herbarium specimens. Voucher specimens of these plants were kept at the National Herbarium. A value of genus coefficient (GC) was determined by dividing the total number of species over the number of genera. In this study, recorded fodder flora presents high genus diversity when GC ≥ 1. Therefore, when GC < 1, this denotes low genus diversity.

The similarity index of Jaccard (IS) was calculated, and the similarity in fodder species composition between the pasture walk and the survey was compared following Kent and Coker [24]. IS was calculated as follows:

\[
IS = ca + b - c
\]

where, \(a\) is the number of species found only in rangelands, \(b\) is the number of species only cited in survey and \(c\) is the number of common species in pasture walk and survey. Finally, IS was multiplied by 100 to calculate the percentage similarity in species composition between pasture walk and survey.

**Breeders’ knowledge assessment**

The difference in richness of grazed species during the drought and rain seasons was found through the chi-square test. The relative frequency of citation (RFC) and percentage of fodder value during pasture walk (FVPW) of each species were calculated.

Relative frequency of citation (RFC) was determined by dividing the number of informants citing a fodder species (FC) by the total number of informants in the survey (\(N\)). RFC was calculated by the formula as described:

\[
RFC = \frac{FC}{N}
\]

The FVPW corresponds to the number of times a species was grazed by the target animal bovine during pasture walk.

A regression procedure was used to examine the correlation between RFC and FVPW. The Pearson correlation coefficient was used for this. Species present on rangelands and having RFC values higher than the mean of RFC were considered as priorities among fodder plants consumed by cattle in Benin.

**Results**

**Taxonomical, morphological and habitat’s diversity of recorded fodder plants**

A total of 257 fodder plants of which 116 for ethnobotanical investigations and 195 for pasture walk, with 52 common species, were recorded as consumed by cattle in Benin. These belong to 181 genera and 54 families. The average number of species recorded per family was 4.78, with 8 families (14.61% of the total) having more species than the average (Table 3). The 10 families that contributed 72.86% of all species were Leguminosae, Poaceae, Euphorbiaceae,
Combretaceae, Asteraceae, Rubiaceae, Malvaceae, Moraceae, Acanthaceae and Amaranthaceae. The most speciose ones being Leguminosae (76 species, 29.45%) and Poaceae (57 species, 22.09%). These families were followed by Euphorbiaceae (12 species, 4.65%), Combretaceae (9 species, 3.48%), Asteraceae (9 species, 3.48%), Rubiaceae (7 species, 2.71%) and Malvaceae and Moraceae (6 species each, 2.37%). Twenty-seven families (50% of the total) were represented by only 1 species each. The remaining 27 families contributed between 2 and 5 species each (0.77–29.45% of the total). The ratio of the number of genera to the number of species was 1.41; we concluded high genera diversity among recorded species. The richest genera were Desmodium, Hypparhenia and Indigofera with 6 species each. The next most diversified genera in terms of species richness were Andropogon, Crotalaria (5 species each), Combretum, Ficus, Schizachyrium, Senna and Tephrosia (4 species each) followed by Acacia, Albizia, Brachiaria, Commelina, Pennisetum, Setaria, Sida, Terminalia and Vigna (3 species each). The low value of Jaccard’s similarity index (34%) means that the species harvested on pasture are distinct from those indicated by the breeders.

Table 3

| Family         | Species (voucher number)                     | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|---------------|----------------------------------------------|-------|--------------|----------|------|----|----|--------|--------|
| Acanthaceae   | *Asystasia gangetica* (L.) T. Anderson (MAS 937) | 6     | *            | Per      | –    | Herb | LS | D      | W      |
|               | *Justicia flavia* (Forssk.) Vahl (MAS 935)   | 6     | ***          | Per      | –    | Herb | LS | D      | W      |
|               | *Monechma ciliatum* (Jacq.) Milne-Redh. (MAS 603) | 13    | **           | Ann      | 0.98 | Herb | LS | D      | W      |
|               | *Nelsonia canescens* (Lam.) Spreng. (MAS 1074) | 13    | **           | Ann      | –    | Liana | LS | DR     | W      |
| Amaranthaceae | *Alternanthera sessilis* (L.) R.Br. ex Roth (MAS 1502) | 0     | –            | Per      | 0.87 | Liana | LS | D      | W      |
|               | *Amaranthus spinosus* L. (MAS 275)            | 6     | **           | Ann      | –    | Herb | LS | D      | W      |
|               | *Celosia*                                     | 25    | **           | Ann      | –    | Herb | Le | R      | W      |
| Family               | Species (voucher number) | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|---------------------|--------------------------|-------|--------------|----------|------|----|----|--------|--------|
| argentea L. (MAS 102) |                          |       |              |          |      |    |    |        |        |
| Pupalia lappacea (L.) Juss. (MAS 551) | 13 ** | Per | – | Herb | LS | DR | W |
| Anacardiaceae       | Anacardium occidentale L. (MAS 288) | 0 – | Per | 0.57 | Shrub | Le | D | WC |
| Lannea acida A.Rich. s.l. (MAS 1010) | 3 * | Per | 0.41 | Tree | Le | D | W |
| Mangifera indica L. |                          | 19 ** | Per | – | Tree | Le, Fr | D | W |
| Annonaceae          | Annona senegalensis Pers. (MAS 196) | 9 * | Per | 2.21 | Shrub | Le | D | W |
| Araliaceae          | Cussonia arborea Hochst. ex A. Rich. (MAS 344) | 6 * | Per | 0.39 | Tree | Le | D | W |
| Arecaeae            | Elaeis guineensis Jacq. | 3 * | Per | – | Tree | Le | DR | C |
| Asclepiadaceae      | Periploca nigrescens Afzel. (MAS 297) | 6 ** | Per | – | Liana | LS | DR | W |
| Asparagaceae        | Asparagus africanus Lam. (MAS 49) | 3 * | Ann | – | Herb | LS | R | W |
| Ageratum conyzoides L. (MAS 127) | 0 – | Ann | 1.23 | Herb | LS | R | W |
| Acanthospermum hispidum DC. (MAS 181) | 0 – | Ann | 0.28 | Herb | LS | D | W |
| Aspilia africana (Pers.) Adams (MAS 42) | 6 * | Per | – | Herb | LS | R | W |
| Aspilia bussei      | 0 – | Per | 0.39 | Herb | LS | DR | W |
| Family          | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|-----------------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
| Bignoniaceae    | *O.Hoffm. & Muschl. (MAS 793)* |     |              |          |    |    |    |        |        |
|                 | *Aspilia helianthoides* (Schumach. & Thonn.) Olív. & Diern (MAS 173) | 9   | *            | Ann      | –  |    |    |        | W      |
|                 | *Chromolaena odorata* (L.) R.M.King (MAS 96) | 22  | *            | Per      | –  |    |    |        | W      |
|                 | *Launaea taraxacifolia* (Willd.) Amin ex C.Jeffrey (MAS 828) | 6   | **           | Ann      | –  |    |    |        | WC     |
|                 | *Tridax procumbens* L. (MAS 818) | 19  | **           | viv      | 0.90 |    |    |        | W      |
|                 | *Vernonia colorata* (Willd.) Drake (MAS 265) | 6   | *            | Ann      | –  |    |    |        | W      |
|                 | *Newbouldia laevis* (P.Beauv.) Seemann ex Bureau (MAS 62) | 3   | *            | Ann      | –  |    |    |        | W      |
| Bignoniaceae    | *Stereospermum kunthianum* Cham. (MAS 454) | 3   | **           | Per      | 0.39 |    |    |        | W      |
| Bombacaceae     | *Adansonia digitata* L. (MAS 176) | 0   | –            | Per      | 1.23 |    |    |        | W      |
|                 | *Bombax costatum* | 0   | –            | Per      | 0.26 |    |    |        | W      |
| Family | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|--------|-------------------------|-----|--------------|----------|----|----|----|--------|--------|
|        |                         |     |              |          |    |    |    |        |        |
| Capparaceae | Cleome viscosa L. (MAS 892) | 9   | *            | Ann      | 0.39 | Herb | LS | R      | W      |
| Celastraceae | Gymnosporia senegalensis (Lam.) Loes. (MAS 1038) | 13  | *            | Per      | –   | Shrub | LS | D      | W      |
| Chrysobalanaceae | Parinari curatellifolia Planch. ex Benth. (MAS 487) | 0   | –            | Per      | 0.64 | Shrub | Le, Fr | DR     | W      |
| Cochlospermaceae | Cochlospermum planchoni Hook.f. (MAS 301) | 22  | **           | Ann      | –   | Herb | Le, Fr | R      | W      |
| Cochlospermaceae | Cochlospermum tinctorium A.Rich. (MAS 875) | 9   | *            | Ann      | –   | Herb | Le | DR     | W      |
| Combretaceae | Anogeissus leiocarpa (De.) Guill. & Perr. (MAS 640) | 25  | **           | Per      | 3.16 | Tree | Le | D      | W      |
| Combretaceae | Combretum collinum Fresen. (MAS 789) | 0   | –            | Per      | 0.77 | Tree | Le | R      | W      |
| Combretaceae | Combretum mucronatum Schumach. & Thonn. (MAS 302) | 16  | **           | Per      | –   | Liana | LS | D      | W      |
| Combretaceae | Combretum nigricans Lepr. ex Guill. & Perr. (MAS 1221) | 0   | –            | Per      | 1.08 | Tree | Le | D      | W      |
| Combretaceae | Combretum paniculatum | 3   | *            | Per      | –   | Liana | LS | DR     | W      |
| Family          | Species (voucher number)                    | FVP | Palatability | Lifespan | RF  | LF | PP | Season | Status |
|-----------------|--------------------------------------------|-----|--------------|----------|-----|----|----|--------|--------|
|                 | Vent. (MAS 593)                            |     |              |          |     |    |    |        |        |
|                 | *Pteleopsis suberosa* Engl. & Diels (MAS 700) | 13  | **           | Per      | –   | Shrub | Le | R     | W      |
|                 | *Terminalia avicennioides* Guill. & Perr. (MAS 696) | 6   | *            | Per 0.51 | Shrub | Le | D  | W      |
|                 | *Terminalia laxiflora* Engl. (MAS 1390)     | 3   | *            | Per      | Shrub | Le | D  | W      |
|                 | *Terminalia macroptera* Guill. & Perr. (MAS 229) | 3   | *            | Per 0.13 | Shrub | Le | DR | W      |
| Commelinaceae   | *Commelina benghalensis* L. (MAS 52)        | 0   | –            | Per 0.64 | Herb | WP | D  | W      |
|                 | *Commelina erecta* L. (MAS 79)              | 9   | **           | Per      | –   | Herb | LS | R     | W      |
|                 | *Commelina forskalaei* Vahl (MAS 177)       | 0   | –            | Per 0.15 | Herb | WP | R  | W      |
| Connaraceae     | *Rourea coccinea* (Thonn. ex Schumach.) Benth. (MAS 15) | 19  | **           | Ann      | Shrub | LS | DR | W      |
| Convolvulaceae  | *Hewittia scandes* (Milne) Mabberley (MAS 884) | 25  | *            | Per      | –   | Herb | LS | D     | W      |
|                 | *Ipomoea involucrata* P. Beauv. (MAS 917)   | 6   | **           | Ann      | –   | Herb | LS | D     | W      |
| Family      | Species (voucher number)                                                                 | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|------------|----------------------------------------------------------------------------------------------------------------|-------|--------------|----------|------|----|----|--------|--------|
|            | * Merremia pinnata (Hochst. ex Choisy) Hallier (MAS 553)                                                | 12    | *            | Ann      | –    | Herb | LS | R      | W      |
| Cucurbitaceae | Momordica charantia L. (MAS 1052)                                                                           | 0     | –            | Per      | 0.64 | Liana | LS | D      | W      |
| Cyperaceae  | Cyperus difformis L. (MAS 738)                                                                              | 3     | *            | Ann      | –    | Herb | WP | D      | W      |
| Cyperaceae  | Cyperus rotundus L. (MAS 430)                                                                               | 1     | *            | Per      | –    | Herb | Le | DR     | W      |
| Cyperaceae  | Cyperus sphacelatus L. (MAS 550)                                                                            | 0     | –            | Ann      | 0.46 | Herb | WP | R      | W      |
| Discoreaceae | Dioscorea cayenensis Lam. (MAS 146)                                                                         | 3     | *            | Ann      | –    | Herb | Le | DR     | WC     |
| Ebenaceae   | Diospyros mespiliformis Hochst. ex A.DC. (MAS 628)                                                          | 0     | –            | Per      | 0.31 | Tree | Le | D      | W      |
| Euphorbiaceae | Alchornea cordifolia (Schumach. & Thonn.) Müll.Arg. (MAS 915)                                                | 6     | *            | Per      | –    | Shrub | Le | D      | W      |
| Euphorbiaceae | Antidesma venosum E.Mey. ex Tul. (MAS 386)                                                                 | 13    | *            | Per      | –    | Shrub | Le | D      | W      |
| Euphorbiaceae | Bridelia ferruginea Benth. (MAS 180)                                                                         | 19    | **           | Per      | 1.16 | Shrub | Le, Fr | D | W |
| Euphorbiaceae | Euphorbia                                                                                                   | 13    | *            | Ann      | –    | Herb | LS | R      | W      |
| Family            | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|-------------------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
| convolvuloides    | Hochst. ex Benth. (MAS 446) |     |              |          |    |    |    |        |        |
| Flueggea virosa   | (Roxb. ex Willd.) Voigt (MAS 607) | 47  | ***          | Per      | 5.14 | Shrub | LS | D     | W      |
| Hymenocardia acida | Tul. (MAS 815) | 13  | **           | Per      | 0.26 | Shrub | Le | DR    | W      |
| Jatropha gossypiifolia L. (MAS 330) | 3  | *          | Per | – | Shrub | LS | D | W     |
| Mallotus oppositifolius (Geisel.) Müll.Arg. (MAS 254) | 6  | **          | Per | 0.77 | Shrub | LS | D | W     |
| Manihot esculenta Crantz | 13  | **          | Per | 0.31 | Shrub | Le, tub | D | C     |
| Margaritaria discoidea (Baill.) Webster (MAS 292) | 9  | *          | Per | – | Tree | Le | DR | W     |
| Phyllanthus amarus | Schumach. & Thonn. (MAS 184) | 31  | **          | Per | – | Herb | LS | D | W     |
| Phyllanthus muellerianus (Kuntze) Exell (MAS 233) | 19 | **          | Ann | 1.08 | Liana | LS | DR | W     |
| Flacourtiaceae    | Flacourtia indica (Burm.f.) Merr. (MAS 212) | 6  | *          | Per | – | Shrub | Le | D | W     |
| Lamiaceae         | Hyptis suaveolens (L.) | 6  | *          | Ann | 0.62 | Herb | LS, Fl | R | W     |
| Family | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|--------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
| Poit. (MAS 541) | | | | | | | | | |
| Leucas martinicensis (Jacq.) R.Br. (MAS 502) | 6 | * | Ann – | Herb | LS, Fl | R | W |
| Poit. (MAS 541) | | | | | | | | | |
| Aftelia africana Sm. (MAS 162) | 16 | *** | Per 1.59 | Herb | Le | DR | W |
| Burkea africana Hook. (MAS 163) | 0 | – | Per 0.41 | Tree | Le | DR | W |
| Cassia sieberiana DC. (MAS 209) | 0 | – | Per 0.77 | Shrub | LS | R | W |
| Chamaecrista mimosoides (L.) Greene (MAS 258) | 9 | * | Ann – | Herb | LS | R | W |
| Chamaecrista rotundifolia (Pers.) Greene (MAS 416) | 16 | ** | Ann 0.51 | Herb | WP | D | W |
| Daniellia oliveri (Rolfe) Hutch. & Dalziel (MAS 123) | 0 | – | Per 1.34 | Tree | Le, Fl, Fr | D | W |
| Detarium microcarpum Guill. & Perr. (MAS 218) | 6 | ** | Per 1.44 | Tree | Le | DR | W |
| Dialium guineense Willd. (MAS 1045) | 3 | * | Per – | Tree | Le | DR | W |
| Isoberlinia doka Craib & Stapf (MAS 173) | 0 | – | Per 0.28 | Tree | Le | R | W |
| Piliostigma thonningii (Schumach.) | 31 | ** | Per 2.83 | Tree | Le, Fr | D | W |
| Family                  | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|-------------------------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
|                         |                          |     | **           | Ann      | –  |    |    |        |        |
| Milne-Redh. (MAS 322)   | Senna hirsuta (L.) H.S. Irwin & Barneby (MAS 488) | 6   | **           | Ann      |    |    |    |        | W      |
|                         | Senna obtusifolia (L.) H.S.Irwin & Barneby (MAS 359) | 3   | *            | Per      | –  |    |    |        | W      |
|                         | Senna occidentalis (L.) Link (MAS 812) | 3   | *            | Ann      | –  |    |    |        | W      |
|                         | Senna siamea (Lam.) H.S.Irwin & Barneby (MAS 336) | 9   | **           | Ann      | –  |    |    |        | W      |
| Leg-Mimosoideae         | Acacia auriculiformis A.Cunn. ex Benth. (MAS 27) | 6   | **           | Per      | –  |    |    |        | W      |
|                         | Acacia nilotica (L.) Willd. (MAS 718) | 3   | *            | Per      | –  |    |    |        | W      |
|                         | Acacia sieberiana DC. (MAS 259) | 13  | **           | Per      | 1.54 |    |    |        | W      |
| Leg-Mimosoideae         | Albizia adianthifolia (Schumach.) W.F. Wright (MAS 84) | 3   | *            | Per      | –  |    |    |        | W      |
|                         | Albizia lebbeck (Schumach.) W.F. Wright (MAS 433) | 6   | *            | Per      | 0.64 |    |    |        | W      |
|                         | Albizia zygia            | 3   | *            | Per      | –  |    |    |        | W      |
| Family            | Species (voucher number) | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|-------------------|--------------------------|-------|--------------|----------|------|----|----|--------|--------|
|                   | (De.) J.F.Macbr. (MAS 1243) |       |              |          |      |    |    |        |        |
| Dichrostachys cinerea (L.) Wight & Arn. (MAS 1319) | 0 | – | Per | 0.39 | Shrub | Le, Fr | DR | W |
| Entada africana Guill. & Perr. (MAS 226) | 3 | * | Per | 0.39 | Tree | Le | D | W |
| Leucaena leucocephala (Lam.) De Wit (MAS 429) | 22 | *** | Per | 1.41 | Tree | Le | D | WC |
| Mimosa pigra L. (MAS 267) | 6 | ** | Per | – | Shrub | Le | D | W |
| Parkia biglobosa (Jacq.) R.Br. ex Benth. (MAS 752) | 0 | – | Per | 0.90 | Tree | Le | D | W |
| Pithecellobium dulce (Roxb.) Benth. (MAS 1007) | 3 | * | Per | – | Tree | LS | D | W |
| Prosopis africana (Guill. & Perr.) Taub. (MAS 953) | 31 | *** | Per | 2.52 | Tree | Le, Fl | R | W |
| Aeschynomene americana L. (MAS 141) | 9 | *** | Per | – | Shrub | Le | R | W |
| Alysicarpus ovalifolius (Schumach.) J.Léonard (MAS 711) | 0 | – | Per | 1.16 | Herb | LS | D | W |
| Alysicarpus rugosus (Willd.) DC. (MAS 166) | 6 | ** | Per | – | Herb | Le, Fl | DR | W |
| Family | Species (voucher number) | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|--------|-------------------------|-------|--------------|----------|------|----|----|--------|--------|
|        | *Arachis hypogea* L. (MAS 94) | 0     | Per          | 0.51     | Herb | Le | DR | C      |        |
|        | *Calopogonium mucunoides* Desv. (MAS 112) | 9     | Per          |          | Liana| LS | R  | W      |        |
|        | *Centrostepa pubescens* Benth. (MAS 295) | 28    | Per          | 0.64     | Liana| LS | D  | W      |        |
|        | *Crotalaria comosa* Baker (MAS 328) | 3     | Ann          |          | Herb | LS | D  | W      |        |
|        | *Crotalaria macrocalyx* Benth. (MAS 393) | 0     | Ann          | 0.77     | Herb | LS | Fl | D      | W      |
|        | *Crotalaria microcarpa* Hochst. ex Benth. (MAS 673) | 0     | Ann          | 0.90     | Herb | LS | D  | W      |        |
|        | *Crotalaria ononoides* Benth. (MAS 636) | 3     | Ann          |          | Herb | LS | D  | W      |        |
|        | *Crotalaria pallida* Aiton (MAS 109) | 3     | Ann          |          | Herb | LS | D  | W      |        |
|        | *Desmodium adscendens* (Sw.) DC. (MAS 617) | 6     | Per          |          | Herb | LS | DR | W      |        |
|        | *Desmodium gangeticum* (L.) DC. (MAS 615) | 6     | Per          |          | Shrub| Le | DR | W      |        |
|        | *Desmodium hirtum* Guin. & Perr. (MAS 326) | 0     | Ann          | 0.67     | Herb | LS | D  | W      |        |
| Family | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|--------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
|        | *Desmodium ramossissimum* D.Don (MAS 524) | 3   | *            | Ann      | –  | Herb | Le | DR     | W      |
|        | Desmodium salicifolium (Poir.) DC. (MAS 571) | 0   | –            | Ann      | 0.80 | Herb | LS | D      | W      |
|        | Desmodium velutinum (Willd.) DC. (MAS 303) | 25  | **           | Ann      | 0.77 | Herb | LS | R      | W      |
|        | *Eriosema griseum* Baker (MAS 631) | 6   | **           | Per      | –  | Shrub | Le | R      | W      |
|        | *Glycine max* (L.) Merr. (MAS 247) | 0   | –            | Ann      | 0.41 | Herb | Le | D      | C      |
| Leg-Papilionoideae | *Indigofera conjugata* Baker (MAS 921) | 3   | **           | Per      | –  | Liana | LS | D      | W      |
|        | *Indigofera dendroides* Jacq. (MAS 304) | 6   | **           | Ann      | 0.77 | Herb | LS | R      | W      |
|        | *Indigofera hirsuta* L. (MAS 159) | 6   | *            | Ann      | –  | Herb | Le, Fr | DR     | W      |
|        | *Indigofera paniculata* Vahl ex Pers. (MAS 118) | 0   | –            | Ann      | 0.39 | Herb | LS, Fr | DR     | W      |
|        | *Indigofera stenophylla* Guill. & Perr. var. stenophylla (MAS 573) | 0   | –            | Ann      | 0.39 | Herb | Le | D      | W      |
|        | *Indigofera tinctoria* L. (MAS 806) | 6   | *            | Per      | –  | Herb | LS | DR     | W      |
| Family | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|--------|-------------------------|-----|--------------|----------|----|----|----|--------|--------|
|  | *Lonchocarpus sericeus* (Poir.) (MAS 363) | 25 | *** | Per | 0.90 | Tree | Le | R | W |
|  | *Millettia thonningii* (Schumach. & Thonn.) Baker (MAS 276) | 3 | * | Ann | – | Shrub | Le | DR | W |
|  | *Pericopsis laxiflora* (Benth. ex Baker) Meeuwen (MAS 821) | 6 | * | Ann | – | Tree | Le | R | W |
|  | *Philenoptera cyanescens* (Sehumaeh. & Thonn.) Roberty (MAS 762) | 0 | – | Per | 1.34 | Shrub | Le | R | W |
|  | *Philenoptera laxiflora* (Guill. & Perr.) Roberty (MAS 582) | 0 | – | Per | 1.08 | Tree | LS | D | W |
|  | *Pseudarthria hookeri* Wight & Am. var. hookeri (MAS 21) | 19 | * | Per | – | Herb | LS | D | W |
|  | *Pseudovigna argentea* (Willd.) Verdc. (MAS 541) | 25 | ** | Per | – | Herb | LS | R | W |
|  | *Pterocarpus erinaceus* Poir. (MAS 1012) | 50 | *** | Per | 5.35 | Tree | Le | DR | W |
|  | *Rhynchosia sublobata* (Sehumaeh. & Thonn.) Meikle (MAS 322) | 6 | ** | Per | – | Herb | LS | DR | W |
|  | *Sesbania* | 25 | * | Per | – | Shrub | Le | D | W |
| Family | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|--------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
|        | grandiflora (L.) Poir. (MAS 396) |     |              |          |    |    |    |        | b      |
|        | Sesbania pachycarpa DC. ssp. pachycarpa (MAS 903) | 9   | **           | Per      | –  | Herb | Le | DR     | W      |
|        | Stylosanthes fruticosa (Retz.) Alston (MAS 669) | 13  | **           | Per      | –  | Herb | LS | D      | W      |
|        | Stylosanthes hamata (L.) Taub. (MAS 709) | 3   | *            | Per      | –  | Herb | Le | DR     | W      |
|        | Swartzia madagascariensis Desv. (MAS 1061) | 3   | **           | Per      | –  | Tree | Le | D      | W      |
|        | Tephrosia bracteolata Guilt. & Perr. (MAS 914) | 16  | *            | Per      | –  | Herb | LS | DR     | W      |
|        | Tephrosia elegans Schumach. (MAS 149) | 3   | **           | Ann      | –  | Herb | LS | D      | W      |
|        | Tephrosia purpurea (L.) (MAS 173) | 13  | **           | Ann 1.54 | Herb | LS | D | W      |
|        | Tephrosia villosa (L.) Pers. (MAS 1033) | 13  | **           | Per      | –  | Herb | LS | D      | W      |
|        | Teramnus labialis (L.f.) Spreng. (MAS 571) | 3   | *            | Ann      | –  | Herb | Le | D      | W      |
|        | Vigna racemosa (G.Don) Hutch. & Dalziel (MAS 249) | 3   | *            | Per      | –  | Herb | Le | D      | W      |
| Family          | Species (voucher number) | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|-----------------|--------------------------|-------|--------------|----------|------|----|----|--------|--------|
| **Loganiaceae** | *Vigna reticulata* Hook.f. (MAS 332) | 3     | *            | Per      | –    | Herb | LS | DR     | W      |
|                 | *Vigna unguiculata* (L.) Walp. (MAS 989) | 0     | –            | Ann      | 0.64 | Herb | Le | DR     | C      |
|                 | *Zornia glochidiata* Rchb. ex DC. (MAS 963) | 3     | *            | Ann      | –    | Herb | LS | DR     | W      |
| **Malvaceae**   | *Strychnos innocua* Delile (MAS 1053) | 0     | –            | Ann      | 0.26 | Shrub | Le | DR     | W      |
|                 | *Gossypium sp.* (MAS 753) | 0     | –            | Ann      | 0.26 | Herb | Le | R      | C      |
|                 | *Hibiscus asper* Hook.f. (MAS 1162) | 13    | *            | Ann      | 0.57 | Herb | Le, Fl | D | W      |
|                 | *Sida acuta* Burm.f. (MAS 92) | 25    | **           | Ann      | 0.64 | Herb | LS | D      | W      |
|                 | *Sida garckeana* Pol. (MAS 173) | 0     | *            | viv      | 0.57 | Herb | LS | D      | W      |
|                 | *Sida linifolia* Juss. ex Cav. (MAS 33) | 13    | *            | viv      | –    | Herb | Le | DR     | W      |
| **Meliaceae**   | *Azadirachta indica* A.Juss. (MAS 1018) | 19    | **           | Per      | –    | Tree | Le | D      | W      |
|                 | *Khaya senegalensis* (Desr.) A.Juss. (MAS 436) | 0     | –            | Per      | 1.39 | Tree | Le | R      | W      |
|                 | *Pseudocedrela kotschyi* (Schweinf.) Harms. (MAS 633) | 31    | **           | Per      | 2.57 | Tree | Le | D      | W      |
| Family          | Species (voucher number)                  | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|-----------------|-------------------------------------------|-----|--------------|----------|----|----|----|--------|--------|
| Menispermaceae  | *Cissampelos mucronata A. Rich. (MAS 916)* | 9   | **           | Per      |    |    |    |        | W      |
| Moraceae        | *Antiaris toxicaria Lesch. (MAS 402)*     | 3   | *            | Per      |    |    |    |        | W      |
|                 | *Ficus ingens (Miq.) Miq. (MAS 113)*      | 0   | –            | Per 0.26 |    |    |    |        | W      |
|                 | *Ficus sur Forssk. (MAS 77)*              | 16  | **           | Per      |    |    |    |        | W      |
|                 | *Ficus sycomorus L. (MAS 169)*            | 0   | –            | Per 0.36 |    |    |    |        | W      |
|                 | *Ficus varifolia Warb. (MAS 412)*         | 0   | –            | Per 0.31 |    |    |    |        | W      |
| Moringaceae     | *Moringa oleifera Lam. (MAS 761)*         | 3   | *            | Per      |    |    |    |        | WC     |
| Musaceae        | *Musa sp. L.*                             | 6   | *            | Per      |    |    |    |        | C      |
| Myrtaceae       | *Syzygium guineense (Willd.) DC. var. guineense (MAS 319)* | 3   | *            | Per      |    |    |    |        | W      |
| Nyctaginaceae   | *Boerhavia diffusa L. (MAS 611)*          | 6   | **           | Ann      |    |    |    |        | W      |
|                 | *Boerhavia erecta L. (MAS 96)*            | 6   | *            | Ann 0.31 |    |    |    |        | W      |
| Ochnaceae       | *Lophira lanceolata Tiegh. ex Keay (MAS 188)* | 9   | **           | Per      |    |    |    |        | W      |
| Olacaceae       | *Olax subscorpioidea*                     | 6   | *            | Per      |    |    |    |        | W      |
| Family          | Species (voucher number) | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|-----------------|--------------------------|-------|--------------|----------|------|----|----|--------|--------|
| Opiliaceae      | *Opillia amentacea* Roxb. (MAS 202) | 6     | *            | Per      |      |    |    |        |        |
| Passifloraceae  | *Passiflora foetida* L. (MAS 436)  | 13    | **           | Per      | 0.57 |    |    | W      | D      | W      |
| Poaceae         | *Acroceras amplexentens* Stapf (MAS 22) | 6     | *            | Ann      |      |    |    |        |        |
|                 | *Anadelphi azeliana* (Rendle) Stapf (MAS 306) | 3     | *            | Per      |      |    |    |        |        |
|                 | *Andropogon chinensis* (Nees) Merr. (MAS 921) | 3     | *            | Per      |      |    |    |        |        |
|                 | *Andropogon fastigiatus* Sw. (MAS 88) | 3     | *            | Ann      |      |    |    |        |        |
|                 | *Andropogon gayanus* Kunth (MAS 109) | 47    | **           | Ann      | 5.81 |    |    |        |        |
|                 | *Andropogon schirensis* Rochst. ex A. Rich. (MAS 534) | 13    | **           | Per      |      |    |    |        |        |
|                 | *Andropogon tectorum* Schumach. & Thonn. (MAS 508) | 31    | **           | Per      | 4.24 |    |    |        |        |
| Poaceae         | *Aristida hordeaca* Kunth (MAS 1033) | 9     | **           | Ann      |      |    |    |        |        |
| Family                                      | Species (voucher number)                      | FVP | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|---------------------------------------------|----------------------------------------------|-----|--------------|----------|------|----|----|--------|--------|
| *Aristida kerstingii* Pilger (MAS 339)      |                                              | 3   | **           | Ann      | –    | Herb | Le  | D      | W      |
| *Bambusa vulgaris* Schrad. ex Wendel (MAS 1020) |                                              | 0   | –            | Per      | 0.13 | Tree | Le  | R      | W      |
| *Beckeropsis uniseta* (Nees) K.Schum. (MAS 1078) |                                              | 0   | –            | Ann      | 0.33 | Herb | Le  | D      | W      |
| *Brachiaria deflexa* (Schumach.) Robyns (MAS 1001) |                                              | 6   | *            | Per      | –    | Herb | Le  | D      | W      |
| *Brachiaria mutica* (Forssk.) Stapf (MAS 444) |                                              | 19  | **           | Per      | –    | Herb | W P | D      | W      |
| *Brachiaria ruziziensis* Germain & Evrard (MAS 757) |                                              | 13  | *            | Per      | –    | Herb | Le  | D      | W      |
| *Ctenium elegans* Kunth (MAS 43)            |                                              | 3   | *            | Ann      | –    | Herb | Le  | D      | W      |
| *Dactyloctenium aegyptium* (L.) Wild. (755) |                                              | 9   | **           | Ann      | –    | Herb | Le  | D      | W      |
| *Digitaria horizontalis* Wild. (MAS 453)    |                                              | 13  | **           | Ann      | 2.29 | Herb | Le  | D      | WC     |
| *Eleusine indica* Gaertn. (MAS 1073)        |                                              | 0   | –            | Ann      | 0.39 | Herb | Le  | D      | W      |
| *Elionurus elegans* Kunth                   |                                              | 3   | *            | Ann      | –    | Herb | Le  | D      | W      |
| Family | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|--------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
| (MAS 523) | Elymandra androphila (Stapf) Stapf (MAS 771) | 3 | * | Per | – | Herb | Le | D | W |
| | Eragrostis aspera (Jacq.) Nees (MAS 343) | 0 | – | Ann | 0.57 | Herb | Le | D | W |
| | Euclasta condylotricha (Steud.) Stapf (MAS 1065) | 0 | – | Ann | 0.26 | Herb | Le | D | W |
| | Heteropogon contortus (L.) P.Beauv. (MAS 817) | 0 | – | Per | 0.15 | Herb | WP | D | W |
| | Hypparhenia barteri (Rack.) Stapf (MAS 117) | 19 | ** | Ann | – | Herb | Le | R | W |
| | Hypparhenia cyanescens (Stapf) Stapf (MAS 943) | 3 | * | Per | – | Herb | Le | D | W |
| | Hypparhenia involucrata Stapf (MAS 418) | 0 | – | Ann | 0.57 | Herb | Le | DR | W |
| | Hypparhenia mutica Clayton (MAS 1017) | 6 | * | Per | – | Herb | Le | D | W |
| | Hypparhenia rufa (Nees) Stapf (MAS 713) | 0 | – | Per | 0.64 | Herb | Le | R | W |
| | Hypparhenia subplumosa Stapf (MAS 602) | 3 | * | Per | – | Herb | Le | D | W |
| Family     | Species (voucher number)                                                                 | FVP  | Palatability | Lifespan | RF  | LF | PP | Season | Status |
|------------|----------------------------------------------------------------------------------------|------|--------------|----------|-----|----|----|--------|--------|
|            | *Imperata cylindrica* (L.) P.Beauv. (MAS 337)                                          | 13   | ***          | Per      | 1.16| Herb | WP| DR     | W      |
|            | *Loudetia togoensis* (Pilg.) C.E.Hubbard (MAS 114)                                    | 3    | *            | Ann      | 0.16| Herb | Le | DR     | W      |
|            | *Microchloa indica* (L.) P.Beauv. (MAS 504)                                            | 0    | –            | Ann      | 0.57| Herb | Le | D      | W      |
|            | *Monocymbium cerasiforme* (Nees) Stapf (MAS 1013)                                      | 8    | ***          | Ann      | 0.16| Herb | Le | R      | W      |
|            | *Oryza sativa* L. (MAS 203)                                                           | 0    | –            | Ann      | 0.90| Herb | Le | R      | C      |
|            | *Panicum maximum* Jacq. (MAS 93)                                                       | 50   | ***          | Ann      | 5.45| Herb | Le | D      | WC     |
|            | *Panicum repens* L. (MAS)                                                              | 6    | **           | Per      | 0.31| Herb | Le | R      | WC     |
|            | *Paspalum scrobiculatum* L. (MAS 104)                                                  | 3    | *            | Per      | 0.31| Herb | Le | D      | W      |
| Poaceae    | *Paspalum vaginatum* Sw. (MAS 26)                                                      | 19   | *            | Per      | 0.31| Herb | Le | R      | W      |
|            | *Pennisetum glaucum* (L.) R.Br. (MAS 710)                                              | 13   | *            | Ann      | 0.31| Herb | Le | R      | W      |
|            | *Pennisetum pedicellatum* Trin. (MAS 309)                                              | 13   | *            | Ann      | 0.26| Herb | Le | D      | W      |
|            | *Pennisetum polystachion* (L.) Schult.                                                 | 13   | *            | Ann      | 0.26| Herb | Le | D      | W      |
| Family | Species (voucher number) | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|--------|--------------------------|-------|--------------|----------|------|----|----|--------|--------|
|        | (MAS 421)                |       |              |          |      |    |    |        |        |
|        | *Rottboellia cochinchinensis (Lour.) (MAS 205)* | 13    | *Per        |          | Herb | Le | R  | W      |        |
|        | *Saccharum officinarum L. (MAS 630)* | 0     | *Per        | 0.39     | Herb | Le | R  | WC     |        |
|        | *Schizachyrium brevifolium (Sw.) Nees (MAS 208)* | 9     | *Per        |          | Herb | Le | R  | W      |        |
|        | *Schizachyrium platyphillum (Franch.) Stapf (MAS)* | 9     | *Ann        |          | Herb | Le | DR | W      |        |
|        | *Schizachyrium ruderale Clayton (MAS 501)* | 9     | *Per        |          | Herb | Le | D  | W      |        |
|        | *Schizachyrium sanguineum (Retz.) Alston (MAS 1054)* | 9     | *Ann        |          | Herb | Le | DR | W      |        |
|        | *Setaria gracilipes C.E.Hubb. (MAS 129)* | 6     | *Ann        | 0.31     | Herb | Le | R  | W      |        |
|        | *Setaria megaphylla (Steud.) T.Durand & Sehinz (MAS 401)* | 0     | *Ann        |          | Herb | Le | R  | W      |        |
|        | *Setaria pumila (Poir.) Roem. & Schult. (MAS 308)* | 3     | *Per        |          | Herb | Le | R  | W      |        |
|        | *Sorghum bicolor (L.) Moench* | 0     | *Ann        | 0.39     | Herb | Le | D  | C      |        |
| Family | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | SeASON | Status |
|--------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
|        | (MAS 152)                |     |              |          |    |    |    |        |        |
|        | *Sporobolus pyramidalis* |     |              |          |    |    |    |        |        |
|        | P. Beauv. (MAS 1044)     | 3   | *            | Ann      | 0.67| Herb| Le | D      | W      |
|        | *Stenotaphrum dimidiatum*|     |              |          |    |    |    |        |        |
|        | (L.) Brongn. (MAS 142)   | 3   | *            | Per      | –   | Herb| Le | DR     | W      |
|        | *Thelepogon elegans*     |     |              |          |    |    |    |        |        |
|        | Roth ex Roem. & Sehult.  | 0   | –            | Per      | 0.41| Herb| Le | R      | W      |
|        | (MAS 744)                |     |              |          |    |    |    |        |        |
|        | *Tristachya superba*     |     |              |          |    |    |    |        |        |
|        | (De Not.) Schweinf. & Aschers. (MAS 519) | 6   | *            | Ann      | –   | Herb| Le | R      | W      |
|        | *Vetiveria nigritana*    |     |              |          |    |    |    |        |        |
|        | (Benth.) Stapf (MAS 1071)| 0   | –            | Per      | 0.13| Herb| Le | D      | W      |
|        | *Zea mays* L.            | 0   | –            | Ann      | 0.51| Herb| Le | D      | C      |
| Polygalaceae | *Securidaca longipedunculata* Fresen. (MAS 74) | 9   | *            | Per      | 0.26| Herb| LS | DR     | W      |
| Pontederiaceae | *Eichhormia crassipes* (Mart.) SolmsLaub. (MAS 531) | 3   | **           | Per      | –   | Herb| Le, Fl| D      | W      |
| Rubiaceae | *Gardenia ternifolia*    |     |              |          |    |    |    |        |        |
|        | Sehumaeh. & Thonn. (MAS 59) | 16  | **           | Per      | 0.39| Tree| Le, Fr| DR     | W      |
|        | *Mitracarpus hirtus* (L.) DC. (MAS 346) | 13  | *            | Per      | –   | Herb| LS, Fl| D      | W      |
| Family   | Species (voucher number)                              | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|----------|------------------------------------------------------|-------|--------------|----------|------|----|----|--------|--------|
|          | Mitragyna inermis (Willd.) Kuntze (MAS 153)         | 3     | *            | Ann      | 1.03 | Tree | Le | R      | W      |
| Rubiaceae| Morinda lucida Benth. (MAS 75)                      | 13    | *            | Per      | –    | Tree | Le | D      | W      |
|          | Sarcocephalus latifolius (Sm.) E.A.Bruce (MAS 154)  | 25    | **           | Per      | 0.67 | Shrub | Le | R      | W      |
|          | Spermacoce hepperrana Verdc. (MAS 243)              | 9     | *            | Ann      | –    | Herb | Le | R      | W      |
|          | Spermacoce stachydea DC. (MAS 617)                  | 6     | *            | Ann      | 1.03 | Herb | Le | R      | W      |
| Sapindaceae | Blighia sapida Konig (MAS 139)                  | 6     | **           | Per      | –    | Tree | Le | DR     | W      |
| Sapindaceae | Deinbollia pinnata (Poir.) Schumach. & Thonn. (MAS 44) | 13    | *            | Per      | –    | Shrub | LS | R      | W      |
|          | Paullinia pinnata L. (MAS102)                        | 25    | **           | Ann      | –    | Liana | LS | D      | W      |
| Sapotaceae | Mimusops kummel Bruce ex A.DC. (MAS 409)            | 19    | **           | Per      | –    | Shrub | Le | D      | W      |
|          | Pouteria alnifolia (Baker) Roberty var. alnifolia (MAS 211) | 6     | *            | Per      | –    | Shrub | Le | D      | W      |
|          | Vitellaria paradoxa                                  | 19    | ***          | Per      | 1.03 | Tree | Le | D      | W      |
| Family                  | Species (voucher number) | FVP | Palatability | Lifespan | RF | LF | PP | Season | Status |
|------------------------|--------------------------|-----|--------------|----------|----|----|----|--------|--------|
| Scrophulariaceae        | C.F.Gaertn. (MAS 312)    |     |              |          |    |    |    |        |        |
|                        | *Striga hermonthica* (Delile) Benth. (MAS 66) | 0   | –            | Per      | 0.93 | Herb | Le | DR     | W      |
| Solanaceae             | *Harrisonia abyssinica* R.Br. ex A.Juss. (MAS 231) | 6   | *            | Per      | –   | Shrub | Le | D      | W      |
| Sterculiaceae          | *Sterculia setigera* Delile (MAS 321) | 0   | –            | Per      | 0.64 | Tree | Le | DR     | W      |
|                        | *Waltheria indica* L. (MAS 87) | 0   | –            | Per      | 0.82 | Herb | LS | R      | W      |
| Taccaceae              | *Tacca leontopetaloides* (L.) Kuntze (MAS 545) | 13  | **           | Per      | –   | Herb | LS | DR     | W      |
| Tiliaceae              | *Grewia cissoides* Hutch. & Dalziel (MAS 273) | 0   | –            | Per      | 0.46 | Shrub | LS | D      | W      |
|                        | *Grewia villosa* Willd. (MAS 718) | 6   | *            | Per      | 0.90 | Shrub | Le | D      | W      |
|                        | *Triumfetta pentandra* A.Rich. (MAS 313) | 0   | –            | Per      | 0.31 | Herb | LS | R      | W      |
| Verbenaceae            | *Clerodendrum capitatum* (Willd.) Schumach. & Thonn. (MAS 362) | 19  | *            | Per      | –   | Liana | LS | D      | W      |
|                        | *Gmelina arborea* Roxb. (MAS 411) | 19  | ***          | Per      | –   | Tree | LS | D      | W      |
| Family          | Species (voucher number) | FVP W | Palatability | Lifespan | RF C | LF | PP | Season | Status |
|-----------------|--------------------------|-------|--------------|----------|------|----|----|--------|--------|
| Zingiberaceae   | *Vitex doniana* Sweet (MAS 143) | 0     | –            | Per      | 0.98 | Tree | Le | D      | W      |
| Zingiberaceae   | *Costus spectabilis* (Fenzl) K.Schum. (MAS 609) | 6     | **          | Per      | –    | Herb | Le, Fl | D      | W      |
| Zygophyllaceae  | *Siphonochilus aethiopicus* (Schweinf.) B.L.Burtt (MAS 164) | 19    | *           | Per      | –    | Herb | Le | D      | W      |
| Zygophyllaceae  | *Balanites aegyptiaca* (L.) Delile (MAS 180) | 0     | –           | Per      | 0.31 | Shrub | Le | D      | W      |
|                 | *Tribulus terrestris* L. (MAS 201) | 3     | *           | Ann      | –    | Herb | LS | DR     | W      |

*Leg-* Leguminosae; *FVPW* fodder value during pasture walk; *RFC* relative citation frequency; lifespan (Per perennial, Ann annual); *PP* plant parts (Le leaves, LS leafy stems, Fr fruits, Fl flowers, tub tubercle, WP whole plant); status (W wild, C cultivated, WC wild and cultivated); palatability (*fairly palatable, **weakly palatable, ***highly palatable), season (D dry season, R rainy season, DR dry and rainy season)

Only 38.74% of species are available during all seasons (perennial species). Concerning their life form, fodder plants include mostly herbs (58%). These were followed by trees (21%), shrubs (16%) and lianas (5%). The majority of these plants were wild (92%) followed by cultivated (5%) while about 3% were reported as wild or cultivated. Fallows and farmlands (79%) were habitat with high proportion of species. The remaining includes the savannah (16%), forest (3%), habitation and meadow (1% each).

**Plant parts consumed**

Even though major plant parts are significant in the bovine alimentation, leaves were the most commonly used plant part with 58% of citation (Fig. 2). It was followed by leafy stem (28%), flowers and fruits (4% each). However, whole plant was cited in 6% of cases.
The relative frequencies of citation (RFC) of 116 cited species are shown in Table 3. RFC varies from 1.12 to 5.81%, with 16 species having RFC higher than 1.38 (the average of RFC). Plant species such as *Andropogon gayanus*, *Panicum maximum*, *Pterocarpus erinaceus* and *Flueggea virosa* which were frequently cited were the four dominant plants used as cattle fodder by the breeders in Benin (Table 3). These were followed by *Andropogon tectorum* (RFC = 4.24%), *Anogeissus leiocarpa* (3.16%), *Piliostigma thonningii* (2.83%), *Pseudocedrela kotschyi* (2.57%), *Prosopis africana* (2.52%), *Digitaria horizontalis* (2.29%) and *Annona senegalensis* (2.21%). Those with the lowest citation frequencies included fodder plants such as *Bambusa vulgaris* and *Vetivera nigritana* (0.12% each).

Percentage of fodder value during pasture walk (FVPW) varied from 3% (52 species) to 50% (2 species) (Table 3). We established 3 groups according to the palatability of fodder: 16 highly palatable, 73 weakly palatable fodder and 113 fairly palatable plants (Table 3).
Selection of priority fodder plants consumed by cattle and their characteristics in Benin

Results from regression analysis showed a significantly positive correlation between relative citation of the species (RFC) and fodder value percentage during pasture walk (FVPW) \( (r = 0.814; p < 0.001) \). There was 66.66\% of the variation of RFC that were explained by the variation of FVPW (Fig. 3). Species with higher RFC values often had higher FVPW and included *Andropogon gayanus*, *Panicum maximum* and *Pterocarpus erinaceus*.

![Correlation between relative frequency of citation (RFC) and fodder value during pasture walk (FVPW)](image)

We considered the 16 fodder plants having RFC higher than 1.38\% (the average of RFC), as top fodder species in Benin (Table 4). According to local people, only 38\% of them were highly palatable (Table 4).

| Nº | Species   | Family        | RFC | FVPW | P | Ls | MT | PP | Properties |
|----|-----------|---------------|-----|------|---|----|----|----|------------|

Table 4

Top 16 fodder plants consumed by the cattle in Benin

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| No | Species                  | Family    | RFC  | FVPW | P   | Ls | MT     | PP   | Properties                                                                 |
|----|--------------------------|-----------|------|------|-----|----|--------|------|----------------------------------------------------------------------------|
| 1  | *Andropogon gayanus*     | Poaceae   | 5.81 | 47   | **  | Ann| Herb   | Le   | Very good forage                                                           |
| 2  | *Panicum maximum*        | Poaceae   | 5.45 | 50   | *** | Ann| Herb   | Le   | Good forage                                                                |
| 3  | *Pterocarpus erinaceus*  | Leguminosae | 5.34 | 50   | *** | Per| Tree   | Le   | Most consumed in drought, increases weight gain                             |
| 4  | *Flueggea virosa*        | Euphorbiaceae | 5.14 | 47   | *** | Ann| Bushy shrub | LS   | Great appetency in drought                                                 |
| 5  | *Andropogon tectorum*    | Poaceae   | 4.24 | 31   | **  | Ann| Herb   | Le   | Very good forage                                                           |
| 6  | *Anogeissus leiocarpa*   | Combretaceae | 3.16 | 25   | **  | Per| Tree   | L e | –                                                                           |
| 7  | *Piliostigma thonningii* | Leguminosae | 2.82 | 31   | **  | Per| Tree   | L e, F r | Good appetency                                                             |
| 8  | *Pseudocedrela kotschyi* | Meliaceae | 2.57 | 31   | **  | Per| Tree   | L e | –                                                                           |
| 9  | *Prosopis africana*      | Leguminosae | 2.52 | 31   | *** | Per| Tree   | L e, F l | Induces milk production                                                    |
| 10 | *Digitaria horizontalis* | Poaceae   | 2.28 | 13   | **  | Ann| Herb   | Le   | Good forage                                                                |
| 11 | *Annona senegalensis*    | Annonaceae | 2.21 | 9    | *   | Per| Shrub  | Le   | –                                                                           |
| 12 | *Afzelia africana*       | Leguminosae | 1.59 | 16   | *** | Per| Herb   | Le   | Induces milk production                                                    |
| 13 | *Acacia sieberiana*      | Leguminosae | 1.54 | 13   | **  | Per| Tree   | L e, F r | Great appetency in drought                                                |
| 14 | *Tephrosia purpurea*     | Leguminosae | 1.54 | 13   | **  | Ann| Herb   | L S | Anthelmintic                                                               |
| 15 | *Detarium microcarpum*   | Leguminosae | 1.44 | 6    | **  | Per| Tree   | L S | Treat diarrhoea, constipation                                              |
| 16 | *Leucaena leucocephala*  | Leguminosae | 1.41 | 22   | *** | Per| Tree   | L e | Nutritious plant                                                           |

RFC relative frequency of citation, FVPW fodder value during pasture walk, P palatability (*fairly, **weakly, ***highly), Ls lifespan, Per perennial, Ann annual, MT morphological type, PP plant parts used, Le leaves, Fl flower, LS leafed stem, Fr fruit

**Discussion**
Diversity of recorded fodder species

Fodder plants consumed by cattle represent 9.01% of the flora of Benin reported by Akoègninou et al. [18]. Among them, only 23.23% are hold by breeders. This shows their low knowledge level about fodder resources. Locally, the clear distinction between the species harvested on pasture and those quoted by the breeders can be explained by the non-control of the plants by the breeders. In vegetation, they are not concerned about feeding cattle as the resource is available and do not continuously monitor the animals. Except in drought, due to lack of grasses, breeders make the choice to cut the branches of shrubs and trees to allow the animals to feed. This was the same on the farms where the drovers cut branches of species to facilitate grazing on the herd. Complementation of cattle diet in the dry season with woody leaves is a common practice in several tropical countries [25, 26, 27, 28, 29, 30]. This technique makes it possible to provide supplements and to limit the decline in milk production, but the choice of a well-browsed and productive species is necessary [28]. Among species affected by this practice are Khaya senegalensis, Afzelia africana, Prosopis africana, Pterocarpus erinaceus, Leucaena leucocephala, Pilostigma thomningii, Acacia sieberiana, etc. The nutrient input of ligneous fodder is significant in quantitative terms, for reducing seasonal fodder shortfalls and maintaining the livestock, but it is not enough to significantly improve the nitrogen levels of diets, which is a production-limiting factor [29].

Specific richness obtained was 5.27, 10.12 and 1.70 times higher the numbers reported by Sèwadé et al., Sidi et al. and Sinsin et al. [15, 16, 31] respectively for fodder flora in the country. These differences would be due to the national scope of the present study and the combined effect of ethnobotanical studies and the transit walks, contrary to earlier work which covered only part of the country, the ethnobotanical investigations or based only on tree fodder inventory. On the other hand, if we compare our data with the number of fodder species reported outside Benin, specific richness appeared to be relatively higher or lower. César and Zoumana [32] reported 214 species consumed by cattle, sheeps and goats in savannas of Côte-d’Ivoire. In southwest China [13] and northeast Brazil [6], it was respectively reported 143 and 136 fodder plant species consumed for cattle. These gaps can only be explained by the same arguments given above. Many of these plant species were widely exploited by livestock in other regions of Africa, for example Uganda, Kenya, Zimbabwe, Ethiopia, Nigeria, Rwanda and Mozambique [7, 33, 34, 35, 36, 37, 38, 39], and elsewhere in the world [6, 40]. They are species with important nutritious value for ruminants and highly used in cropping systems. We can cite Leucaena leucocephala, Panicum maximum, Andropogon gayanus, Imperata cylindrica, Pterocarpus erinaceus, Cynodon dactylon, Digitaria horizontalis, Anacardium occidentale, Mangifera indica, Anogeissus leiocarpus, Alchornea cordifolia, Chamaecrista rotundifolia, Eleusine indica, etc.

Among 185 plant families represented in Benin [18], 29.18% were recorded as fodder plant families. The most diversified in terms of species were Leguminosae and Poaceae. The importance of these families is not a particularity for the fodder flora, but it is a general characteristic of Benin flora because they respectively represent 14.8 and 9.3% among 2807 species [18]. Our findings suggested high genera diversity among recorded species. Thus, in a context of the species rarity, Benin flora provides the possibility to select a great number of fodder species.
Knowledge about recorded fodder species and use priority by local communities

Though the importance of Leguminosae and Poaceae among recorded plant families is related to the characteristic of Benin flora, this is prominent in the literature, and information regarding the potential productivity and nutritional value is abundant, mainly due to the preference of animals for these two families. Breeders, in permanent touch with their animals, accumulate concurrently day by day the experiences as well on zoo-technique plan as sanitary in order to improve their knowledge on the production and reproduction of animals. Thus, traditional knowledge about foders of communities should build on the base of their observations and this is orally handed down through generations. Today, they have increased their knowledge and they select great foders following two main criteria namely quality and availability during the dry season. When we asked factors determining fodder quality, they had cited the palatability, aptitude of the fodder to increase milk production, to treat cattle pathologies, and their ability to fatten cattle. As overall objective of breeders is to sustainably feed cattle in order to improve their production and reproduction, important foders were selected on the base of these criteria. Indeed, our study revealed Benin breeders preferentially use 16 fodder species that should be considered as priorities. They mostly belong to Leguminosae and Poaceae; Leguminosae being classified as sweet and fattening plants while Poaceae classified as palatable and productive in other regions. These findings are consistent with many studies [9, 41, 42, 43]. Among the 16 priority species selected, some have already been identified by Sidi et al. [15] as priority fodder plants in northern Benin namely Pterocarpus erinaceus, Afzelia africana, Acacia sieberiana, Piliostigma thonningii and Flueggea virosa. These species were also reported in other regions (Sénégal, Cameroon, Niger, etc.) [25, 27, 28] as priority woody species used by pastoralists in Sudanian zone.

Trees and shrubs represented high proportion among foders cited by local communities. The preference of breeders for these life forms should be due to their availability in all the seasons but also to the relative low contents of crude protein and some minerals in tropical grass species [6, 32, 44, 45].

The plant part used in animal feed is an important criterion of the nutritional [12, 46] and ecological [47] point of view. The widespread use of leaves for fodder in our study is in accordance with the findings of Ayantundé et al. [48] in southwestern Niger, where leaves are the most widely plant part used for fodder and traditional medicine by the agropastoralists.

Fodder species and sustainable production of cattle in Benin

We think that the valorization and sustainable utilisation of 16 priority foders could help to improve the cattle production. Among these plants, breeders listed Afzelia africana, Acacia sieberiana, Prosopis africana, Piliostigma thonningii, Digitaria horizontalis, Leucaena leucocephala, Pterocarpus erinaceus, Flueggea virosa, Panicum maximum and Andropogon gayanus as forage providing important nutritional properties with high palatability. Literature informs that this nutritive value hold by these plants is due to their content in total nitrogenous substances, which are mostly important in L. leucocephala, P. erinaceus, A. africana, A. sieberiana, P. africana [48] and P. maximum and A. gayanus [49]. This makes these plants
genuine protein banks for feeding of ruminants during the both seasons due to the presence of
two types of fodders (annual and perennial). In addition, according to the breeders, some of these
fodders hold many medicinal properties. *Tephrosia purpurea* was recognised as being efficiently
used to treat helminthiasis, whereas *Detarium microcarpum* was cited to address several
gastrointestinal disorders notably diarrhoea and constipation. Furthermore, breeders recognised
*P. africana* and *A. africana* as plants involved in increasing of the production of milk after their
grazing by the cow. This knowledge hold by local breeders comes from a deep relation between
human and biological resources of its local environment. Volpato and Puri [49] showed the
Sahrawi recognise in detail the relations between forage and the taste, smell or health and
nutritional properties of camel milk because camel milk was the main output of camel husbandry
and a staple food in the Sahrawi pastoral system. Currently, the valorization of the local
knowledge related to these species needs further studies in particular phytochemical and
pharmacological to confirm medicinal properties, as well as anatomical, to identify their anti-
nutritional drivers’ content such as lignins, which block the digestibility of nitrogen in rumen.

Most of top fodders form a component of livelihood strategies in the country because they remain
an important source of health care and constitute an essential basis in traditional medicine
improvement. They are also valued for their timber and their trade importance. Unfortunately, the
large combined and increasing demand for these plants and the consequent increase in the rate of
collection negatively affected the wild populations of many species, to the point that some
species are now considered to be threatened with extinction. Thus, 2 fodder species among 16
priorities (12.50%) were classified as endangered plant species according to the International
Union for Nature Conservation (https://www.iucnredlist.org/) and Adomou et al. [5]. We will cite
*A. africana* and *P. erinaceus*. This handicaps their sustainable use. Agroforestry species such as
*Vitellaria paradoxa* and *Khaya senegalensis* benefit from particular management practices such
as assisted natural regeneration, seeding or often sapling transplantation within the farmlands
[50]. But some species as *A. africana* seems to be neglected [50]. Urgent conservation measures
must be taken for ensuring their sustainability use in Benin.

Pasture production is traditionally unknown in Benin, but forage cultivation is done on national
farms [51]. Cultivated fodders have been experimented with but are of little importance in
smallholder stock rearing. Fortunately, some fodders are cropped in several state farms such as *L.
leucocephala, Brachiaria* spp., *P. maximum* and *A. gayanus*. However, this does not fully ensure
t heir fodder needs for livestock. So the development of a breeding program or improvement of
the priority forage species on these farms should be considered. After a promising species has
been identified, evaluated and developed into a cultivar by selection or breeding, the seed of the
resulting cultivar has to be made available to farmers for testing and use.

**Conclusion**

The combination of ethnobotanical studies and transit walks constituted efficient means for the
documentation of 257 fodder plants consumed by cattle in Benin. Specific richness obtained
during transit walk demonstrates the importance of follow-up in identifying fodder plants. In
addition, this paper provided the lifespan, life form, most commonly used parts for fodder, in
palatability, status, and a listing of priority fodder plants. The 16 top priorities were considered as
important fodder resources used in Benin. Further studies are needed including an anatomical evaluation of 16 fodder species consumed by cattle for assessing their digestive capacity.

**Abbreviations**

*Ann:* Annual  *C:* Cultivated  *D:* Dry season  *DR:* Dry and rainy season  *FEB:* State farm of Bétécoucou  *FEK:* State farm of Kpinnou  *FEO:* State farm of Okpara  *FES:* State farm of Samiondji  
*Fl:* Flowers  *Fr:* Fruits  *FVPW:* Fodder value during pasture walk  *Le:* Leaves  
*Leg:* Leguminosae  *LS:* Leafy stems  *MT:* Morphological type  *Per:* Perennial  *PP:* Plant parts  
*R:* Rainy season  
*RFC:* Relative frequency of citation  *Temp:* Temperature  *tub:* Tubercle  *W:* Wild  
*WC:* Wild and cultivated  *WP:* Whole plant

**Declarations**

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**Availability of data and materials**

All datasets on which the conclusions of the paper rely made available in the manuscript. The voucher specimens are kept at the Laboratory of Botany and Plant Ecology at National Herbarium of Benin and will be available upon request.

**Authors’ contributions**

OJMAS, DGH and AAC conceived and designed the research. OJMAS collected the data. AAC and YF provided the botanical identification of the species. OJMAS, DGH and AAF analysed the data. OJMAS wrote the manuscript. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**

All farmers and breeders gave their consent before conducting the interview. The pasture walk was authorised by the Coordinator of PAFILAV (Programme d’Appui aux Filières Lait et Viande) that ensure the management of state farms.
Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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