Ethnoveterinary knowledge of sheep and goat farmers in Benin (West Africa): effect of socioeconomic and environmental factors

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Abstract
Sheep and goats are two of the main animal species raised in Benin and one of the main sources of income for people living in rural areas. Faced with the inaccessibility of synthetic veterinary products and their low purchasing power, the majority of breeders use ethnoveterinary practices to treat small ruminants diseases. The specific objectives of the current study were (1) to document the traditional knowledge regarding the disorder groups treated and the medicinal plants used in the health and zootechnical management of small ruminants in Benin and (2) to assess the effect of gender, ethnicity, agro-ecological zone and herd size associated with them. To achieve these objectives, an ethnoveterinary survey was conducted in different agro-ecological zones from September 2018 to February 2019. A questionnaire was administered to 506 breeders. The data were analyzed through calculation of the Fidelity Level (FL), Cultural Importance Index (CI) and Informant Consensus Factor (ICF). Ten disorder groups were treated by the people surveyed. These were mainly digestive disorders (D) and reproductive disorders (W), both presenting a ICF value of 0.8. A total of 101 medicinal plants belonging to 42 families and 90 genera were recorded. Gender, ethnicity, agro-ecological zone and flock size were the socioeconomic and environmental factors that significantly influenced the level of ethnoveterinary knowledge. Chemical and biological analysis are needed on less studied plants such as, Striga hermonthica, Crossopteryx febrifuga, Elaeis guineensis and Momordica charantia.

1. Introduction
Small ruminants are one of the main sources of income for poor families. In Benin, their number in 2018 was estimated at 2,875,000 (1,921,000 goats and 954,000 sheep), ranking second after poultry (FAOSTAT, 2018, http://www.fao.org/faostat/fr/#data/QA). Sheep and goats were contributed to 13% of total meat production in Benin in 2013 (Mensah et al., 2018). For the breeders, small ruminants play an economic role but also have social, cultural and religious functions (Dossa et al., 2007, 2015; Lakew et al., 2017). Sheep and goats are kept by breeders mainly for economic function and the income are used to buy foods, clothes, to pay school fees for children and solve people health problems.
problems (Dossa et al., 2007). In addition, small ruminants are used in certain sociocultural practices such as marriage, traditional ceremonies and their excrements serve to organic fertiliser (Mensah et al., 2018).

Small ruminants farming in Benin encounter certain constraints namely, diseases that lower their performance (Hounzangbé-Adoté, 2001; Dossa et al., 2007). According to Attindéhou et al. (2012), gastrointestinal parasitosis remain the main disease encountered in sheep and goats farms. In addition to this, diarrhoea, scab, respiratory problems and reproductive disorders are the most symptoms identified in small ruminants farms in South of Benin (Hounzangbé-Adoté, 2001; Dossa et al., 2007), that lead to high mortality. Similarly, in Nigeria, diarrhoea and pneumonia are encountered, respectively, in 12.4% and 20.3% of small ruminants farming (Omoike, 2006).

Faced with the inaccessibility of synthetic veterinary products and their low purchasing power, the majority of breeders use ethnoveterinary practices to treat animals (Dassou et al., 2015a; Houndje et al., 2016). Thus, several studies conduct in Benin have addressed ethnoveterinary practices by listing the medicinal plants used to treat livestock diseases (Hounzangbé-Adoté, 2001; Ogni et al., 2014; Dassou et al., 2015a; Houndje et al., 2016). However, most of these studies inventoried medicinal plants used to treat diseases of all domestic animals (Ogni et al., 2014; Dassou et al., 2014, 2015a), while medicinal plants as well as the traditional recipes used by breeders depend on the animal species targeted. For example, Ouachinou et al. (2019) analysed medicinal plants used to treat gastrointestinal disorders in cattle in Benin. The few studies analysing ethnoveterinary practices in sheep and goats farming in Benin have been limited to the South (Hounzangbé-Adoté, 2001; Attindéhou et al., 2012), while small ruminants are distributed across the entire country. The northern part of the country is home to a number of sociocultural groups not found in the South, which practice sheep and goats farming. This area is not easily accessible to veterinary agents and products. Breeders are therefore obliged to develop ethnoveterinary practices to ensure the well-being of their animals. Ethnoveterinary medicine practices depend
on the ethnic groups and resources available in the area (Wanzala et al., 2005). Moreover, studies conducted in the South analysing plants used to treat parasitic diseases (Attindehou et al., 2012), while ethnoveterinary practices in sheep and goats farming cannot be limited to parasitic diseases only.

In this study, we present the results of an ethnoveterinary survey to document traditional knowledge and practices related to the zoo-sanitary management of sheep and goats farms in Benin. Specifically, the study aims to:

- Document the traditional knowledge regarding the disease groups treated and the medicinal plants used for the health and zootechnical management of small ruminants in Benin.
- Assess the effect of gender, ethnicity, agro-ecological zone and herd size associated on this traditional knowledge.

2. Material and methods

2.1. Study area

The study was conducted in Benin (West Africa), in 6 of the 8 agro-ecological zones defined (Figure 1). SICC/Benin (2016) (https://www.changementsclimatiques.bj/zones-agro-ecologiques-de-la-republique-du-benin/) defines these areas as follows:

- Zone 1 (Far North Benin) hosts the largest part of the forest reserves with the W National Park of Niger. Its climate is of Sudano-Sahelian type, with temperature reaching 40 °C in the shade in the dry season. The zone includes 2 municipalities, one being Karimama.
- Zone 3 (Food crop region of South Borgou) is essentially characterized by a very high availability of agricultural land. It covers 8 municipalities including N'Dali. It is part of Sudanian zone and the climate is characterized by a rainy season from April to September and a dry season that lasts almost 5 months.
- Zone 4 (West zone of Atacora) benefits for the presence of Atacora chain which leads to a particular climate where the temperatures are cooler and thunderstorms more frequent than in the other zones. Precipitation varies from 800 to 1350 mm annually. The main river is the Pendjari with its tributaries. The zone hosts 8 municipalities including Toucoutouma and Boukoumbe.
- Zone 6 (Zone dominated by laterite soils) is located in the southern part of Benin and counts 22 municipalities including Covë and Za-Kpota. The climate is marked by two rainy seasons (March–July; October–November) and two dry seasons (December–February; August). Annual precipitation varies between 1000 to 1400 mm.
- Zone 7 (Zone of depressions) is the smallest of the 8 agro-ecological zones in terms of area and hosts the municipality of Lalo. On the climatic level, it is quite comparable to zone 6 with, however, a high relative humidity (around 85%).
- Zone 8 (Region of fisheries and vegetable crops): a main characteristics of this zone is the presence of inland and maritime fishing in addition to plant and animal production. Geographically, it is the most southerly zone and occupies the fluvio-lacustrine zone of the Atlantic, Mono, Oueme and Zou departments. It covers 13 municipalities including Bopa.

The population of Benin was estimated at 12,118,842 in 2019. Fon, Adj, Yoruba, Bariba, Dendi, Peuhl, Otammari, Yoa and Lokpa are the main sociocultural groups encountered (INSAE, 2016). Christianity, Islam and Vodoun are the main religions practiced. Agriculture, livestock and handicraft are the main activities. Eight more poor municipalities where small ruminants breeding is predominant were selected to host the study. Then, we used the 8 agro-ecological zones defined to identify those covered by the respective municipalities. In each municipality, 4 villages were chosen based on their accessibility and the ethnoveterinary practice to treat small ruminants diseases.

2.2. Sampling

A baseline survey was conducted beforehand and this allowed to identify 4 villages per municipality to conduct the survey. The baseline was carried out with the support of Non Governmental Organisations (NGOs) and governmental institutions that intervene in the target municipalities and made it possible to choose villages with easy accessibility and predominance of ethnoveterinary practices. The sample size (n) per municipality was determined according to Dagnelie (1998) formula (Equation 1).

\[
\text{n} = \frac{U^2 \times p(1-p)}{d^2}
\]

Where n is the sample size of the population to be surveyed per municipality, \(U^2\) = 1.96 is obtained from the standard distribution table of normal distribution with \(\alpha = 0.05, p = 80\%\) being the proportion of the population using medicinal plants to treat small ruminants diseases, and d (d = 0.075) being the margin of error we fixed. Based on the formula, a minimum of 56 persons was interviewed per municipality. Therefore, a minimum of 14 persons were selected per village to participate in the study.

2.3. Data collection

The ethnobotanical survey was conducted from September 2018 to February 2019 and surveyed 506 people identified by purposive selection. The choice of respondents was based on their availability and willingness to participate in the study. Approval from the ethics committee of the University of Abomey-Calavi was granted. A questionnaire was developed and took into account, among other things the characteristics of the respondents (gender, age, ethnicity ...), the main plants and handicraft are the main activities. Eight more poor municipalities where small ruminants breeding is predominant were selected to host the study. Then, we used the 8 agro-ecological zones defined to identify those covered by the respective municipalities. In each municipality, 4 villages were chosen based on their accessibility and the ethnoveterinary practice to treat small ruminants diseases.

| Variables                  | Description                  | Frequency |
|---------------------------|------------------------------|-----------|
| Sex                       | Male                         | 366 (72.4%)|
|                           | Female                       | 140 (27.6%)|
| Sociocultural groups      | Fon                          | 126 (24.9%)|
|                           | Otammari                     | 78 (15.4%)|
|                           | Peuhl                        | 63 (12.4%)|
|                           | Sahoue                       | 62 (12.2%)|
|                           | Adjia                        | 61 (12.1%)|
|                           | Dendi                        | 48 (9.5%) |
|                           | Natimba                      | 23 (4.6%)  |
|                           | Wama                         | 25 (4.9%)  |
|                           | Bariba                       | 25 (3.1%)  |
| Age                       | [20 40)                      | 141 (27.9%)|
|                           | [40 60)                      | 220 (43.5%)|
|                           | [60 80)                      | 108 (21.3%)|
|                           | [80 100]                     | 37 (7.3%)  |
| Religion                  | Animist                      | 241 (47.6%)|
|                           | Christian                    | 144 (28.5%)|
|                           | Muslim                       | 121 (23.9%)|
| Level of education        | Illiterate                   | 340 (67.2%)|
|                           | Alphabet in local language   | 34 (6.7%)  |
|                           | Primary level                | 80 (15.8%)|
|                           | Secondary level              | 40 (7.9%)  |
|                           | University level             | 12 (2.4%)  |
| Main activity             | Agriculture                  | 369 (72.9%)|
|                           | Breeding                     | 54 (10.7%) |
|                           | Handicraft                   | 43 (8.5%)  |
|                           | Phytotherapy                 | 41 (8.1%)  |
Table 2. Quantitative analysis of medicinal plants used to treat small ruminants diseases in Benin.

| Family          | Specie                              | Vernacular name | Origin         | PC  | CI  |
|-----------------|-------------------------------------|-----------------|----------------|-----|-----|
| Anacardiaceae   | Mangifera indica L.                 | Amanga (f)      | From the garden| 15  | 0.03|
|                 | Papilia lappacea (L.) Juss.         | Trédoagbokof (f)| From the wild  | 5   | 0.01|
|                 | Spondias mombin L.                  | Akikinton (f)   | From the garden| 105 | 0.208|
| Annonaceae      | Annona senegalensis Pers.           | Yariti (b)      | From the wild  | 3   | 0.006|
| Apocynaceae     | Saba senegalensis (A. DC.) Pichon    | Agbanakof (f)   | From the wild  | 1   | 0.002|
|                 | Thevetia peruviana (Pers.) K.Sehum. | Tenia (w)       | From the wild  | 2   | 0.004|
| Arecaceae       | Elaeis guineensis Jacq.             | Detin (f)       | From the farm  | 24  | 0.047|
| Asclepiadaceae  | Calotropis procera (Ait.) Alt. f    | Sagayi (d)      | From the garden| 2   | 0.004|
|                 | Leuconostor hastata (Pers.) Decne   | Sokpototori (p) | From the wild  | 1   | 0.002|
|                 | Pergularia daamia (Forsk.) Chiov.   | Kpanyawen (f)   | From the wild  | 3   | 0.006|
| Asteraceae      | Acanthus rhizoides L.               | Vepré (f)       | From the wild  | 1   | 0.002|
|                 | Chromolaena odorata (L.) R.M.King   | Agatoutin (f)   | From the wild  | 4   | 0.008|
|                 | Tridax procumbens (L.) L.           | Azoniman (f)    | From the farm  | 2   | 0.004|
|                 | Vernonia amygdalina Delile           | Kakawaabou (w)  | From the garden| 17  | 0.034|
| Bignoniaceae    | Newbouldia javaris (P. Beauv.) Seem | Desrégue (f)    | From the garden| 20  | 0.04|
|                 | Stereocarpus kunthianum Cham        | Brewebe (b)     | From the wild  | 1   | 0.002|
| Boraginaceae    | Rhodogyne alata (Sprague) Roberthy  | Kptin diboun (f)| From the wild  | 15  | 0.03|
| Caricaceae      | Carica papaya L.                    | Kpentin (f)     | From the garden| 10  | 0.02|
| Chrysobalanaceae| Mananthes plicatula (Mart.) France  | Kpakpiku (b)    | From the wild  | 2   | 0.004|
| Combretaceae    | Anogeissus leiocarpa (Decne)        | Alighangangmi (p)| From the wild  | 8   | 0.016|
|                 | Combretum glutinosum (L.) ex De    | Bousou (c)      | From the wild  | 16  | 0.032|
|                 | Guiera senegalensis J.F. Gmel       | Gueloke (p)     | From the wild  | 2   | 0.004|
|                 | Pilocarpus macrophlebus Engl. & Diels| Kouautounabou (w) | From the wild | 1   | 0.002|
|                 | Terminalia ivieioides Guill. & Perr.| Tigéréi (p)     | From the wild  | 3   | 0.006|
| Connaraceae     | Roussea coccinea (Thom. ex Schumach.) Benth. | Gbédebédé (f) | From the wild  | 3   | 0.006|
| Crassulaceae    | Bryophyllum pinnatum (Lam.) Oken    | Dodoeti (a)     | From the wild  | 1   | 0.002|
| Cucurbitaceae   | Momordica charantia L.1753          | Gniñaksin (f)   | From the wild  | 12  | 0.024|
| Dichapetalaceae | Dichapetalum madagascariense Poir.  | Ngbo (f)        | From the wild  | 1   | 0.002|
| Dioscoreaceae   | Dioscorea hispida (Benth.) Poit.    | Dintant (e)     | From the wild  | 20  | 0.04|
| Ebenaceae       | Diospyros mespiliformis Hochst. ex A. Rich | Wonyibu (b) | From the wild  | 4   | 0.008|
| Euphorbiaceae   | Bridelia ferruginea Benth.          | Hinhon (s)      | From the wild  | 2   | 0.004|
|                 | Euphorbia balsamifera Aiton         | Tchouloyi (p)   | From the wild  | 3   | 0.006|
|                 | Euphorbia poisonii Pax              | Lokoto (d)      | From the wild  | 4   | 0.008|
|                 | Pluegia virsa (Roeb. ex Willd.) Voigt | Gbáiyikuinit (f)| From the wild  | 1   | 0.002|
|                 | Jarophyta eurea L.                  | Niyipotin (f)   | From the wild  | 2   | 0.004|
|                 | Manihot esculenta Crantz            | Ajängun (f)     | From the farm  | 4   | 0.008|
|                 | Margaritaria dioica (Baill.) Webster| Wusu poyi (b)   | From the wild  | 1   | 0.002|
| Icacinaceae     | Icacinia ritchiana Oliv.            | Agbébetin (f)   | From the wild  | 2   | 0.004|
| Irvingiaceae    | Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill. | Aslof (f) | From the garden | 1   | 0.002|
| Lamiaeae        | Hystis suaveolens (L.) Poit.        | Azonghidi (f)   | From the farm  | 3   | 0.006|
|                 | Ocimum gratissimum L.               | Tchao (f)       | From the garden| 35  | 0.069|
|                 | Platostoma africanum P.Beauv.       | Sima (f)        | From the wild  | 1   | 0.002|
| Leguminosae     | Acacia gourmaensis A. Chev.         | Taani (p)       | From the wild  | 11  | 0.022|
|                 | Acacia macrostachya Reichenb. ex DC | Sacounwa (p)    | From the wild  | 1   | 0.002|
|                 | Acacia nilotica (L.) Willd. ex Del. | Gawai (p)       | From the wild  | 2   | 0.004|
|                 | Afzelia africana Smith ex Pers      | Kparcabou (w)   | From the wild  | 2   | 0.004|
|                 | Casalpinia bonduc (L.) Roxb.        | Ajikinton (f)   | From the garden| 26  | 0.051|
|                 | Cajanus cajan (L.) Millsp.          | Ottriri (w)     | From the farm  | 3   | 0.006|
|                 | Gliricidia sepium (Jacq.) Kunth ex Wilh. | Tchantar (w) | From the farm  | 5   | 0.01|
|                 | Leucaena leucocephala (Lam.) De Wit | Forfitin (f)    | From the farm  | 2   | 0.004|
|                 | Mucuna pruriens (L.) DC. var. pruriens | Kpassekònti (f)| From the farm  | 2   | 0.004|
|                 | Parkia biglobosa (Jacq.) R. Br. ex G. Don | Ahwatin (f)| From the farm  | 4   | 0.008|
|                 | Periploca laxiflora (Benth.) ex van Meuwen | Wesajof (f) | From the wild  | 2   | 0.004|
|                 | Pilostigma reticulatum (DC.) Hochst. | Kláñloma (f)    | From the wild  | 1   | 0.002|
|                 | Pilostigma dementii (Schumach.) Milne-Redh | Kláñloma (f) | From the wild  | 4   | 0.008|
|                 | Prosopis africana (Guill. & Perr.) Taub | Kohi (p) | From the wild  | 3   | 0.006|
|                 | Pierocarpus erinaceus Poir.         | Gbérètton (f)   | From the wild  | 15  | 0.03|
|                 | Sesame oleaceum (L.) Roxb.          | Amsou (f)       | From the wild  | 1   | 0.002|

(continued on next page)
### Table 2 (continued)

| Family          | Specie                  | Vernacular name         | Origin                  | FC | CI |
|-----------------|-------------------------|-------------------------|-------------------------|----|----|
| Malvaceae       | Abelmoschus esculentus   | Laadje (p)              | From the farm           | 2  | 0.004 |
|                 | Adansonia digitata      | Kpessa (f)              | From the farm           | 40 | 0.079 |
|                 | Hibiscus sabdariffa     | Pounla (w)              | From the wild           | 4  | 0.008 |
| Meliaceae       | Azadirachta indica      | Kininutin (f)           | From the garden         | 19 | 0.038 |
|                 | Khaya senegalensis      | Boukoua (o)             | From the wild           | 61 | 0.121 |
|                 | Pseudocedrela kotchiyi  | Totosiré (w)            | From the wild           | 1  | 0.002 |
| Moraceae        | Ficus exasperata        | Bansou (b)              | From the garden         | 2  | 0.004 |
|                 | Ficus sur Porsak.       | Volima (f)              | From the garden         | 2  | 0.004 |
|                 | Ficus sycomorus         | Moukamkambou (o)        | From the garden         | 13 | 0.026 |
|                 | Ficus umbellatus        | Voma (f)                | From the garden         | 1  | 0.002 |
| Moringaceae     | Moringa oleifera        | Yovokpatin (f)          | From the garden         | 53 | 0.105 |
| Myrtaceae       | Eucalyptus camaldulensis| Boboro (o)              | From the farm           | 2  | 0.004 |
|                 | Psidium guajava         | Samporu (b)             | From the wild           | 1  | 0.002 |
|                 | Psidium guineense       | Kenkun (f)              | From the wild           | 6  | 0.012 |
| Ochnaceae       | Lophira lanceolata      | Karereti (p)            | From the wild           | 2  | 0.004 |
|                 | Ximenia americana       | Minimbou (w)            | From the wild           | 3  | 0.006 |
| Opiliaceae      | Opilia amentacea         | Soukousoukoi (p)        | From the wild           | 1  | 0.002 |
| Pedaliaceae     | Sesamum indicum         | Agboma (f)              | From the wild           | 2  | 0.004 |
| Poaceae         | Dendrocalamus asper     | Bambou (b)              | From the wild           | 1  | 0.002 |
| Polygalaceae    | Securidaca longpedunculata| Wapohou              | From the wild           | 1  | 0.002 |
| Rubiaceae       | Crossoseperey febrifuga| Rimatajogouai (p)       | From the wild           | 7  | 0.014 |
|                 | Mitragyna inermis (Wild.}| Kabe (d)                | From the wild           | 5  | 0.012 |
|                 | Morinda lucida          | Tchiketi (a)            | From the farm           | 55 | 0.109 |
|                 | Sarcocephalus latifolius| Godotin (f)             | From the wild           | 2  | 0.004 |
| Rutaceae        | Citrus limon (L.)       | Yovozin (f)             | From the garden         | 3  | 0.006 |
|                 | Zanthoxylum zanthoxyloides| Hétin (f)              | From the farm           | 63 | 0.125 |
| Sapindaceae     | Blighia sapida          | Pouroumbou (w)          | From the garden         | 1  | 0.002 |
| Scrophulariaceae| Striga hermonthica (Delile)| Manli (d)              | From the wild           | 52 | 0.103 |
| Solanaceae      | Datura innoxia          | Cocaine (w)             | From the wild           | 4  | 0.008 |
|                 | Nicotiana tabacum       | Titabaasi (o)           | From the garden         | 4  | 0.008 |
|                 | Solanum dasyphyllum Schumach. &Thonn | Tibouanacard (o) | From the garden         | 14 | 0.028 |
| Tiliaceae       | Grewia mollis Juss.     | Sahambou (w)            | From the wild           | 1  | 0.002 |
| Verbenaceae     | Gnetum arborum Roxb.    | Foftin (f)              | From the wild           | 1  | 0.002 |
| Vitaceae        | Citrus populnea Guill. & Perr| Goumei (p)         | From the farm           | 8  | 0.016 |
|                 | Citrus quadrangularis L.| Hambereti (p)          | From the wild           | 4  | 0.008 |
| Zygophyllaceae  | Balanites aegyptiaca (L.)| Garbé (d)             | From the wild           | 5  | 0.012 |

Vernacular language: f = Fon; b = Bariba; o = Otammarì; p = Peulh; s = Sahouè; d = Dendi; w = Wam; n = Natimba; a = Adja FC: Frequency of citation; and CI: Cultural Importance Index.

used to treat small ruminants diseases and improve their productivity, the parts used (roots, bark, leaves), recipe preparation, difficulties related to plant usage, development of the formulation and degree of satisfaction (efficacy of plants). The survey was conducted in the local languages of each community and local interpreters were used if necessary.

#### 2.4. Plant collection and identification

At the end of each interview, voucher specimens of inventoried plants were obtained from interviewees, harvested from the wild, farm or garden. Herbarium specimens were mounted and identified at the National Herbarium of Benin, University of Abomey-Calavi, using the analytical flora of Benin (Akoêginou et al., 2006). Plant specimens were coded and deposited in the herbarium. It was not possible to obtain specimens for all plants. There were seasonal plants that were not available during the survey. We therefore deleted the data for these plants (3 plants) before data analysis.

#### 2.5. Data analysis

##### 2.5.1. Diversity of inventoried medicinal plants

The collected data were used to establish the list of inventoried plants to treat small ruminants diseases. The number of species by genus and family was determined. To assess the diversity of plants used to treat small ruminants diseases, the Generic Coefficient (Rgc) which is the ratio number of species (Ns) over number of genera (Ng) (the inverse of the ratio defined by Fan et al. (2017) was determined (Equation 2).
Rgc = \frac{N_s}{Ng} \quad \text{(2)}

With ns being the number of inventoried species, Ng the number of genera and Rgc the Generic Coefficient. If Rgc = 1, then the plants used to treat small ruminants diseases have low diversity. Otherwise, each inventoried genera has only one species. If Rgc > 1, there is a high generic diversity within plants used to treat small ruminants diseases.

2.5.2. Quantitative analysis of inventoried medicinal plant species

To assess the most important medicinal species in the treatment of sheep and goats diseases in Benin, the CI was determined (Tardio and Pardo-De-Santayana, 2008) (Equation 3).

\[ CI = \frac{\sum U_{d=1} \sum n_{i-1} \text{URui}}{N} \quad \text{(3)} \]

Where dg being the total number of diseases groups, N being the number of respondents, UR being Use-Report number and CI being the Cultural Importance Index. The more the CI of a plant tends towards 1, the more important it is to the community.

2.5.3. Recorded small ruminants disease groups

The symptoms cited by the respondents were categorized into 10 disease groups using the second version of International Classification of Primary Care (ICPC-2, 2003) as suggested by Staub et al. (2015) and previously used by Miara et al. (2019). The ICF of Heinrich et al. (1998) were calculated to determine the level of consensus around the plants used to treat each disease category. It is calculated according to the formula below (Equation 4).

\[ ICF = \frac{Nur - Nt}{Nur - 1} \quad \text{(4)} \]

With Nur being the number of times a particular category p of disorders is mentioned, Nt being the number of plant (s) mentioned for the treatment of this particular disorders p. If ICF >0.5, then there is a high degree of consensus. In other words, the respondents agree on the plants used to treat this disease category. On the other hand, if ICF <0.5, this means that the respondents do not agree on the plants needed to treat this disease group.

2.5.4. Main plants used to treat disease groups

The analysis of the collected data made it possible to propose a list of plants used to treat each disease group. The majority of plant species are used to treat two or more disease categories. Thus, to select the most appropriate plants for the treatment of each disease category, the FL of Friedman et al. (1986) was calculated (Equation 5).

\[ FL = \frac{Np}{N} \quad \text{(5)} \]

With Np being the number of informants who mentioned a species for the treatment of a disease category p; N being the number of informants who mention the species for any disease category and FL being the Fidelity level. If FL > 0.5, then there is a high degree of consensus around the use of this species for the treatment of this disease category p and therefore this plant seems appropriate to treat this type of disease.

2.5.5. Socioeconomic and environmental factors affecting ethnoveterinary knowledge level

A matrix was constructed using socioeconomic and environmental factors (age, gender, ethnicity, agro-ecological zone, religion, household size, educational level, small ruminants herd size and the origin of the knowledge) as independent variables and the number of plants cited for the treatment of small ruminants diseases as a dependent variable. A classification analysis based on a decision tree was applied to the matrix to access socioeconomic and environmental factors which affect local knowledge to treat small ruminants diseases with plants. The analysis were carried out in R software (R Core Team, 2013), using rpartordinal package as describing by Archer (2010) and the differences were considered significant at the 5% level. Analyse of variance was performed for each factor affecting ethnoveterinary knowledge level, to access how factors influence ethnoveterinary practices.

3. Results and discussion

3.1. Socioeconomic characteristics of the respondents

A total of 506 small ruminants breeders were surveyed. They belonged to 9 sociocultural groups across Benin, namely Fon (24.9%), Oummari (15.4%), Peuhl (12.5%), Salsoe (12.3%), Adjia (12.1%), Dendi (9.5%), Wama (4.9%), Natimba (4.6%) and Bariba (3.9%). The average age of the respondents was 49 ± 16 years. The majority of the people surveyed were men (72.9%) (Table 1). This was probably due to the purposive selection of respondents who were mostly heads of households. Indeed, for cultural reasons, women are not called upon to speak publicly, especially about traditional knowledge. During the survey, some women who own small ruminants preferred to let their husbands speak because they felt that their husbands had a better knowledge of this aspect of animal breeding. This confirms the observations of Houngangbé-Adoté (2001) who concludes that women have practically no knowledge of ethnoveterinary practices. Interviews with the women during the survey took place in case of absence of the husband (head of the household) or with widows. Most of those surveyed personne were

| Disease category | Nur | Nt | ICF |
|------------------|-----|----|-----|
| Digestive disorders (D) | 448 | 72 | 0.8 |
| Reproductive disorders (W) | 183 | 34 | 0.8 |
| Blood and hematopoietic organ disorders (B) | 21 | 5 | 0.8 |
| Musculoskeletal disorders (L) | 21 | 6 | 0.8 |
| General and non-specific disorders (A) | 96 | 29 | 0.7 |
| Metabolic and nutritional diseases (T) | 31 | 10 | 0.7 |
| Respiratory disorders (R) | 65 | 25 | 0.6 |
| Neurological disorders (N) | 3 | 2 | 0.5 |
| Skin disorders (S) | 35 | 19 | 0.5 |
| Eye diseases (F) | 5 | 5 | 0.0 |

Nur: Number of times a particular category p of disorders is mentioned, Nt: Number of plant (s) mentioned for the treatment of this particular Disorders groups, ICF: Informant Consensus Factor.
| Plant | PC | CS | VN | PP | PM | AR |
|-------|----|----|----|----|----|----|
| Zanthoxylum zanthoxyloides (Lam.) Watermann | 61 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Striga hermonthica (Dellie) Benth. | 46 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Wp | Po | Ora |
| Adansonia digitata L., 1753 | 31 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | | Po | Ora |
| Khaya senegalensis (Desr.) A.Juss. | 31 | Día, Ind, Ano | Mirasra (f) Domédéde (a) | Ba, Ma, De | Ora |
| Morinda lucida Benth. | 29 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Spondias mombin L. | 23 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Morinda oleifera Lam. | 22 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Po, De | Ora |
| Elaeis guineensis Jacq. | 20 | Día, Ind, | Dan do home (d) Vlonkou le home (o) | Le | Gr | Ora |
| Caesalpinia bonduc (L.) Roxb. | 19 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | De, Gr | Ora |
| Azadirachta indica A. Juss. | 14 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba, Ma, Po | Ora |
| Pierocarpus erinaceus Poir. | 13 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Ba, Le, Po, Ma | Ora |
| Newbouldia laevis (P. Beav.) Seem | 12 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Tr, Gr | Ora |
| Vernonia amygdalina Delile | 11 | Día, Gap | Dan do home (d) Vlonkou le home (o) | Le | Gr, Tr | Ora |
| Ocimum gratissimum L. | 10 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Tr, De | Ora |
| Carica papaya L. | 9 | Día, Ind | Dan do home (d) Vlonkou le home (o) | Se | Po | Ora |
| Momordica charantia L., 1753 | 7 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Tr, Ma | Ora |
| Anogeissus leiocarpa | 6 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba | Ma, De | Ora |
| Vitex doniana Sweet, 1827 | 5 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Ba | De, Ma | Ora |
| Balanites aegyptiaca (L.) Delile | 4 | Ind, Gap | Dan do home (d) Vlonkou le home (o) | Se | Ma | Ora |
| Datura innoxia Mill., 1768 | 4 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Ma | Ora |
| Euphorbia poissonii Pax | 4 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | St, Le | Ma | Ora |
| Padium guineense Sw. | 4 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr, Ora |
| Crossopteryx febrifuga (DC.) Guill. & Perr. | 3 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba | Po | Ora |
| Hibiscus sabdariffa L., 1753 | 3 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | De | Ora |
| Mangifera indica L. | 3 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba | Ma, Gr | Ora |
| Ximenia americana L. | 3 | Día, Ind | Dan do home (d) Vlonkou le home (o) | Ro | Po, De | Ora |
| Acacia nilotica (L.) Willd. ex Delile | 2 | Día, Ind | Dan do home (d) Vlonkou le home (o) | Se | De | Ora |
| Bridelia ferruginea Benth. | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Citrus limon (L.) Burm.f | 2 | Día, Ind, Gap | Dan do home (d) Vlonkou le home (o) | Le | Po | De | Ora |
| Ficus sycomorus L., 1767 | 2 | Día, Ind, Gap | Dan do home (d) Vlonkou le home (o) | Le | Gr | Ora |
| Gliricidia sepium | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Acacia nilotica | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba | Ma, De | Ora |
| Manihot esculenta | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | | | Ora |
| Manihot esculenta Crantz | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Myrtagyna inerma (Wildl.) Kuntze | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Parkia biglobosa (Jacq.) R. Br. ex G. Don | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba, Se | Ma, Po | Ora |
| Senna occidentalis (L.) Link | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Terminalia arvenseoides Guill. & Perr. | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Ro | De | Ora |
| Thevetia peruviana (Pers.) K.Sehum. | 2 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Tr | Ora |
| Abelmoschus esculentus (L.) Moench. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | St, De | Ora |
| Acanthospermum hispidum De. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Tr | Ora |
| Blighia sapida Koenig | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba | Po | Ora |
| Cajanus cajan (L.) Millsp. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Chromolaena odorata (L.) R.M.King | 1 | Día | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Cissus quadrangularis L. | 1 | Día, Ind | Mirasra (f) Domédéde (w) | St, Ma, | Ora |
| Dichapetalum madagascurense Poir. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Diospyros mespiliformis Hochst. ex A. Rich | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ma, Gr | Ora |
| Eucalyptus camaldulensis Dehn | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le, Ba | Ma | Ora |
| Grewia mollis Juss. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Ba | Tr | Ora |
| Hymenosporum vittatum (L.) Poit. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (w) | Le, St | De | Ora |
| Irvingia gabonensis (Aubry-Lecomte ex O’Rorke) Baill. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Le | Gr | Ora |
| Lophira lanceolata Tiegh. ex Keay | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (w) | Ba, Le | De | Ora |
| Marantaceae polyandra (Benth.) France | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (w) | Ba, Ro | Po, De | Ora |
| Margaritaria discoidea (Baill.) Webster | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (w) | Ba | Po | Ora |
| Mucuna pruriens (L.) DC. var. pruriens | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (w) | Le | Gr | Ora |
| Nicotiana tabacum L. | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (w) | Le, St, De, Po | Ora |
| Pericopsis javiforma (Benth.) van Meeuwen | 1 | Día, Ind, Gap | Mirasra (f) Domédéde (a) | Ba | Ma, Po | Ora |

(continued on next page)
Table 4 (continued)

| Plant                        | FC  | CS | VN           | PP  | PM | AR |
|------------------------------|-----|----|--------------|-----|----|----|
| *Pilostigma reticulatum* (DC.) Hochst. | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Ba | Ma | Ora |
| *Pilostigma thunbergii* (Schumach.) Milne-Redh. | 1   | Ind | Adogo houn (p) | Le | Ma | De | Ora |
| *Prosopis africana* (Guill. & Perr.) Taub | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Ba | Po | De | Ora |
| *Psidium oleifolium* (Sm.) E.A.Busch | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | Po | Ora |
| *Pterospermum javanense* Engl. & Diels | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | Po | Ora |
| *Papaya lappacea* (L.) Juss. | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | Tr | Gr | Ora |
| *Rhodophyllum breviculpe* (Sprague)Koberry | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | Gr | Tr | Ora |
| *Saba senegalensis* (A. DC.) Fichon | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | De | Ora |
| *Sarcocephalus latifolius* (Sm.) E.A.Brace | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | Po | Ora |
| *Securidaca longipedunculata* Fres. | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | Po | Ora |
| *Solanum dasypylphum* Schumach. &Thonn | 1   | Dia, Ind, Gap | Mirra (f) Domédédé (a) | Le | Po | Ora |
| *Triad precumbens* L. | 1   | Ind, Ano | Enoumado (a) Ehdijdji (a) | Le | Tr | Gr | Ora |
| *Vigna racemosa* (G.Don) Huitch. & Daleziel | 1   | Dia | Mirra (f) | Le | Gr | Ora |
| *Vietellaria paradoxa* C.F.Gaertn., 1807 | 1   | Dia, Ind | Mirra (f) Ehdijdji (a) | Ba | Ma | De | Ora |

Reproductive disorders (W)

| Plant                        | FC  | CS | VN           | PP  | PM | AR |
|------------------------------|-----|----|--------------|-----|----|----|
| *Spondias mombinii* L.       | 3   | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Tr | Loc |
| *Rhodophyllum breviculpe* (Sprague)Koberry | 2   | Dys, Rep, Aga | Sin ton do anonminan (w) | Le | Gr | Tr | Ora |
| *Solanum dasypylphum* Schumach. &Thonn | 10  | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Po | Ora |
| *Acacia gourmaensis* A. Chev | 8   | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Ba | Po | Ora |
| *Ficus sycomorus* L.        | 15  | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Gr | Ora |
| *Clusa populnea* Guill. & Perr | 8   | Dys, Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | St | Ro | Ora |
| *Newholldia laevii* (P. Beauv.) Seem | 11  | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Tr | Gr | Ora |
| *Vigna unguiculata* (L.) Walp. | 2   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Se | Po, Gr | Ora |
| *Croosypyrus februnya* (Azel. ex G. Don) Benth | 3   | Dys, Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le, Ba | Po | Ora |
| *Euphorbia Sallymerra* Alton | 3   | Dys, Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le, St | De | Ora |
| *Rauara cocccinea* (Thonn. ex Schumach.) Benth. | 3   | Dys, Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | Gr | Tr | Ora |
| *Striga hermonitica* (Delile) Benth. | 3   | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Wp | Po | Ora |
| *Annona senegalensis* Pers | 2   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | Gr | Ora |
| *Calotropis procera* (Ait.) Ait. f | 1   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | De | Ora |
| *Manihot esculenta* Crantz | 1   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | Gr | Ora |
| *Morinda lucida* Benth. | 1   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | Gr | Ora |
| *Murning oleifera* Lam. | 2   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le, Po, De | Ora |
| *Sesamum indicum* L. | 1   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le, Gr | Or | Ora |
| *Zanthoxylum xanthoxylotes* (Lam.) Watermann | 2   | Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | Gr | Ora |
| *Abelmoschus esculentus* (L.) Moench. | 1   | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | St | De | Ora |
| *Adansonia digitata* L. | 1   | Dys, Mas | Evi dijdji gbonnou (a) Viko tonan (f) | Ba, Le | Po | Ora |
| *Afzelia africana* Smith ex Pers | 1   | Dys, Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | Po | Ora |
| *Cassipina bonduc* (L.) Roxb. | 2   | Dys, Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | De, Gr | Ora |
| *Chromolaena odorata* (L.) R.M.King | 1   | Dys, Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le, Tr, Ma, Gr | Der, Ora |
| *Diospyros mespilorifoms* Hochst. | 1   | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Ma | Gr | Ora |
| *Ficus sur* Forssk. | 1   | Dys, Rep | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Gr | De | Ora |
| *Leptadenia hastata* (Pers.) Decne | 1   | Rep, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le | Ma | Ora |
| *Mangifera indica* L. | 1   | Dys, Aga, Mas | Sin ton do anonminan (w) | Anon dor (b) | Le, Ba, Ma | Gr | Ora |
| *Mitragyna inermis* (Willd.) Kuntze | 1   | Dys, Rep, Aga, Mas | Evi dijdji gbonnou (a) Viko tonan (f) | Ba | Ma | Ora |
| *Pelargonium ochrus* (Forssk.) Chiov. | 1   | Dys, Rep, Aga, Mas | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Tr | Ocu |
| *Pilostigma thunbergii* (Schumach.) Milne-Redh. | 1   | Dys, Rep, Aga, Mas | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Tr | Ocu |
| *Prosopis africana* (Guill. & Perr.) Taub | 1   | Dys, Mas | Evi dijdji gbonnou (a) Viko tonan (f) | Le | Po | Ora |
| *Pseudocedrela kotschyi* (Schweinf.) Harms | 2   | Cou, Nad | Kem (f) Ekpin (a) Aminis (f) | Le | Tr | Nas |
| *Rhus senegalensis* (Desr.) A.Juss. | 7   | Cou, Nad | Kem (f) Ekpin (a) Aminis (f) | Le, Ba | Ma | De | Ora |
| *Dioscorea hirtiflora* Benth. | 3   | Cou, Nad | Kem (f) Ekpin (a) Aminis (f) | Ro | Ma | Po | Ora |
| *Vernonia amygdalina* Delile | 3   | Cou | Kem (f) Ekpin (a) Aminis (f) | Le | Gr, Tr | Ora |
| *Azadirachta indica* A. Juss | 2   | Cou, Nad | Kem (f) Ekpin (a) Aminis (f) | Le, Ba, Ma, Po | Ora |
| *Parkia biglobosa* (Jacq.) R. Br. ex G. Don | 2   | Cou, Nad | Kem (f) Ekpin (a) Aminis (f) | Le, Ba, Se | Ma, Po | Ora |
| *Adansonia digitata* L., 1753 | 1   | Cou, Nad | Kem (f) Ekpin (a) Aminis (f) | Le, Ba | Po | Ora |

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### Table 4 (continued)

| Plant                                      | FC  | CS   | VN      | PP | PM | AR |
|--------------------------------------------|-----|------|---------|----|----|----|
| Ceaalspnia boudac (L.) Roxb.               | 23  | Fev  | Xoox    |    |    |    |
| Rhaya senegalensis (Desr.) A. Juss         | 16  | Fev  | Xoox    |    |    |    |
| Morinda lucida Benth.                      | 1   | Njad | Ekuin   |    |    |    |
| Annona senegalensis                        | 1   | Njad | Ekuin   |    |    |    |
| Acacia macrostachya                        | 1   | Njad | Ekuin   |    |    |    |
| Vitex doniana                              | 1   | Njad | Ekuin   |    |    |    |
| Morinda lucida Benth.                      | 1   | Njad | Hontchichow | |    |    |
| Newbouldia laevis (P. Beauv.)              | 1   | Njad | Ekuin   |    |    |    |
| Optia amentanecous Roxb.                   | 1   | Njad | Hontchichow | |    |    |
| Flueggea virosa (Roxb. ex Willd.) Voigt    | 1   | Njad | Foutchite |    |    |    |
| Gliricidia sepium                          | 1   | Njad | Foutchite |    |    |    |
| Flueggea virosa (Roxb. ex Willd.) Voigt    | 1   | Njad | Foutchite |    |    |    |
| Vitellaria paradoxa                         | 1   | Njad | Ekuin   |    |    |    |
| General and non-specific disorders (A)      | 1   | Njad | Hontchichow | |    |    |

| Skin disorders (S)                         | 7   | Sca  | Tchaabé |    |    |    |
| Rhaya senegalensis (Desr.) A. Juss         | 3   | Wos  | Tchaabé |    |    |    |
| Ocimum gratissimum                         | 3   | Sca  | Edjekpo |    |    |    |
| Papaila lappace (L.) Juss.                 | 3   | Sca  | Edjekpo |    |    |    |
| Vitex doniana                               | 3   | Sca  | Tchaabé |    |    |    |
| Chromolaena odorata (L.) R.M.King           | 2   | Sca  | Edjekpo |    |    |    |
| Vitellaria paradoxa                         | 2   | Sca  | Tchaabé |    |    |    |
| Acacia macrostachya Reichenb. ex DC        | 1   | Wos  | Tchaabé |    |    |    |
| Annona senegalensis Pers.                  | 1   | Wos  | Tchaabé |    |    |    |
| Asadhracchi indica A. Juss                 | 1   | Wos  | Tchaabé |    |    |    |
| Carica papaya                               | 1   | Sca  | Tchaabé |    |    |    |

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Table 4 (continued)

| Plant                          | PC | CS | VN | PP | AM |
|--------------------------------|----|----|----|----|----|
| Girra senegalensis J.F.Gmel    | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le, Ba | Po | Ora |
| Mangifera indica L.            | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le, Ba | Ma, Gr | Ora |
| Marantchus polyantra (Benth.) Prance | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Ba, Ro | Po, De | Ora |
| Morinda charantia              | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le | Tr, Ma | Ora |
| Moringa oleifera Lam.          | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le, Po, De | Ora |
| Pilostigma thunbergii (Schumach.) Milne-Redh | 1  | Sca | Edelko (a) | Le, Ma, De | Ora |
| Sarcopocalypse flavifolia (Sm.) E.A.Bruce | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Ba, Ro | Ma | Der |
| Spandius mombin L.             | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le | Tr | Ma, Ora |

Metabolism, nutrition and endocrine disorders (T)

| Plant                          | PC | CS | VN | PP | AM |
|--------------------------------|----|----|----|----|----|
| Guiera senegalensis J.F.Gmel   | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le, Ba | Po | Ora |
| Momordica charantia            | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le, Ba | Ma, Gr | Ora |
| Leucaena leucocephala          | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Ba, Ro | Po, De | Ora |
| Khaya senegalensis             | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le | Tr, Ma | Ora |
| Ficus umbellata                | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le, Po, De | Ora |
| Moringa oleifera Lam.          | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le, Po, De | Ora |
| Guiera senegalensis (Desr.) A. Juss | 1  | Sca | Edelko (a) | Le, Ma, De | Ora |
| Leucena leucophyrsa (Lam.) De Vit | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Ba, Ro | Ma | Der |
| Morinda charantia              | 1  | Sca, Wos | Tchaabé (p) Akli (f) Akpa (d) | Le | Tr | Ma, Ora |

Blood and hematopoietic organs disorders (B)

| Plant                          | PC | CS | VN | PP | AM |
|--------------------------------|----|----|----|----|----|
| Dioscorea hirtijlora           | 11 | Ano, Avi, Stg | Etouya (f) Esonamado (a) | Le, Gr, Po, De | Ora |
| Adonsonia digitata L., 1753     | 7  | Stg | Etouya (f) Ehoueuy yihoue (a) | Ba, Le | Po, Ora |
| Elaeis guineensis Jacq.        | 4  | Stg | Etouya (f) Ehoueuy yihoue (a) | Le | Gr, Ora |
| Ficus exasperata Vahl          | 2  | Stg | Etouya (f) Ehoueuy yihoue (a) | Le | Po, Ora |
| Glicidade sepium (Jacq.) Kunth ex Walp. | 2  | Stg | Etouya (f) Ehoueuy yihoue (a) | Le | Gr, Ora |
| Ficus sycomorus L., 1767       | 1  | Stg | Etouya (f) Ehoueuy yihoue (a) | Le | Gr, Ora |
| Ficus umbellata                | 1  | Stg | Etouya (f) Ehoueuy yihoue (a) | B | Po, Ora |
| Khaya senegalensis             | 1  | Stg | Etouya (f) Ehoueuy yihoue (a) | Ba, A, Ma, De | Ora |
| Leucena leucophyrsa (Lam.) De Vit | 1  | Avi, Stg | Etouya (f) Vitamine houedi (d) | Le | Gr | Ora |
| Morinda charantia              | 1  | Ano, Stg | Etouya (f) Vitamine houedi (d) | Le | Tr | Ma, Ora |

Musculoskeletal disorders (L)

| Plant                          | PC | CS | VN | PP | AM |
|--------------------------------|----|----|----|----|----|
| Combretum glutinosum Perr. ex De | 16 | Bof | Ewin (o) Ehin (n) | Ba | Ma | Loc |
| Diospyros mespiliformis Hochst. ex A. Rich | 1  | Bof | Ewin (o) Ehin (n) | Le, Ma | Gr | Loc |
| Eucalyptus camaldulensis Dehn    | 1  | Bof | Ewin (o) Ehin (n) | Le, Ba | Ma | Ora |
| Morinda oleifera Lam.            | 1  | Bof | Ewin (o) Ehin (n) | Le, Po, De | Ora |
| Pericopsis laxiflora (Benth.) van Meeuwen | 1  | Bof | Ewin (o) Ehin (n) | Ba | Ma, Po | Ora |
| Pilostigma thunbergii (Schumach.) Milne-Redh | 1  | Bof | Ewin (o) Ehin (n) | Le, Ma, De | Ora |

Eye disorders (F)

| Plant                          | PC | CS | VN | PP | AM |
|--------------------------------|----|----|----|----|----|
| Balanites asperata (L.) Del.    | 1  | Eyd, Ree | Nounkoun-mian (f) | Se | Ma | Ocu |
| Citrus limon (L.) Burm.f         | 1  | Eyd | Ouncouvi ko nachi (a) | Le, Po, De | Ora |
| Hibiscus sabdariffa L., 1753    | 1  | Eyd | Ouncouvi ko nachi (a) | Le | De | Ocu |
| Pergularia daemia (Forssk.) Chiov. | 1  | Eyd, Ree | Nounkoun-mian (f) | Le | Tr | Ocu |
| Terminalia avicennoides Guill. & Perr. | 1  | Eyd | Ouncouvi ko nachi (a) | Ro | De | Ora |

Neurological disorders (N)

| Plant                          | PC | CS | VN | PP | AM |
|--------------------------------|----|----|----|----|----|
| Cassia populnea Guill. & Perr.  | 1  | Ner, Agi | Hominsin (f) Dormesi (p) | St, Ro | Po | Ora |
| Diospyros mespiliformis Hochst. ex A. Rich | 1  | Ner, Agi | Eilawla (h) Hlahla (s) | Le | Ma, Gr | Ora |

Notes: FC: Frequency of Citation; CS: Clinical signs (Dia: Diarrhea, Ind: Indigestion, Gap: Gastrointestinal parasitosis, Ano: Anorexia, Dys: Dysstocia, Rep: Retained placenta, Aga: Agalactia, Mas: Mastitis, Cou: Cough, Nad: Nasal discharge, Fev: Fever, Prh: Prickly hairs, Sca: Scabies, Wos: Wound on the skin, Avi: Avitaminosis, Stg: Stunted growth, Hae: Haemorrhage Ana: Anaemia, BoF: Bone fracture, Eyd: Eye discharge, Ree: Red eye, Ner: Nervousness, Agi: Agitation); VN: Vernacular name (f = Fon; b = Bariba; o = Otammar; p = Peulh; s = Sahoué; d = Dendi; w = Wamu; n = Natimba; a = Adja) PP: Plant Part (Le: Leaves, Ba: Bark, Se: Seed, Ro: Root, St: Stem, Wp: Whole plant); PM: Preparation Modes (Ma: Maceration, Gr: Grazing, Tr: Trituration, De: Decocation, Po: Powder); AR: Administration Route (Ora: Oral; Der: Dermal, Ocu: Ocular, Nas: Nasal, Loc: Local).

uneducated (67.2%) and had agriculture and livestock as their main activities. These results confirm the observations of Ogni et al. (2014), Usba et al. (2016) and Ouachinou et al. (2019) who showed that breeding is mainly done by uneducated people. In fact, small ruminants breeding is mainly done in rural areas, which concentrate the majority of the uneducated (Le Gall and Leboucq, 2003), although more and more sheep and goats farming is encountered in periurban areas (Dossa et al., 2015). On average, those surveyed kept 10 ± 11 heads of small ruminants, which is relatively high compared to that found by Hounzangbé-Adoté (2001) and Lakew et al. (2017). This could be related to the choice of agro-ecological zones where small ruminants breeding is predominant.

3.2. Diversity of inventoried medicinal plants

A total of 101 species of medicinal plants belonging to 42 families and 90 genera were inventoried during the survey (Table 2). The richest families were Leguminosae (22 species, 21.6%), Euphorbiaceae (7 species, 6.9%), Combretaceae (5 species, 4.9%), Rubiaceae (4 species, 3.9%), Moraceae (4 species, 3.9%), Meliaceae (4 species, 3.9%) and Asteraceae (4 species, 3.9%). The Rgc was 1.1, which indicates the high diversity of medicinal species used to treat small ruminants diseases. This implies that each genera holds in average more than one species. The genera with high species number were Ficus (4 species), Acacia (3 species) and Sena (3 species). This diversity is very high compared to those
obtained by Tamboura et al. (1998), Hounzangbé-Adoté (2001), Vineger et al. (2007), Usha et al. (2016), Ahoyo et al. (2017) and Kebede et al. (2018) but low compared to values of Dassou et al. (2015a) and Ouachinou et al. (2019). This difference may be explained by variation of knowledge between the sociocultural groups. This high diversity could also be explained by the fact that the study covered multiple agro-ecological zones that contain different plant species. Indeed, Houinato and Sinsin (2002) have shown that vegetation varies according to agro-ecological zones. A high diversity of small ruminants diseases can justify also the high diversity of medicinal plants used by breeders. The high diversity observed in this study testifies the importance of ethnoveterinary practices in the health care of sheep and goats. Indeed, according to the breeders, herbal remedies are first offered to animals after observations of pathological signs and it is after the failure of these that they call the veterinarian or technician. The CI ranged from 0.002 to 0.208. The most important plants in the treatment of sheep and goats diseases were Spordias mombin, Zanthoxylum zanthoxyloides, Khaya senegalensis, Morinda lucida and Moringa oleifera with CI of 0.208, 0.125, 0.121, 0.109 and 0.105, respectively. These different species were previously inventoried in ethnoveterinary surveys (Hounzangbé-Adoté, 2001; Kabore et al., 2007; Attindéhou et al., 2012; Dassou et al., 2015a; Ouachinou et al., 2019).

### 3.4. Plants used to treat different disorders groups

Ten disease categories were identified in our survey. These were mainly digestive disorders (D: diarrhea, indigestion, anorexia, gastrointestinal parasitosis) cited by 49.3% of respondents. This disease group was followed by reproductive disorders (W: dystocia, mastitis, agalactia, retained placenta), general and non-specific disorders (A: fever, anorexia) and respiratory disorders (R: cough, nasal discharge) cited respectively, by 20.2%, 10.6% and 7.2% of the respondents (Figure 2). These results corroborate those of Hounzangbé-Adoté (2001), Dossa et al. (2007), Ogni et al. (2014) and Lakew et al. (2017) who found that the main symptoms encountered in small ruminants farms are diarrhea, anorexia and gastrointestinal parasitosis, which lead to high mortality. According to the breeders, these diseases are more common in the rainy season and are probably related to moisture that promotes the development of pathogens. Indeed, Underwood et al. (2015) have shown that, ruminants breeding environment contains multiple pathogenic bacteria and fungi which cause diseases. According to these authors, the development of these pathogens is depending of several environmental factors, including moisture and temperature. Reproductive disorders (W) are the second category of disorders that was frequently cited by respondents. Ogni et al. (2014) and Dassou et al. (2015a) made the similar observations in some Beninese farms. Indeed, this category of disorders includes cases of dystocia, mastitis and agalactia. This was probably due to the lack of hygiene in the farms, which promotes the development of infectious agents and contamination of reproductive organs such as udders. In fact, Al-Momani et al. (2008) have shown that small ruminants agalactia in northern Jordan is associated with some production and health management practices. In addition, uncontrolled mating between different breeds may be the reason of dystocia observed. In West-Africa, small ruminants flocks are characterised by the presence of multiple genotypes and uncontrolled mating (Dossa et al., 2015). ICF calculation yielded 0.8, 0.8, 0.8, 0.8, 0.7, 0.7 and 0.6 respectively, for group disorders D, W, B, L, A, T and R (Table 5). This indicates the high degree of consensus between the respondents in relation to the plants used to treat these different disease groups.

### 3.4. Plants used to treat different disorders groups

The results showed that disease groups frequently encountered, such as digestive disorders (D), reproductive disorders (W) and general non-specific diseases (A) were treated, respectively, with 72, 34 and 29 medicinal plants (Table 4). On the other hand, musculoskeletal disorders (L), eye disorders (F) and neurological disorders (N) were treated, respectively, with 6, 5 and 2 medicinal plants. Most of the listed plants were used to treat two or more disease categories. Thus, their FL was used to identify the frequently plants used to treat each disease group (Table 5). For the treatment of digestive diseases for example, among the 72 plants used, 20 were selected which merit further research. These are Zanthoxylum zanthoxyloides; Striga hermonthica; Khaya senegalensis; Adansonia digitata; Morinda lucida; Spordias mombin; Elaeis guineensis; Caesalpinia bonduc; Asadraehchia indica; Newbouldia laetsch; Cartica papaya; Momordica charantia; Anogeissus leiocarpa; Vitex doniana; Parkia biglobosa and Crossopteryx febrifuga; with FL, respectively, 0.9, 0.8, 0.5, 0.7, 0.5, 0.6, 0.8, 0.7, 0.7, 0.6, 0.9, 0.5, 0.7, 0.6 0.5 and 0.4. Previous studies have already shown that these plants are used to treat digestive disorders in domestic animals (Hounzangbé-Adoté, 2001; Kabore et al., 2007; Vineger et al., 2007, Djoueche et al., 2011; Attindéhou et al., 2012; Usha et al., 2016; Ouachinou et al., 2019). In addition, chemical and biological studies have been conducted and confirmed the in vivo and in vitro

### Table 5. List of three main medicinal plants used to treat each disease group of small ruminants in Benin.

| Plants | FC | FL |
|--------|----|----|
| Digestive disorders (D) | | |
| Zanthoxylum zanthoxyloides (Lam.) Watermann | 61 | 0.9 |
| Striga hermonthica (Delile) Benth. | 46 | 0.8 |
| Adansonia digitata L., 1753 | 31 | 0.7 |
| Reproductive disorders (W) | | |
| Spordias mombin L. | 79 | 0.7 |
| Rhodoglyphalon brevicupa (Sprague) Roberty | 14 | 0.9 |
| Solanum dasycalyx Schumach. &Thonn | 13 | 0.9 |
| Respiratory disorders (R) | | |
| Ocimum gratissimum L. | 20 | 0.5 |
| Mangifera indica L. | 10 | 0.6 |
| Khaya senegalensis (Desr.) A.Juss. | 7 | 0.1 |
| General and non-specific disorders (A) | | |
| Morinda lucida Benth. | 23 | 0.4 |
| Khaya senegalensis (Desr.) A. Juss. | 16 | 0.2 |
| Moringa oleifera Lam. | 16 | 0.3 |
| Skin disorders (S) | | |
| Khaya senegalensis (Desr.) A. Juss. | 7 | 0.1 |
| Nicotiana tabacum L. | 3 | 0.7 |
| Pupalia lappa (L.) JUSS. | 3 | 0.6 |
| Metabolism, nutrition and endocrine disorders (T) | | |
| Moringa oleifera Lam. | 11 | 0.2 |
| Adansonia digitata L., 1753 | 7 | 0.1 |
| Enzias guineensis Jacq. | 4 | 0.1 |
| Blood and hematopoietic organs disorders (B) | | |
| Dioscorea hispida L. Benth | 17 | 0.8 |
| Crossopteryx febrifuga (Afzel. ex G. Don) Benth | 1 | 0.1 |
| Guiera senegalensis J.F. Gmel | 1 | 0.5 |
| Musculoskeletal disorders (L) | | |
| Combretum guineense Perr. ex De | 16 | 1.0 |
| Diospyros mespiliformis Hochst. ex A. Rich | 1 | 0.2 |
| Rauvolfia camaldulensis Dehn | 1 | 0.5 |
| Eye disorders (F) | | |
| Balantus oegtiphantes (L.) Del | 1 | 0.2 |
| Citrus limon (L.) Burm.f | 1 | 0.3 |
| Hibiscus sabdariffa L., 1753 | 1 | 0.2 |
| Neurological disorders (N) | | |
| Citrus papaya Guill. & Perr | 1 | 0.1 |
| Diospyros mespiliformis Hochst. ex A. Rich | 1 | 0.2 |

FC: Frequency of Citation; FL: Fidelity Level.
Efficacy of some of these plants (Chandrawathani et al., 2006; Agaie and Onyeyili, 2007; Kabore et al., 2009; Azando et al., 2011; Olounladé et al., 2011; Koné et al., 2012). In previous studies, Z. zanthoxylloides, A. indica, A. leioarpa and S. mombin have shown a strong activity in treatment of gastrointestinal parasitosis of small ruminants (Chandrawathani et al., 2006; Agaie and Onyeyili Kabore et al., 2009; Azando et al., 2011), this may be explained traditional usage of these plants. Chemical analysis of these plants revealed that they contain mainly, tannins, flavonoids, alkaloids and anthraquinones (Igwe et al., 2010; Barku et al., 2013), that may be the reason for their effectiveness. Nevertheless, S. hermonthica; M. charantia and E. guineensis were less studied. Some medicinal plants inventoried during the survey are versatile and therefore well-suited for the treatment of several disease categories. As an example A. digitata is also indicated for the treatment of metabolism and nutrition disorders (T). Similarly, S. mombin can be used to treat reproductive disorders (W). This corroborates the results of Adedokun et al. (2010) and Gbolade and Adeyemi (2008), who found that these plants can be used in the treatment of reproductive disorders and gastrointestinal parasitosis, respectively.

The majority of the recipes proposed were composed exclusively of plants. The leaves (64.2%), the barks (17.2%) and the whole plants (7.3%), are the main parts used. The majority of recipes are prescribed in the form of fresh leaves to be grazed by small ruminants (45.2%). Other methods of preparation were maceration (21.5%), decoction (10.8%), pounding (8.7%), powder (6.9%) and trituration (6.8%).

3.5. Influence of socioeconomic and environmental factors on traditional knowledge

Ethnoveterinary medicine involves natural resources use (plants, minerals, animal organs) and supernatural resources (prayers, incantations, magic) to treat animals (Wanzala et al., 2005). However, magico-religious practices contribution to livestock treatments remains to be proven according to several authors (Assogbadjo et al., 2011; Dassou et al., 2015b). Thus, natural resources use, especially plants, appears to be a key element to evaluate the ethnoveterinary knowledge level of livestock farmers (Kouchade et al., 2017; Miara et al., 2019). However, the number of medicinals plants cited alone to measure the level of knowledge related to ethnoveterinary practices appears insufficient because ethnoveterinary medicine covers many other aspects not taken into account. Sometimes there is a gap between knowledge and actual use of medicinal plants. Indeed, farmers consider ethnoveterinary knowledge as a family secret and do not share all the information with outsiders. This is one of the major limitations for ethnoveterinary surveys.

The results showed that size of the small ruminants flock (P = 0.001), gender of respondents (P = 0.045), agro-ecological zone (P = 0.008) and ethnicity of respondents (P = 0.017) significantly influenced the level of knowledge related to plants used to treat small ruminants diseases (Figure 3). These results corroborate those of Assogbadjo et al. (2011) and Dassou et al. (2015b) who showed that agro-ecological and phytogeographic zones, ethnicity and educational level influence traditional knowledge. Analyse of variance results showed that respondents from agro-ecological zone 1 (Karimama) have a high level of knowledge compared to other zones considered in our study (P = 0.00797). This may be explained by the lack of money, the absence of veterinary services and the inaccessibility of sanitary products in the municipality of Karimama (INSAE, 2016). Thus, to cope with the sanitary management of their animals, breeders are forced to turn to ethnoveterinary practices. Le Gall and Leboucq (2003) have shown that the absence of veterinary services and the inaccessibility of health products are the main constraints to livestock development in sub-Saharan Africa. In addition, our study reveals that the practice of ethnoveterinary medicine in small ruminants farms depends on herd size (P = 0.023). In fact, analyse of variance results showed that, the larger the herd size, the less breeders use plants to treat small ruminants diseases. For small flocks class (1 ≤ Flock <10), respondents use an average 3 plants compared to 1 for large flocks (60 ≤ Flock <70). This may be explained by the fact that breeders who have a large flock may have difficulty in preparing traditional recipes for all animals. Similarly, these farmers could have more financial capacity than those who have a small flock and are therefore able to buy veterinary products and

Figure 3. Decision tree showing socioeconomic and environmental factors that influence significantly ethnoveterinary knowledge level within small ruminants breeders in Benin. Flock: Small ruminant flocks size, Sex: Respondent sex, Zone: Agro-ecological zone and Ethn: Ethnicity of the respondent. Each node indicates the factor that significantly influences ethnoveterinary knowledge level and specifies at which level the difference lies. For example, node 1 indicates that flocks size significantly (P = 0.001) influences ethnoveterinary knowledge level and specifies that farmers with a flocks size of 2 or less have a different level of knowledge than those with a flocks size of more than 2.
pay veterinary services. Although several ethnobotanical surveys have been conducted to evaluate the effect of certain factors on the level of knowledge, the present work remains the only one to prove that there is a link between herd size and the level of knowledge in ethnoveterinary practice. Like herd size, ethnicity is also linked to the knowledge of the plants used to treat small ruminants disorders. These results are consistent with those of Assogbadjo et al. (2011) and Kouchade et al. (2017) who found that traditional knowledge varies according to sociocultural groups in Benin. Indeed, the results showed that Dendi and Peuhl have a strong knowledge (on average 3 plants per respondent) compared to Adja, Wama, Otamari and Natimba (on average 1.5 plants per respondent). This can be linked to the fact that these two sociocultural groups are herding societies and therefore strongly care for wellness of their animals (Dassou et al., 2020).

4. Conclusions

Traditional ethnoveterinary practices continue to contribute to the improvement of animal production. The present study demonstrated that it is used by a majority of small ruminants breeders in Benin to treat livestock diseases. The main disease groups encountered were those of digestive system and those related to reproductive organs. Gender, agro-ecological zone, sociocultural group and herd size are factors that significantly influence the level of knowledge of plants used to treat sheep and goats diseases. The most frequently plants were Z. xanthoxyloides, K. senegalensis, M. lucida, M. oleifera and S. hermonthica. Chemical and biological studies have been conducted on several of these plants. Nevertheless, certain inventoried plants namely, S. hermonthica, E. guineensis, C. fruticosa and M. charantia were less studied. Thus, chemical and biological studies are needed to test the properties attributed to these plants and characterize active compounds responsible to the probable biological activities.

Declarations

**Author contribution statement**

Esaïe Tchetan: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Abidouin Pascal Olounlade: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

Thierry Dehouegnon Houehanou: Analyzed and interpreted the data; Wrote the paper.

Erick Virgile Bertrand Azando; Sylvie Mawule Hounzangbe-Adote: Conceived and designed the experiments; Performed the experiments.

Ako Kivonu: Contributed reagents, materials, analysis tools or data.

Joelle Quetin-Leclercq: Conceived and designed the experiments.

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**Data availability statement**

Data included in article/supplementary material/referenced in article.

**Declaration of interests statement**

The authors declare no conflict of interest.

**Additional information**

No additional information is available for this paper.

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