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NOTES ON NEGLECTED AND UNDERUTILIZED CROPS

Ethnobotanical investigation and diversity of Gbolo (*Crassocephalum rubens* (Juss. ex Jacq.) S. Moore and *Crassocephalum crepidioides* (Benth.) S. Moore), a traditional leafy vegetable under domestication in Benin

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Abstract Thirty five villages randomly selected across ethnic and agro-ecological zones of Benin were surveyed to document the indigenous knowledge associated with the domestication (bringing into cultivation), production and utilization of vegetable Gbolo (*Crassocephalum* spp.). The study revealed the existence of different morphotypes (1–4 per village) corresponding to two botanical species (*Crassocephalum rubens* (Juss. ex Jacq.) S. Moore) and (*Crassocephalum crepidioides* (Benth.) S. Moore) found unequally distributed throughout the country. The domestication (bringing into cultivation from the wild) of Gbolo was started in many villages and with some tribes in southern Benin, the vegetable is already being produced in sole cropping for commercial purposes. Regular consumption (49.90 % of responses) and scarcity (20.30 % of responses) were the two main reasons attributed by the interviewees for domestication of the vegetable. The cultural practices recorded were of five categories. The commonest cropping system found was mixed or inter-row cropping (92.31 % of producers) with either vegetable crops (53.85 % of producers) or non-vegetable crops (38.46 % of users). Sauce prepared with either fresh or dried leaves was the main type of preparation of Gbolo and the vegetable was reported to possess special nutritional and medicinal values. For further promotion, important researches directions are suggested.

Keywords Benin · *Crassocephalum* · Cultural practices · Domestication · Leafy vegetable · Morphological diversity

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Introduction

There is great diversity of plants in sub-Saharan Africa that are used for food and other purposes (Burkill et al. 1985; Almekinders and de Boef 2000). Akoègninou et al. (2006) reported for the flora of Benin, a total of 2,807 useful plant species among which are the traditional leafy vegetables (TLVs). Traditional leafy vegetables are plants whose leaves (including immature green pod and flowers) are socially accepted, used and consumed by the local populations (Dansi et al. 2008a). They are rich in fibres, vitamins and minerals such as carotene (provitamin A), ascorbic acid, riboflavin, iron, iodine, calcium, etc. (Odhav et al. 2007; Mensah et al. 2008). In addition to their high concentration in micronutrients, vegetables provide little dietary energy, making them valuable in energy limited diets. The fibre they contain has been reported to have beneficial effects on blood cholesterol and aids in the prevention of large bowel diseases, while in diabetic subjects, they improve glucose tolerance (Odhav et al. 2007; Mensah et al. 2008). Throughout the world and in West Africa in particular, quite a large number of TLVs have long been known and reported to have health protecting properties and uses (Odhav et al. 2007, Mensah et al. 2008, Schippers 2002; Abukutsa-Onyango 2004; Francisca and Eyzaguirre 2007; Dansi et al. 2008a).

In Benin, a biodiversity inventory and documentation survey recently conducted on TLVs throughout the country revealed a total of 187 plant species among which the vegetable locally known as Gbolo was found to be of paramount interest (Dansi et al. 2008a). Gbolo comprising two species namely *Crassocephalum rubens* (Juss. ex Jacq.) S. Moore and *Crassocephalum crepidioides* (Benth.) S. Moore, is highly consumed throughout Benin. It is used as a nutraceutical and believed to have antibiotic, anti-helminthes, anti-inflammatory, anti-diabetic, anti-malaria and blood regulation properties and also treats indigestion, liver complaints, colds, intestinal worms, and hepatic insufficiency in addition to its nutritional value, (Dansi et al. 2008a; Dansi et al. 2012). Quite unlike most leafy vegetables that are seasonal, Gbolo is available all year round because it can be collected at the time of plenty, sun dried, stored and further used, when needed, during the long dry season mainly in the arid and semi-arid zones. Despite its known ethnobotanical and nutritional values, Gbolo has been long time neglected by the scientific research. Consequently, its production remains traditional and its domestication process has hardly progressed.

To develop a concrete research and development program for the promotion of this vegetable for the benefit of producers and consumers, indigenous knowledge should be considered. The objectives of this study were three folds:

- Document the indigenous knowledge related to the folk nomenclature, use, intraspecific diversity, traditional cultural practices and domestication of the species and examine their variation, strength and weakness across villages and ethnic areas
- Draw the geographical distribution map of the species and propose appropriate zones for the *in situ* conservation of the genetic resources of these species
- Collect samples to establish a national germplasm collection of *Crassocephalum* spp. for *ex situ* conservation and further research and development studies

Materials and methods

The study area

The Republic of Benin is situated in West Africa and between the latitudes 6°10′N and 12°25′N and longitudes 0°45′E and 35°5′E (Adam and Boko 1993). It covers a total land area of 112,622 km^2 with a population estimated at about 7 millions (Adomou 2005). The south and the north where people are more diverse and concentrated are occupied respectively by 10 (Adja, Cotafon, Holly, Ouémègbe, Péda, Saxwè, Toli, Watchi, Xwla, Yorouba) and 14 (Ani, Bariba, Berba, Boko, Dendi, Ditamari, Gourmantche, Kotokoli, Lokpa, M'bermin, Natimba, Peulh, Wama) ethnic groups while the centre is shared by only 5 (Fè, Fon, Idatcha, Mahi, Tchabè). The south and the centre are relatively humid agro-ecological zones with bimodal rainy seasons and mean annual rainfall varying from 1,100 to 1,400 mm/year (Adam and Boko 1993). The north is situated in arid and semi arid agro-ecological zones characterized by unpredictable and irregular rainfall oscillating between 800 and 950 mm/year with modal rainy season. Mean annual temperatures

range from 26 to 28 °C and may exceptionally reach 35–40 °C in the far northern localities (Adomou 2005; Akoègninou et al. 2006). The country has 2,807 plant species (Akoègninou et al. 2006). Vegetation types are semi-deciduous forest (south), woodland and savannah woodland (centre-east and north-east), dry semi deciduous forest (centre-west and south of northwest) and tree and shrub savannahs (far north).

Sites selection and survey

Thirty five (35) villages (12 in the south, 10 in the centre and 13 in the north) belonging to diverse ethnical and agro-ecological (humid, semi arid, arid) zones were randomly selected and surveyed using Dansi et al. (2008a, b) method (Table 1). Data were collected with the aids of participatory research

Table 1 List of administrative locations and ethnic groups of the villages surveyed

N°	Villages	Districts	Regions	Ethnics groups
1	Ablode	Lokossa	South	Sawhè, Cotafon
2	Adanhondjigon	Zogbodomey	Centre	Fon
3	Awaya	Dassa	Centre	Idasha
4	Ayetedjou	Kétou	South	Holly
5	Banon	Bantè	Centre	N'tcha
6	Cotiakou	Tanguiéta	North	Natimba
7	Dendougou	Dendougou	North	Yom
8	Dodji	Zè	South	Aizo
9	Dogla	Dangbo	South	Goun
10	Ekpa	Savalou	Centre	Ifè
11	Fouditi	Ikpinlè	South	Yoruba
12	Ganvié	Ganvié	South	Aizo
13	Gbéré	Savé	Centre	Tchabè
14	Gogbo	Adjohoun	South	Gun
15	Iyanatowe	Onigbolo	South	Holly
16	Kali	Nikki	North	Bariba
17	Kanahoun	Savalou	Centre	Mahi
18	Kawado	Ouaké	North	Lokpa
19	Kika	Parakou	North	Bariba
20	Konou	Bembèrekè	North	Bariba
21	Koussoukoingou	Boucoumbé	North	Ditamari
22	Kpassagbéga	Copargo	North	Yom
23	Kpevidji	Klouékanmè	South	Adja
24	Makrougourou	Kouandé	North	Bariba
25	Magoumi	Glazoué	Centre	Idasha
26	Nagayilé	Bassila	North	Ani
27	Namontiaga	Cobly	North	M'bermin
28	Naogon	Covè	Centre	Mahi-Fon
29	Ouedo	Abomey-Calavi	South	Aizo
30	Sarakou	N'dali	North	Bariba
31	Sebou	Tchaourou	North	Bariba
32	Toui	Kilibo	Centre	Tchabè
33	Wédémè-Péda	Lokossa	South	Péda, Cotafon
34	Yoko	Sakété	South	Yoruba
35	Zounkon	Djidja	Centre	Fon

appraisal (PRA) tools and techniques such as direct observation, group discussions, individual interviews and field visits using a questionnaire (Dansi et al. 2008a, b; Eteka et al. 2011). Interviews were conducted with the help of interpreters from each area. As TLVs are mainly women's affair, women local organisations were involved in the study in each site, in order to facilitate precise data collection. Prior to group meeting, farmers were requested in advance to bring samples of the species and, if any, samples of their known diverse forms. Specific information about the area (agro-ecological zone, name of location, name of sub-location, name of village, ethnic group) were first collected after detailed presentation of the research objectives to the farmers. In the course of the discussion, some key information were recorded on each of the species. These were the vernacular name of the species and its meaning, status (wild, cultivated), habitat, season of availability, period of consumption, part used for food, degree of consumption (importance of the species), modes of consumption, post harvest storage, perceived nutritional value, intraspecific morphological diversity, cultural importance, medicinal properties, seed conservation, germination (nursery handling and management), date of planting, planting density, use of pesticides, fertiliser (type, dose and frequency of application), harvest (number and period) and the cropping system (sole cropping, mixed cropping). The level of domestication (i.e. bringing into cultivation) attained by the species in each village was determined using the seven steps scale described by Vodouhè et al. (2011) and Dansi et al. (2012). Field (home gardens, cultivated fields, bushes, shallows) visits were organised in order to observe the plant species under cultivation or in their natural habitat. In each village surveyed, a morphological description was carried out *in situ* on the different forms of the species encountered. Descriptors (developed using traditional knowledge) considered were related to the stem (habit, branching, and size), the leaves (shape, number of lobes, length, width, and hairiness), the flowers (colour, presence of peduncle, position of the inflorescence) and the seeds (colour).

Data analysis

Data were analysed using descriptive statistics (frequencies, percentages, means, etc.) to generate summaries and tables at different (villages, ethnic areas and regions) levels. Cluster analysis was performed with plants described *in situ* as individuals and the morphological traits as variables and scored, for each plant, as 1 when applicable or 0 if not. Using this methodology, 40 individuals and 21 variables were created and a binary matrix compiled. Pairwise distances between ethnic groups were computed by NTSYS-pc 2.2 (Rohlf 2000), using Jaccard coefficient of similarity (Jaccard 1908). Similarity matrix was used to design a dendrogram using UPGMA cluster analysis (Sneath and Sokal 1973; Swofford and Olsen 1990). The same procedure was used to analyse the relationships between producers of Gbolo interviewed in terms of cultural practices used. Here, producers were considered as individuals and the cultural practices as variables and also scored as described above.

Results and discussions

Systematic and botanical description

Crassocephalum crepidioides (Benth.) S. Moore (Family ASTERACEAE), J. Bot. 50: 211(1912); FWTA 2: 246; FT 147; Jeffrey, Kew bull. 46: 908(1986); Fragm. Flor. Geobot. 36, 1:354 (1991); FTEA 610.

Syn.: *Gynura crepidioides* Benth., Hook., Niger Fl.: 437 (1849).

Short description [Fig. 1a; Grubben and Denton (2004); See also: Burkill (1997), Akoegninou et al. (2006), Jeffrey (2001)]:

Erect, slightly succulent, annual herb up to 100(−180) cm tall; stem rather stout, soft, ribbed, branches pubescent. Leaves arranged spirally, simple to pinnately lobed or pinnatifid; stipules absent; lower leaves with short petiole, upper ones sessile; blade elliptical to obovate-elliptical in outline, 6–18 cm × 2–5.5 cm, usually lobed, irregularly serrate, base of lower leaves tapered and often long-decurrent into petiole, hairy. Inflorescence a cylindrical head 13–16 mm × 5–6 mm arranged in a terminal corymb, many-flowered; outer involucral bracts unequal, 1–4 mm long, inner ones 1–2-seriate, 8–12 mm long. Flowers bisexual, equal; corolla tubular, 9–11 mm long, yellow or orange with reddish brown top; stamens with anthers united into a tube, purple; ovary inferior, 1-celled, style 2-branched. Fruit a ribbed achene c. 2 mm long, hairy, dark

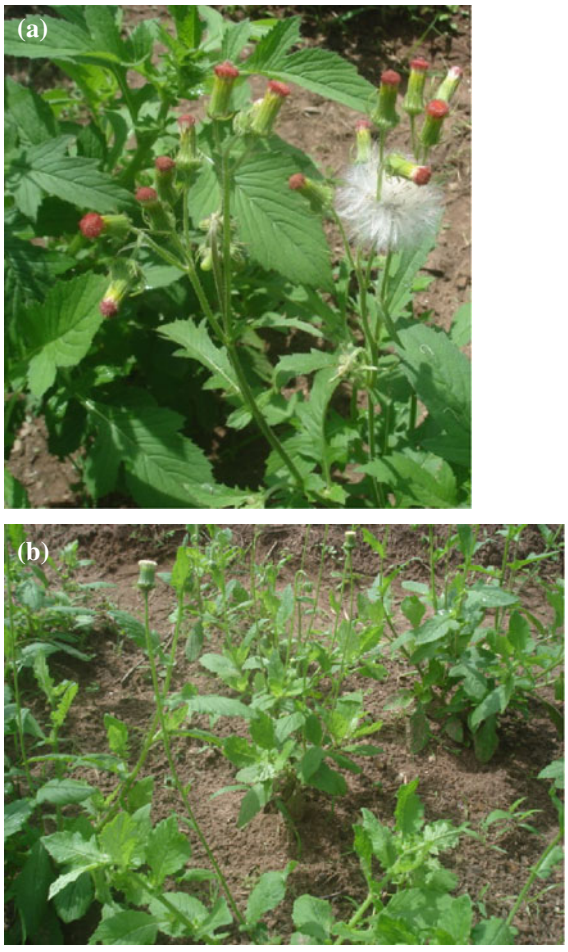

Fig. 1 Flowering plants of *C. crepidioides* and of *C. rubens*. **a** *Crassocephalum crepidioides* in the field at Kika in the north of Benin. **b** *C. rubens* in a home garden at Ablodé in the southeast of Benin

purplish, crowned by white, caducous pappus hairs 9–12 mm long.

Crassocephalum rubens (Juss. ex Jacq.) S. Moore, J. Bot. 50: 212 (1912); FWTA 2: 248; FIS 2: 491; FT 147; Jeffrey, Kew Bull. 46: 907 (1986); Fragm. Flor. Geobot. 36, 1: 350 (1991); FTEA 608.

Syn.: *Senecio rubens* Juss. ex Jacq., Hort. Vindob. 3: 50, t. 98 (1777); *Gynura cernua* Benth., Hook., Niger Fl.: 437 (1849).

Short description (Fig. 1b; Grubben and Denton (2004); See also: Burkill 1997; Akoegninou et al. 2006; Jeffrey 2001):

Erect, annual herb up to 80 cm tall. Leaves arranged spirally, sessile; stipules absent; blade of lower leaves elliptical, oblanceolate or obovate, 4.5–16 cm × 2–5 cm, either not lobed, 2–4-lobed or rarely pinnately lobed; blade of upper leaves narrowly lanceolate, elliptical or ovate, not lobed or 6–8 lobed. Inflorescence a head, up to 18 heads arranged in a terminal corymb. Flowers bisexual, equal; corolla tubular, 8–10 mm long, violet, mauve or purple. Fruit a ribbed achene, up to 2.5 mm long, crowned by white pappus hairs 8–12 mm long.

Diversity, folk nomenclature, taxonomy and geographical distribution

In 11 villages (Toui, Banon, Ekpa, Gbere, Awaya, Ayetedjou, Naogon, Iyanatowé, Fouditi, Gogbo, Ganvié) surveyed, local communities reported the existence of two categories of Gbolo that they distinguish by the intensity of the odour of their leaves when triturated. In the remaining villages, only one type was reported. Within each category, interviewees reported the existence of different morphotyes with regard to their morphological traits related to the stem, the inflorescence, the leaf and the seeds (Table 2). The number of morphotypes recorded varies from 1 to 4 per village (Table 3). Among the morphological traits (8 in total, Table 2) listed by interviewees, the most frequently used are the colour of the inflorescence (25.70 % of responses), the breath of the leaves (19.81 % of responses) and the number of the peduncles (15.79 % of responses).

At 68 % of similarity, the dendrogram constructed using as individuals the different variants observed and described *in situ* per village, and as variable the above listed morphological traits, yielded two groups G1 and G2 with 7 and 4 morphotypes respectively

Table 2 Morphological traits used to distinguish species and morphotypes of vegetable Gbolo and their relative importance

Types of organs	Parameters	% of responses
Seed	Colour	4.64
Inflorescence	Colour	25.70
	Number of peduncles	15.79
Leaf	Breadth	19.81
	Aspect	9.29
	Number of lobes	10.53
Stem	Relative plant height	7.74
	Shape of the stem	6.50

Table 3 Diversity of Gbolo in the villages surveyed

Villages	Number of types of Gbolo (TG) reported	Total number of variants	Number of variants per type of Gbolo	
			TG 1 *C. crepidiodes*	TG2 *C. rubens*
Ablodé	1	1	0	1
Adanhondjigon	1	1	0	1
Awaya	1	1	0	1
Ayétédjou	2	2	1	1
Banon	2	3	2	1
Cotiakou	1	1	0	1
Dendougou	1	1	0	1
Dodji	1	1	0	1
Dogla	2	2	1	1
Ekpa	2	4	2	2
Fouditi	2	2	1	1
Ganvié	1	1	0	1
Gbéré	2	2	1	1
Gogbo	1	1	0	1
Iyanatowe	2	2	1	1
Kali	1	1	0	1
Kanahoun	1	1	0	1
Kawado	1	1	0	1
Kika	2	2	1	1
Konou	1	1	0	1
Koussoukoingou	1	1	0	1
Kpassagbéga	1	1	0	1
Kpévidji	1	1	0	1
Magoumi	1	2	0	2
Makrougourou	1	1	0	1
Nagayilé	1	1	0	1
Namontiaga	1	1	0	1
Naogon	2	2	1	1
Ouedo	1	1	0	1
Sarakou	1	1	0	1
Sebou	1	1	0	1
Toui	2	3	2	1
Wèdèmè-Péda	1	1	0	1
Yoko	1	1	0	1
Zounkon	1	1	0	1

(Fig. 2). Plants of these groups have the following characteristics:

- G1: Erect plant up to 165 cm tall; Stem stout, soft, ribbed and pubescent; Broad, most often hairy and highly lobed leaves; Inflorescence's peduncle branched with many flower buds; Corolla yellow or orange with reddish brown top; Brown seeds. Leaves with low odour when triturated.
- G2: Plant up to 100 cm tall with cylindrical and not pubescent stems; medium-sized leaves with few (2–3 lobes) lobes. Their inflorescence peduncles are not branched, have yellow flower buds with

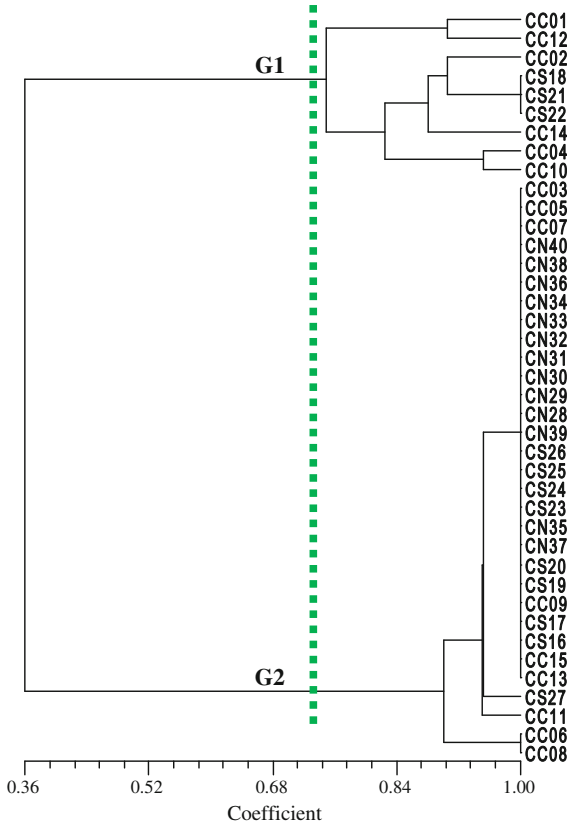

Fig. 2 Dendrogram constructed with the UPGMA method showing the diversity and the classification of the different morphotypes of Gbolo (*Crassocephalum* spp.) recorded

brown or white tops and black seeds. Leaves with intense odour when triturated

Following the Benin analytic flora (Akoegninou et al. 2006) and based on the relative intensity of the leaves' odour when triturated (www.prota.org), plants in G1 and G2 correspond to *Crassocephalum crepidioides* and *C. rubens* respectively. These results clearly show that the local communities surveyed and the interviewees in particular have good knowledge of this leafy vegetable they use and that, in terms of classification, identification and use, their knowledge would be extremely useful to geneticists and breeders as reported on yam (Dansi et al. 2000; Dansi et al. 2010). The diversity observed within the two groups G1 and G2 is already an indication of the existence of a well-established intraspecific morphological diversity within Gbolo that a more structured and expanded botanical survey and collection followed by in-depth agro-morphological characterisation trials will surely better highlight. With traditional leafy vegetables, intraspecific agromorphological diversity is frequent and has been reported on many species including *Hibiscus sabdariffa* and *Amaranthus cruentus* (Diouf et al. 2007), *Gymnantheum amygdalinum* (Mih et al. 2008) and *Sesamum radiatum* (Dansi et al. 2012).

The geographical distribution maps of the species (Fig. 3) revealed that they are unequally distributed throughout the country. *C. rubens* is distributed everywhere in the survey zone (Fig. 2) and was found alone in 24 of the villages surveyed, while in the 11 remaining villages it was found together with *C. crepidiodes* (Fig. 2). *Crassocephalum crepidiodes* mainly occupies the centre and the southeast of the country. The superimposition of the geographical distribution maps of the species with both Benin soil and climate maps helped to understand their respective ecology. Both species are absent in the far north of Benin characterised by an arid climate. *Crassocephalum crepidioides* occurs only in the humid zones where the rainfall is between 1,400 and 1,600 mm. With regard to this, its absence in the southwest was not expected and constituted an indication that other factors such as the nature and the pH of the soils might be involved in determining the geographical distribution of this species. To clarify this, some pedological investigations in relation to the species will be required. Based on the findings of this study, Central Benin which has yielded the greatest richness of genetic diversity of the two species would be the recommended area for carrying out the *in situ* conservation of these plant genetic resources. These finding are similar to those reported by Adéoti et al. (2009) on *Acmella uliginosa, Ceratotheca sesamoides, Justicia tenella* and *S. radiatum,* four important traditional leafy vegetables in Benin.

Throughout the study zone, 14 vernacular names varying across ethnic groups and villages are used to designate the species (Table 4). Among them, 8 were already reported by Dansi et al. (2009a) and two are common to many ethnic groups in some precise geographical zones. In the centre and in the southeast occupied by the ethnic groups Nago composed of the tribes Fè, Idatcha, Tchabè, Holly and Yoruba, *C. rubens* and *C. crepidioides* are commonly known as, and most frequently called, Gbolo. In the southwest inhabited by the tribes Adja, Watchi, Cotafon, Saxwe, Péda and Xwla they are generally called Akogbo. In Yorouba land of Nigeria and according to PROTA

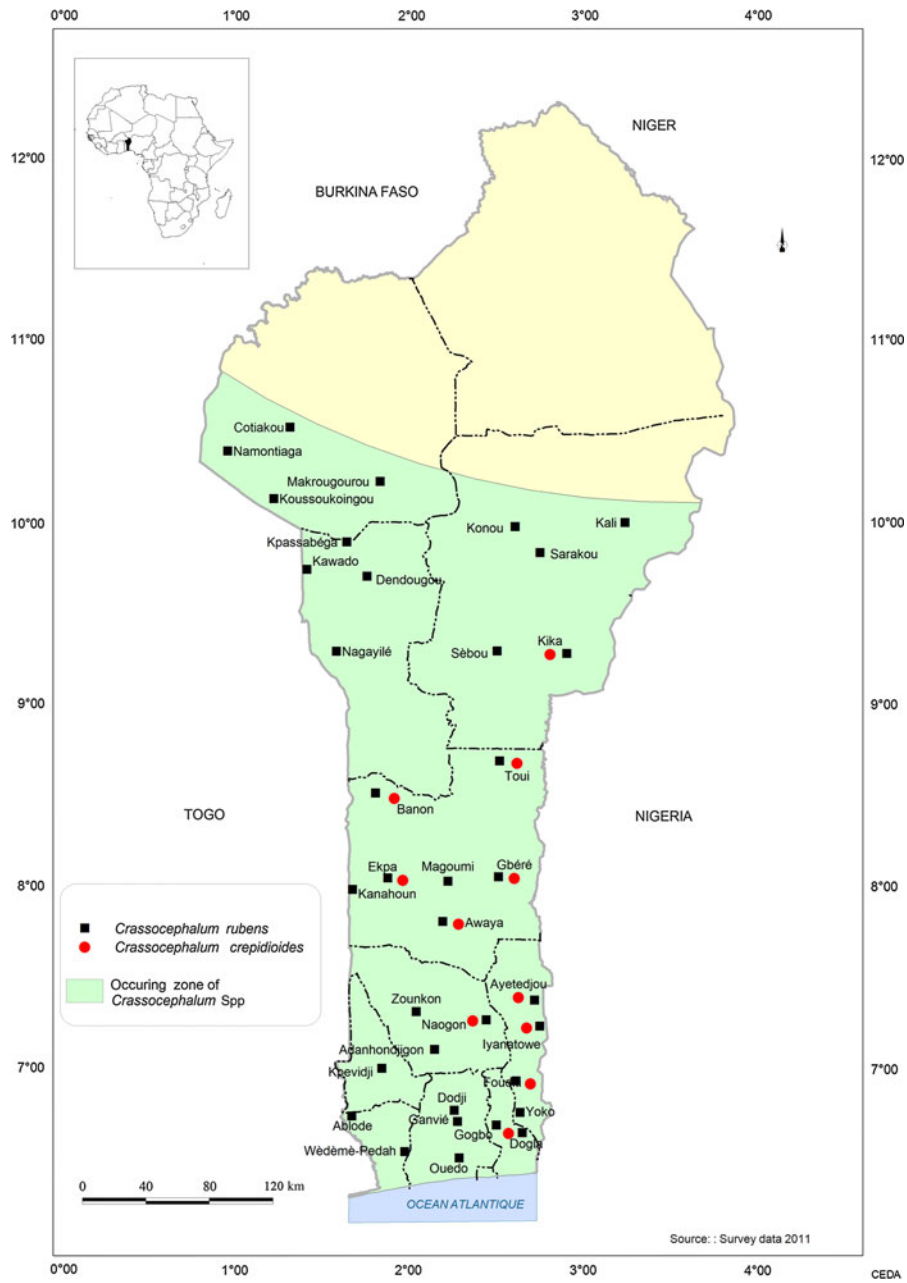

Fig. 3 Benin map showing the geographical distribution of *C. rubens* and *C. crepidioides*

free-web database (www.prota.org) and the Mansfeld's Encyclopedia of Agricultural and Horticultural Crops (Hanelt and IPK 2001), this vegetable is known under the name of Ebolo or Bolo. In the Nago cultural area of Benin, the name Gbolo used to designate *C. rubens* or *C. crepidiodes* is very closed to, and appears as a deformation of, Ebolo or Bolo. This can be easily understood when considering the origin and the evolution of the tribes that form the Nago group. According to Adam and Boko (1993) they are all derived from the mother group Yoruba who originated from Oyo (Nigeria) and which, from the southeast, migrated to, scattered and diversified in, central Benin.

The analysis of the meanings of vernacular names compiled in Table 4 confirms the existence of various scenarios (unexplained names, synonymy, and same name across ethnic area) which are specific to folk nomenclature as reported by Mekbib (2007) on

Table 4 Variation and meaning of Gbolo vernacular names across ethnic groups surveyed

Vernacular names and corresponding ethnic groups	Meaning
Gbolo (Adja, Aïzo, Fè, Gun, Holly, Idatcha, Ntcha, Yorouba, Tchabè)	Unknown
Kankangbénin (Natimba)	Stick of drum
Tignikoroya (Wama)	Young people's garland of flowers
Adjèfè (Fè), Adaflagboman (Yom), Akogbo (Cotafon, Fon, Mahi, Péda, Watchi, Sawhè), Bouyèbouyè (Yoruba), Duho (Sawhè), Ebourè (Yoruba), Hôwounhôgui (Mahi), Olongobiè (Ani), Terikiagborou (Bariba), Tihuhaate tipuote (M'bermin), Wankadjobrou (Ditamari)	Eat and burp

sorghum and Dansi et al. (2009a) on TLVs. The fact of burp after eating of *C. Ruben* or C. *crepidiodes* sauce is the most used criteria in naming this vegetable as 84.61 % (11 out of 13) of the vernacular names recorded (Table 4) refer to that. Two names, Kankangbénin in Natimba and Tignikoroya in Wama, refer to the shape of the floral peduncle (stick of drum) and to the beauty of the flowers (young people's garland of flowers). To distinguish the two species in the villages where they coexist, male and female duality is used. A second name meaning male or female is added to the principal one to distinguish them. With the Mahi ethnic group in central Benin, "Akogbo assou" designates *C. crepidioides* while "Akogbo assi" refers to *C. rubens*.

Domestication

According to Pourkheirandish and Komatsuda (2007), plant domestication is defined as the evolutionary process whereby a population of plants becomes accustomed to human provision and control. It is generally considered to be the end-point of a continuum that starts with exploitation of wild plants, continues through cultivation of plants selected from the wild but not yet genetically different from wild plants and ends with the adaptation to the agro ecology through conscious or unconscious human morphological selection, and hence genetic differences distinguishing the domesticated species from its wild progenitor (Hammer 1984; Harlan 1992; Parker et al. 2010; Sakuma et al. 2011, Dansi et al. 2012). Therefore, it is essential to distinguish between domestication and its initial phase which can be called "bringing into cultivation". Following Vodouhè et al. (2011), bringing into cultivation of a leafy vegetable can be seen as a long process of seven steps leading to the development of the best cultural practices or technological packages necessary to master mass production in order to move from a proto-culture (wild species maintained in the fields for use when found during land preparation) to traditional home garden cultivation and later on to production in market gardens for food and economic purposes. These steps as defined by Vodouhè et al. (2011), Dansi et al. (2012) are as follow:

- Step 0: Species entirely wild and collected only when needed;
- Step 1: Wild species maintained in the fields when found during land preparation;
- Step 2: Farmers start paying more attention to the preserved plants for their survival and their normal growth. A sort of ownership on the plants starts;
- Step 3: The reproductive biology of the species is understood and multiplication and cultivation of the species in the home gardens or in selected parts of cultivated fields are undertaken;
- Step 4: The species is produced (in sole cropping) and harvested using traditional practices;
- Step 5: To improve the quality of the product, farmers adopt specific criteria to select plants that better satisfy peoples
- Step 6: Development of appropriate pests and disease protection and food processing methods.

In the study area and as reported for *S. radiatum* (Eteka et al. 2011, Dansi et al. 2012), domestication of Gbolo, in the sense of bringing into cultivation, is in progress. Reasons put forward by the interviewees to justify the domestication of Gbolo are of six types: Regular consumption as vegetable (49.90 % of responses), scarcity of the species in the fields around the villages and its unavailability at the wild for use during dry season (20.30 % of responses), high perceived nutraceutical value through regular consumption (16.73 % of responses), contribution to household

income through commercialization (10.23 % of responses) and difficulty of the harvesting in the bush (2.84 % of responses). In reality, these six factors listed above portray three key aspects which are food, household income and scarcity, the first two being the most important. These results which are in agreement with those reported by Hildebrand (2003) in southwest Ethiopia and Casas et al. (2007) in Mesoamerica are not surprising since plant domestication always seek to bring out the maximum human benefit within a species. They also support the statement of Vodouhè et al. (2011) according to which domestication of a plant starts, when its usefulness is proved, its demand is confirmed and regular, its availability around dwellings is seriously decreasing and when getting the desired quantity on time for use becomes problematic.

The levels attained in its domestication (i.e. bringing into cultivation) phase vary among region, villages and ethnic groups (Table 5). In the Centre and in the North, Gbolo was mainly found at levels 1 and 2 (more than 50 % of the villages surveyed). At the opposite site, the species were found at the levels 3 and 4 in the majority (60 %) of the villages of the south. Levels 5 and 6 were not found. In terms of ethnic groups and at 86 % of similarity, the dendrogram (Fig. 4) constructed based on the diverse levels found yielded five groups namely G1, G2, G3, G4, and G5. The G4 groups together the Cotafon, Yorouba, Goun, and Holly tribes of the south in which the vegetable was found at level 4 which means that it was produced in sole cropping and harvested using traditional practices (Vodouhè et al. 2011). In G5 represented by the Sahouè (south) alone, Gbolo was found at level 3. G3, G2, and G1 assemble the ethnic groups in which the vegetable was found at level 0, 1 and 2 respectively. The groupings observed seem to be a function of the degree of consumption of the species and this was expected because Dansi et al. (2008a; 2009a, b) had earlier reported that Cotafon, Goun, Holly, Sahouè and Yorouba tribes most frequently consumed this vegetable in Benin.

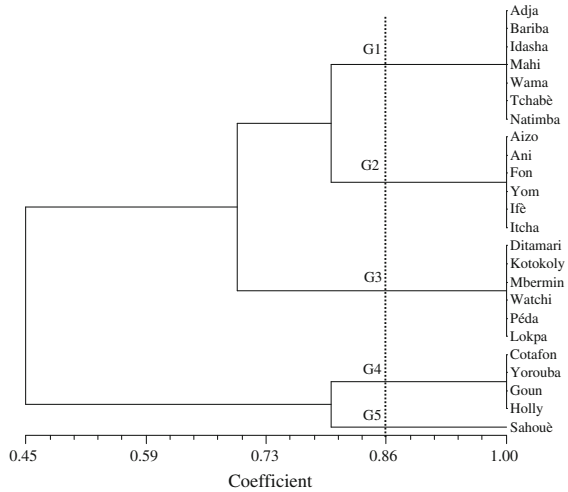

Fig. 4 UPGMA dendrogram based on Jaccard coefficient of similarity showing the grouping of the ethnic groups with regard to the various domestication levels recorded

Cultivation practices, cropping systems, harvesting and preservation methods

In the villages where production of Gbolo has started, the vegetable was grown at different sites. These include home gardens (65.2 % of responses), fertile portions of the cropland (28.4 % of responses) and near riverbanks and swamps (6.4 % of responses). According to farmers, leafy vegetables were mostly grown near the homestead for diverse reasons. These were: easy access (manuring, watering, daily use) when required (70.14 % of responses), protection from thieves, birds and animals (20.1 % of responses) and high soil fertility from the dumping of kitchen refuse leading to high yields (9.76 % of responses). They were grown near the rivers and in swamps for easy watering mainly during the dry season. Similar

Table 5 Percentage of villages recorded for the different levels of domestication in the study zone and throughout agro-ecological zones (L0 to L4 are domestication levels)

Regions	Levels of domestication				
	L0	L1	L2	L3	L4
Study zone	19.05	35.72	23.8	14.29	7.14
South	6.66	13.34	20	40	20
Centre	20	30	50	0	0
North	29.41	58.82	11.77	0	0

Table 6 Traditional farming practices applied to Gbolo (*Crassocephalum* sp.) and percentage of users

Cultural practices	Types of practices	Percentage of users
Planting material	Seed	73.08
	Young plant	26.92
Nursery making	Nursery	61.54
	No nursery	38.46
Mulching	Mulching	07.69
	No mulching	92.31
Nursery duration	4 week	50
	6 week	12.5
	7 week	37.5
Sowing method	Broadcasting	89.47
	Bulk seedlings	10.53
Planting method	Random planting	80.77
	Planting in rows	19.23
Plant spacing	25 cm	15.38
	30 cm	23.08
	40 cm	61.54
Association with other crops	Sole cropping	07.69
	With vegetable crops	53.85
	With non vegetable crops	38.46
Number of days to the 1st harvest	4 week (25–30 days)	26.92
	6 week (30–45 days)	73.08
Harvest frequency	4 week	88.46
	6 week	11.54

results were reported in Igbo cultural area of Nigeria for *Telfairia occidentalis* (Akoroda 1990) and in Benin for the traditional leafy vegetables in general (Dansi et al. 1999).

The commonest cropping systems (Table 6) used by the producers of Gbolo visited were found to be mixed or inter-row (92.31 % of producers) with either vegetable crops (53.85 of producers) or non-vegetable crops (38.46 of users). Sole cropping is applied by only 7.69 % of the producers. In the mixed and inter-row cropping, the base crop is usually cassava, groundnut and maize. Land preparation, planting and weeding were traditionally effected using hand hoes. No chemicals (fertilisers and insecticides) were used. When fertilization was necessary, compost manure was applied. Sowing was mainly by broadcasting followed by transplanting of young plant (89.47 % of producers). Nursery followed by transplanting in rows is applied by only 19.23 % of the producers interviewed (Table 6). In sole cropping, three types of spacing were adopted. These were 25 m × 25 m (average 25 m within and between rows), 30 m × 30 m, and 40 m × 40 m. As it was the case for *S. radiatum* Thonn. ex Hornem. and *J. tenella* (Nees) T. Anderson (Eteka et al. 2011), some agronomic trials should be conducted to determine the appropriate spacing to optimise the production for the benefit of both producers and consumers. All the interviewees reported the possible use of cutting as planting material as indicated in PROTA (www.prota.org) however, due to low growing and productivity reasons as they reported, none of them use it. Unlike staple crops, such as cassava, yams or maize, traditional leafy vegetables are usually short cycle crops and are harvested more frequently (Dansi et al. 2008a). With respect to Gbolo, across villages and ethnic groups, the first harvest is done between four and 6 weeks after transplanting and is, afterwards, repeated 3–6 time before flowering.

The multivariate analysis carried out on the producers of Gbolo (domestication level 3 and 4) using the different practices as variables revealed the existence in the study area of five categories (G1, G2, G3, G4 et G5) of producers (Fig. 5) hence corresponding to five

different packages of cultural practices. G1, G2 and G3 constitute producers applying the most advanced technological package (level 4 of bringing into cultivation) characterised by preparation of nursery, bulk seedling, planting in row and sole (producers of G3) or almost (mixture with some other vegetables) sole (Producers of G1 and G2) cropping. Producers of these groups are all market gardeners located in the peri-urban zones and producing for commercialisation. The other two groups (G4 and G5) use less advanced production technological packages (level 3 of bringing into cultivation). Our findings are similar to those recently published in Benin on *S. radiatum* and *J. tenella* (Eteka et al. 2011).

All the interviewees reported that Gbolo can be collected at the time of plenty, dried in the sun soon after harvesting and stored in traditional containers. It appears therefore as a vegetable suitable for the arid zones of northern Benin. In over 50 % of the cases, interviewees indicated that they chopped the vegetables before drying. Majority of the producers (69 %) indicated drying TLVs without blanching. Apart from drying on reed mats or sacks (23.07 % of the respondents), naturally occurring flat stone surfaces are taken advantage of, and used as, drying surfaces where these are found. Majority of the farmers (76.93 %) reported that the drying process is faster on the stone than on the mat or sack. Dried and preserved vegetables lasted between 2 and 3 months and are used for both own consumption and selling.

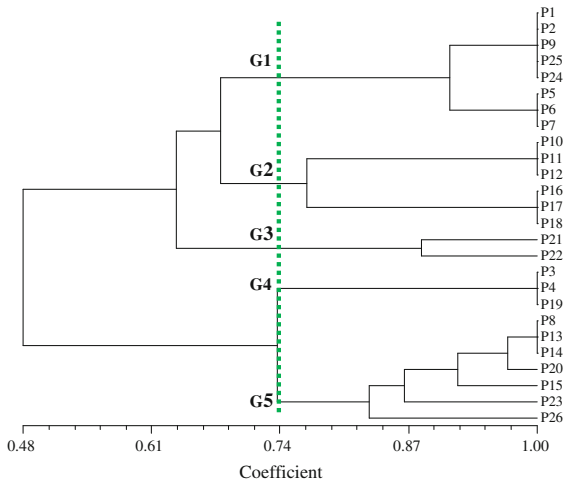

Fig. 5 UPGMA dendrogram based on Jaccard coefficient of similarity showing the categories of producers of *Crassocephalum* spp. according to the indigenous farming practices used

For hygienic reasons and to speed the drying process in order to help the communities to increase the amount of vegetables they usually preserved and which rarely last the entire dry season, there is a need to improve the drying methods by investigating the use of solar dryers as proposed by Dansi et al. (2009a).

Seeds system and on-farm seed maintenance

As domestication of Gbolo is in progress, seed systems are still not refined. The plant produce seeds easily under farmers' conditions. Therefore, seed availability was not seen as a major problem in the rural areas surveyed but harvesting from the flowered plants and seeds storage were identified as a problem. The methods farmers use to handle seeds are similar across regions but vary between households. Seeds harvested and sun-dried are packaged in various materials and stored in homesteads in granaries. The storage materials include bottle, box of cigar or matches, gourd, piece of cloth, piece of paper, polythene bag, pot and tin. Their degree of utilisation expressed as percentage of responses were 15.38, 18.46, 6.15, 12.31, 29.23, 3.08 and 4.62 % respectively. No chemical treatment was reported. According to the respondents and as also reported by Dansi et al. (2009a, b) and Eteka et al. (2011), availability, culture and habit were the reasons that determine the frequent use of the above listed materials in their respective zones. In the rural zones of the North, gourd or African calabash (*Lagenaria siceraria*) in its high diversity is widely produced and constitutes the most important traditional container. In the southern and central regions, polythene bags, bottles and boxes are plentiful and therefore readily available. In terms of storage period, farmers reported that these conservation systems may keep the viability of seeds anywhere between 6 and 9 months.

Preparation, nutritional importance, medicinal value and cultural significance

Sauces are the main type of preparation of Gbolo and this is done following the three types reported by Dansi et al. (2008a) and with fresh or dried leaves. In the villages surveyed, Gbolo is believed (farmers' perception) to possess special nutritional qualities. It is regularly consumed by the pregnant women to prevent anaemia and by the breast-feeding mothers to stimulate milk production and regain lost blood during delivery. It

is also said, when regularly consumed, to give stoutness and facilitate good growth, dentition and bones' solidification in the children. This vegetable is also recommended for pregnant women whose direct salt intake should be at minimal. Chemical analysis carried out in Nigeria (Dairo and Adanlawo 2007) and in Benin (Yehouenou et al. 2010; Adjatin et al. 2012) on this traditional vegetable revealed that the contents of the leaves in raw protein and in crude lipids expressed in percentage of dry matter are respectively 27.13, 3.45 % for *C. crepidioides*; 26.43 and 2.75 % for *C. rubens*. The content of vitamin C for 100 g of fresh leaf is of 9.17 mg for *C. crepidioides* and 3.60 mg for *C. rubens*. The content of ash is of 19.76 and 19.02 % for *C. rubens* and *C. crepidioides* respectively. The content for sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), iron (Fe), Manganese (Mn) and copper (Cu) are 2,129.04, 4,469.91, 434.13, 3,845.88, 1.6, 8.22 and 2.6 mg respectively for *C. rubens* and these are higher than those in *C. crepidioides*. These data fully support farmers' perception and indicate that Gbolo is a nutritionally rich vegetable. The survey revealed that in the zones where the two species are available, consumers' preference for one or the other species vary with the ethnic groups. In Mahi cultural area *C. rubens* is more appreciated than *C. crepidioides* while with the Nago ethnic group, it is rather *C. crepidioides* which is more preferred.

According to the local communities surveyed, Gbolo like *A. uliginosa* and many other traditional leafy vegetables (Dansi et al. 2008a) has some curative, regulative and stimulative properties besides food qualities and is used as neutraceutical. The species is believed to have antibiotic (94.28 % of villages), anti-helminthes (42.85 % of villages), anti-inflammatory (80 % of villages), anti-fungal or candidiasis (68.57 % of villages), anti-diabetic (34.28 % of villages), anti-malaria (17.14 % of villages) and blood regulation (74.28 % of villages) properties and also useful in treating indigestion, hepatic insufficiency and liver complaints (85.71 % of villages), colds (11.42 % of villages) and intestinal worms (48.57 % of villages). Chemical analysis of the leaves extract of this species (Adjatin et al. 2012) revealed quite rightly the presence of tannins, flavonoïds, steroids, mucilage, reducing compounds, coumarins and C—heterosids that are recognized as possessing pharmacological properties intervening in the prevention and the treatment of several human pathologies such as hypertension, headaches, breast cancer, burns, inflammations, injuries, liver complaints, infections and sexually transmitted diseases (Aniya et al. 2002; Dairo and Adanlawo 2007). These data support the local communities' observations indicated above.

In the ethnic group Fè in central Benin, the consumption of Gbolo is prohibited for the followers of the Divinity Mouloukou (God of the earth). In Benin and as reported by Dansi et al. (2008a) this situation seems frequent in the regions where fetishism (traditional religion) is well developed.

Germplasm collected and research perspectives

Ninety (90) accessions of Gbolo (54 of *C. rubens* and 36 of *C. crepidioides*) were collected throughout the survey zone. The number of accessions sampled varied from one to three per village. Seeds were collected from both wild plants and plants under domestication or cultivation in home gardens or in the fields, packaged and numbered according to well established guidelines for germplasm collection (Guarino et al. 1995). Part of the germplasm collected was kept as seed collection while the remaining one was established in the field after nursery in screen house (Fig. 6) for research purposes.

In total, the study showed that the production of Gbolo (*C. rubens, C. crepidioides*) in Benin is still traditional and biologic. Its first phase of domestication process (i.e. bringing into cultivation) as found across surveyed areas is still ongoing and should be supported with appropriate agricultural experiments (plant densities, time of planting, number of harvests; type, quantities and time of application of fertilisers, etc.) for intensive and optimal production in the market gardens. Raising public awareness on the value and importance of Gbolo (*C. rubens*; *C. crepidioides*) for food, nutrition and health will also contribute to promoting this vegetable and generate substantial resources for producers. For further promotion of the crop, the following research actions are suggested:

1. Additional germplasm collection from different agroecological zones
2. Agromorphological characterisation for identification of the best performing morphotypes to be involved in crop improvement efforts
3. Assessment of the genetic diversity using molecular markers

Fig. 6 Nursery of Gbolo (*C. rubens* and *C. crepidioides*) in a screen house made with the seeds of the 90 accessions collected in the study zone

4. Cytogenetic investigation: intraspecific, interspecific and geographical variation of ploidy levels and nuclear DNA content
5. Validation of antimicrobial, anti-diabetic, anti-inflammatory and blood pressure regulation properties attributed by the local communities to the leaf extracts of the two species

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References

Abukutsa-Onyango MO (2004) *Crotalaria brevidens* Benth. In: Grubben GJH, Denton OA (eds) Plant resources of tropical Africa 2 vegetables. Backhuys Publishers, Leiden, Wageningen, pp 229–231

Adam S, Boko M (1993) Le Bénin Les éditions du Flamboyant. EDICEF, Cotonou, p 6

Adéoti KA, Dansi A, Ahoton L, Ahohuendo BC, Ahanchédé A, Vodouhè R, Ahanchédé A (2009) Sélection of sites for the *in situ* conservation of four traditional leafy vegetables consumed in Bénin. Int. J. BiolChem. Sci. 3:1357–1374

Adjatin A, Dansi A, Sanoussi AF, Badoussi E, Gbaguidi F, Azokpota P, Vodouhè R, Akouègninou A, Akpagana K, Sanni A (2012) Proximate, mineral and vitamin C composition of vegetable Gbolo [*Crassocephalum rubens* (Juss. Ex Jacq.) S. Moore and *C. crepidioides* (Benth.) S. Moore] in Benin. J Biol Life Sci (in press)

Adomou AC (2005) Vegetation patterns and environmental gradients in Benin: Implications for biogeography and conservation, Ph.D. Thesis, Wageningen University, The Netherlands

Akoègninou A, Van der Burg WJ, Van der Maesen LJG (eds) (2006) Flore analytique du Bénin. Backhuys Publishers, Leiden, p 1034

Akoroda MO (1990) Ethnobotany of *Telfaria occidentalis* (Cucurbitaceae) among Igbos of Nigeria. Econ Bot 44:29–39

Almekinders C, de Boef W (2000) Encouraging diversity; in the conservation and development of plant genetic resources. Intermediate Technology Publication, London, p 1034

Aniya Y, Koyama T, Miyagi C, Miyahira M, Inomata C (2002) Free radical scavenging and hepatoprotective actions of *Crassocephalum crepidioides* from Okinawa Islands. Jpn J Pharmacol 88:187–191

Burkill HM, Dalziel JM, Hutchinson J (1985) The useful plants of west tropical Africa. Royal Botanic Gardens, UK

Burkill HM (1997) The useful plants of West Tropical Africa, vol 4, 2nd edn. Families M–R. Royal Botanic Gardens, Kew, Richmond, United Kingdom, pp 969

Casas A, Otero-Arnaiz A, Perez-Negron E, Valiente-Banuet A (2007) *In situ* management and domestication of plants in Mesoamerica. Ann Bot 100:1101–1115

Dairo FAS, Adanlawo IG (2007) Nutritional quality of *Crassocephalum crepidioides* and *Senecio biafrae*. Pak J Nutr 6:35–39

Dansi A, Mignouna HD, Zoundjihékpon J, Sangare A, Ahoussou N, Asiedu R (2000) Identification of some Benin Republic's Guinea yam (*Dioscorea cayenensis/Dioscorea rotundata* complex) cultivars using randomly amplified polymorphic DNA. Genet Resour Crop Evol 47:619–625

Dansi A, Adjatin A, Adoukonou-Sagbadja H, Faladé V, Yedomonhan H, Odou D, Dossou B (2008a) Traditional leafy

vegetables and their use in the Benin Republic. Genet Resour Crop Evol 55:1239–1256

Dansi A, Adjatin A, Adoukonou-Sagbadja H, Akpagana K (2008b) Production and traditional seeds conservation of leafy vegetables in Benin rural areas. Bulletin de la Recherche Agronomique du Benin 59:59–70

Dansi A, Adjatin A, Adoukonou-Sagbadja H, Faladé V, Adomou AC, Yedomonhan H, Akpagana K, de Foucault B (2009a) Traditional leafy vegetables in Benin: folk nomenclature, species under threat and domestication. Acta Botanica Gallica 156:183–199

Dansi A, Adjatin A, Vodouhè R, Adéoti K, Adoukonou-Sagbadja H, Faladé V, Yédomonhan H, Akoègninou A, Akpagana K (2009b) Biodiversité des légumes feuilles traditionnels consommés au Bénin (IRDCAM-IFS-FAST). p 182

Dansi A, Adoukonou-Sagbadja H, Vodouhè R (2010) Diversity, conservation and related wild species of Fonio millet (*Digitaria* spp.) in the northwest of Benin. Genet Resour Crop Evol 57:827–839

Dansi A, Vodouhè R, Azokpota P, Yedomonhan H, Assogba P, Adjatin A, Loko LY, Dossou-Aminon I, Akpagana K (2012) Diversity of the neglected and underutilized crop species of importance in Benin. Sci World J 2012:932947. doi:10.1100/2012/932947

Diouf M, Mbengue BN, Kanté A (2007) Caractérisation des accessions de 4 espèces de légumes feuilles traditionnels (*Hibiscus sabdariffa* L., *Vigna unguiculata* (L.) Help. *Amaranthus* spp. L. et *Moringa oleifera* Lam. au Sénégal. Afr J Food Nutr Dev 7:1–14

Eteka CA, Ahohouendo BC, Dansi A, Assogba-Komlan F, Vodouhè R, Ahoton LE, Ahanchédé A, Sanni A, Hounhouigan J (2011) Indigenous production and domestication of *Sesamum radiatum* and *Justicia tenella*, two traditional leafy vegetables consumed in Benin. Afr J Agric Res 6:5891–5904

Francisca IS, Eyzaguirre P (2007) African leafy vegetables: their role in the world health organization's global fruit and vegetables initiative. AJFAND 7:1–17

Grubben GJH, Denton OA (eds) (2004) PROTA (Plant Resources of Tropical Africa). Wageningen, Netherlands (www.database.prota.org)

Guarino L, Ramanatha Rao V, Reid R (eds) (1995) Collecting plant genetic diversity: technical guidelines. International Plant Genetic Resources Institute (IPGRI), Rome, Italy; Plant Production and Protection Division, FAO, Rome, Italy; World Conservation Union (IUCN), Gland, Switzerland; CABI, Wallingford, UK. 748 pp. ISBN: 0-85198-964-0

Hammer K (1984) The domestication syndrome. Kulturpflanze 32:11–34

Hanelt P, Institute of Plant Genetics and Crop Plant Research (eds) (2001) Mansfeld's Encyclopedia of agricultural and horticultural crops. 1–6. Springer, Berlin, p 3716

Harlan JR (1992) Crops and Man, 2nd edn. American Society of Agronomy/Crop Science Society of America, Madison, WI

Hildebrand EA (2003) Motives and opportunities for domestication: an ethno-archaeological study in southwest Ethiopia. J Anthropol Archaeol 22:358–375

Jaccard P (1908) Nouvelles recherches sur la distribution florale. Bull Soc Vaudoise Sci Nat 44:223–270

Jeffrey C (2001) Compositae. In: Hanelt P, Institute of Plant Genetics and Crop Plant Research (eds), vol 4. Springer, Berlin, pp 2035–2145

Mekbib F (2007) Infra-specific folk taxonomy in sorghum (*Sorghum bicolor* (L.) Moench) in Ethiopia: folk nomenclature, classification, and criteria. J Ethnobiol Ethnomed 3:645–663

Mensah JK, Okoli RI, Ohaju-Obodo JO, Eifediyi K (2008) Phytochemical, nutritional. Afr J Biotechnol 7:2304–2309

Mih AM, Tonjock KR, Ndam LM (2008) Morphological characterization of four selections of vernonia hymenolepis A. Rich. (Asteraceae). World J Agric Sci 4:220–223

Odhav B, Beekrum S, Akula Us, Baijnath H (2007) Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. J Food Compos Anal 20:361–448

Parker MI, Lopez I, Petersen JJ, Anaya N, Cubilla-Rios L, Potter D (2010) Domestication syndrome in Caimito (*Chrysophyllum cainito* L.) fruit and seed characteristics. Econ Bot 64:161–175

Pourkheirandish M, Komatsuda T (2007) The importance of Barley genetics and domestication in a global perspective. Ann Bot 100:999–1008

Rohlf FJ (2000) NTSYS-pc version 2.2: numerical taxonomy and multivariate analysis system. Exeter Software, New York

Sakuma S, Salomon B, Komatsuda T (2011) The domestication syndrome genes responsible for the major changes in plant form in the Triticeae crops. Plant Cell Physiol 52:738–749

Schippers RR (2002) African indigenous vegetables: an overview of the cultivated species 2002-revised version on CD-ROM. Natural Resources International Limited, Aylesford, UK

Sneath PHA, Sokal RO (1973) Numerical taxonomy. San Francisco, Freeman

Swofford DL, Olsen GJ (1990) Phylogeny reconstruction. In: Hillis DM, Moritz C (eds) Molecular systematic. Sinauer Associates, Sunderland, Mass

Vodouhè R, Dansi A, Avohou HT, Kpèki B, Azihou F (2011) Plant domestication and its contributions to *in situ* conservation of genetic resources in Benin. Int J Biodivers Conserv 3:40–56

Yehouenou B, Wotto V, Bankole H, Sessou P, Noudogbessi J-P, Sohounhloue D (2010) Chemical study and antimicrobial activities of volatile extracts from fresh leaves of *Crassocephalum rubens* (Juss. & Jacq.) S. Moore against food-borne pathogens. Biotehnologii Industrie Alimentara 11:341–349