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Review

Current knowledge and future prospects on the declining *Uvaria chamae* P. Beauv in sub-Saharan Africa: A global systematic review for its sustainable management

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ABSTRACT

Uvaria chamae P. Beauv is known as a key shrub species providing several goods and services for sustaining livelihoods in Sub-Saharan Africa. Despite its great medicinal importance for local communities, little is known about its conservation status and sustainable management strategies regarding the current overexploitation of the species' fruits through traditional agroforestry systems. Here, we addressed a global systematic review of the current state of knowledge on several aspects of research of *U. chamae* for setting further breeding programmes and conservation initiatives. A total of 744 publications were identified based on the extensive bibliometric review of its sustainable management and conservation status over the last three decades (1991-2021) through existing online databases. Only 257 publications were finally included in the current review after deep scrutinization which were in line with several aspects of the conservation ecology and management of *U. chamae* in Africa. All retained papers came globally from the five sub-regions, and particularly 13 countries in Africa. Most of them were recorded in West Africa (n = 245) compared to the other sub-regions where few studies exist on this intensively harvested shrub species. Approximately 89% of the retained publications came from five of West African countries including Nigeria (n = 151), Benin (n = 30), Côte d'Ivoire (n = 18), Guinea (n = 16), and Togo (n = 14). In-depth bibliometric analysis revealed critical knowledge gaps on *U. chamae* in terms of its geographic distribution; conservation status; tree growth, productivity and propagation; morphological diversity; molecular genetic diversity; reproductive biology; ecophysiological performances; socio-economic importance; biochemical analysis; and structural characterization. The current review paves the way for developing further long-term management programs of *U. chamae* in Africa.

1. Introduction

For thousands of years, humans have used natural ecosystems for their survival. Some wild medicinal and aromatic plants are a major resource for sustaining rural livelihoods (Perrino et al., 2021). Indeed, the wild edible tree species are identified to provide both key macronutrients and micronutrients for rural communities during food shortage (Salvi and Katewa, 2014). For example, the wild food plants (WFP) in particular, provide pronounced dietary diversity and can make an important contribution to micronutrient intake (Grivetti and Ogle, 2000; Welssels et al., 2020). For many residents in sub-Saharan Africa, WFP constitute an essential livelihood safety net when other sources of food fail, such as during times of drought or other climate-related impact periods (Vinceti et al., 2013; Wunder et al., 2014). Overexploitation of natural resources for survival during lean periods leads to degradation of these resources. This degradation results in the reduction of species, leading to a lack of food and medicine from the forest, for example, for local people whose livelihoods depend heavily on the forest (Kalaba et al., 2009).

Natural resources are constantly exposed to the persistent and often uncontrolled degradation. The dynamics of savanna ecosystems are linked to climate change, the rate of fires that cross them and the human activities that affect them (Nacoulma et al., 2011; Traoré et al., 2011). *Uvaria chamae* P. Beauv. commonly known as "finger root" or "bush banana" is a shrub species which provides several products for local people. This fruit tree species belonging to the Annonaceae family is described as a key multipurpose aromatic species. Its

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aromatic fruits are commonly used in the food industry to flavor drinks and foods (Igoli et al., 2005). The roots and leaves are used to prevent and treat heart cancer (Adams and Moss, 1999; Vârban, 2009). Nowadays, many tropical species are threatened due to overexploitation, especially of their roots to meet the needs of local populations, and lack of conservation policies, which may influence their sustainable management (Assogba et al., 2018). Indeed, the increasing pressure on the species' root does not guarantee its sustainability especially in its natural habitats (Fachola et al., 2019). In addition, cattle graze on regeneration (suckers and seedlings) of *U. chamae*, preventing population survival of the species (Gnoumou and Adouabou, 2021).

In the current context of climate-smart agriculture, countries in the regions facing radical climate change need to explore and identify the most resilient species that will facilitate agricultural adaptation to climate change (Houndonougbo et al., 2020). In Benin, the species is still wild and is generally found in savannahs, gallery forests, agricultural fields and fallows (Akoègninou et al., 2006). Despite increasing efforts to document the traditional uses (Ajibesin et al., 2008) and potential threats (Gnoumou and Adouabou, 2021) on *U. chamae*, little is still known about its sustainable management and domestication in Africa. Similarly, there are few systematic reviews that have addressed critical aspects related to the sustainable management of the species in Africa. Given the quality of the work (on traditional uses, phytochemical properties and biological activities of the species) already published, it is crucial to capitalize the available information on *U. chamae* in order to clearly identify gaps in knowledge and future prospects. Recent systematic reviews in the ecological sciences appear to highlight transparent and reproductive approaches to literature searching. The rigor they demonstrate in the process of identifying and selecting relevant publications for a good systematic review, is not the case with traditional narrative reviews (Houndonougbo et al., 2020; Hayton, 2008). Outputs of systematic reviews are derived from scientific databases and bibliographic tools that are often used in the selection of relevant publications. This approach could be a source of bias in the literature searches. It is therefore important to combine different sources of literature with a view to limiting this bias (Yu et al., 2016). For example, international search engines (i.e. Google Scholar and Science Direct) are mainly explored for literature reviews from other continents in addition to African Journals Online (AJOL) which has been identified as a key African scientific database (Houndonougbo et al., 2020).

This study aims to present an updated overview of the available knowledge on *U. chamae* in sub-Saharan Africa for its sustainable management. Specifically, the study aims to (i) document several aspects related to the current uses and management of bush banana based on the available literature, and (ii) identify critical knowledge gaps in order to establish a roadmap for research avenues on *U. chamae* in sub-Saharan Africa for its sustainable management.

2. Material and methods

2.1. Literature search approach

We gathered scientific papers on *U. chamae* using three online search engines: African Journals Online (www.ajol.info), ScienceDirect (www.sciencedirect.com) and Google Scholar (www.googlescholar.com). Science Direct and Google Scholar are international databases, while African Journals Online holds African literature (Houndonougbo et al., 2020). A literature search was conducted for the articles published over the last three decades (1991-2021) to critically document many aspects related to the sustainable conservation of *U. chamae* in Africa. The publications were collected using the following search terms including "*Uvaria chamae*" or "finger root" or "bush banana" and "conservation biology" or "conservation ecology" considering the species's range on an African scale. All recorded publications were read and critically analyzed for their inclusion in the systematic review. The compilation of the research results was done according to several aspects. The documentation of these aspects will provide useful information for the conservation and sustainable management policies of the *U. chamae*. These aspects were related to: (i) Ecology and geographic distribution, (ii) Taxonomy and botanical description, (iii) Traditional uses, (iv) Phytochemical properties and biological activities, (v) Morphological diversity, (vi) Molecular genetic diversity, (vii) Reproductive biology, (viii) Ecophysiological performances, (ix) Socioeconomic importance, (x) Growth, productivity and propagation, (xi) Structural characterization, threats and conservation status of *U. chamae*.

2.2. Retained publications and journals of publication considered

The publications collected in the three electronic databases were critically reviewed. This concerns their titles, abstracts and keywords which were globally examined in order to appreciate the relevance of their inclusion (link with the species) or not in the present systematic review. Publications identified as duplicates and case studies published outside the range of the species were discarded. Studies that are broad in scope and sometimes span a long period of time were also excluded from this review (see Akabassi et al., 2022). Only selected publications were carefully analyzed in four steps: (1) checking the relevance of the publication based on the title, i.e., whether the publication addresses an aspect related to *U. chamae*; (2) reading the abstracts to determine whether the article is relevant to the review; (3) downloading and reading the full article when step two did not provide relevant information to be considered in the review; and (4) collecting publications that meet the inclusion criteria of this review. Additional details derived from the selected publications were compiled for this literature synthesis. These include (i) journal and title of the publication; (ii) publication keywords; (iii) date of publication; (iv) country in which the study was conducted; (v) aspect(s) addressed in the study that may be related to the ecology, usage, threats, and conservation status of *U. chamae*. Using ArcGIS version 10.2 (ESRI, Redlands, California, USA), we constructed spatial distribution maps of the number of publications in sub-regions and countries according to the native range of *U. chamae* in Africa. A total of 744 publications were first recorded via the three online databases. About 487 publications were then excluded. These were either studies with unrelated topics and duplicates, or studies outside the native range of *U. chamae*. As a result, 257 eligible publications were finally retained in this bibliographic synthesis (Fig. 1). These publications cover the last three decades. These retained articles were globally published in 92 journals, including (19) journals identified by AJOL, (7) by Science Direct and (66) by Google Scholar. Yet, only 80 journals were finally recorded after eliminating twelve duplicates in the three databases.

3. Results

3.1. Spatio-temporal patterns of publications on U. chamae

Overall, the number of recorded publications on *U. chamae* has increased sharply with some fluctuations over the past three decades (Fig. 2). About 82.25% of the selected publications were published between 2009 and 2020. The lowest number of publications was recorded between 1994 and 2008 while the highest number (n = 31) was recorded in 2020. No publications were recorded between 1991 and 1993, as well as in 1998. The selected publications were mainly from four sub-regions that cover the native range of *U. chamae* in Africa. The majority of publications were from West Africa (245), followed by Austral Africa (09), Central Africa (02) and East Africa (01) (Fig. 3a). Publications on *U. chamae* are particularly recorded in 13 African countries. These are mainly Nigeria (n = 151), Benin (n = 30)

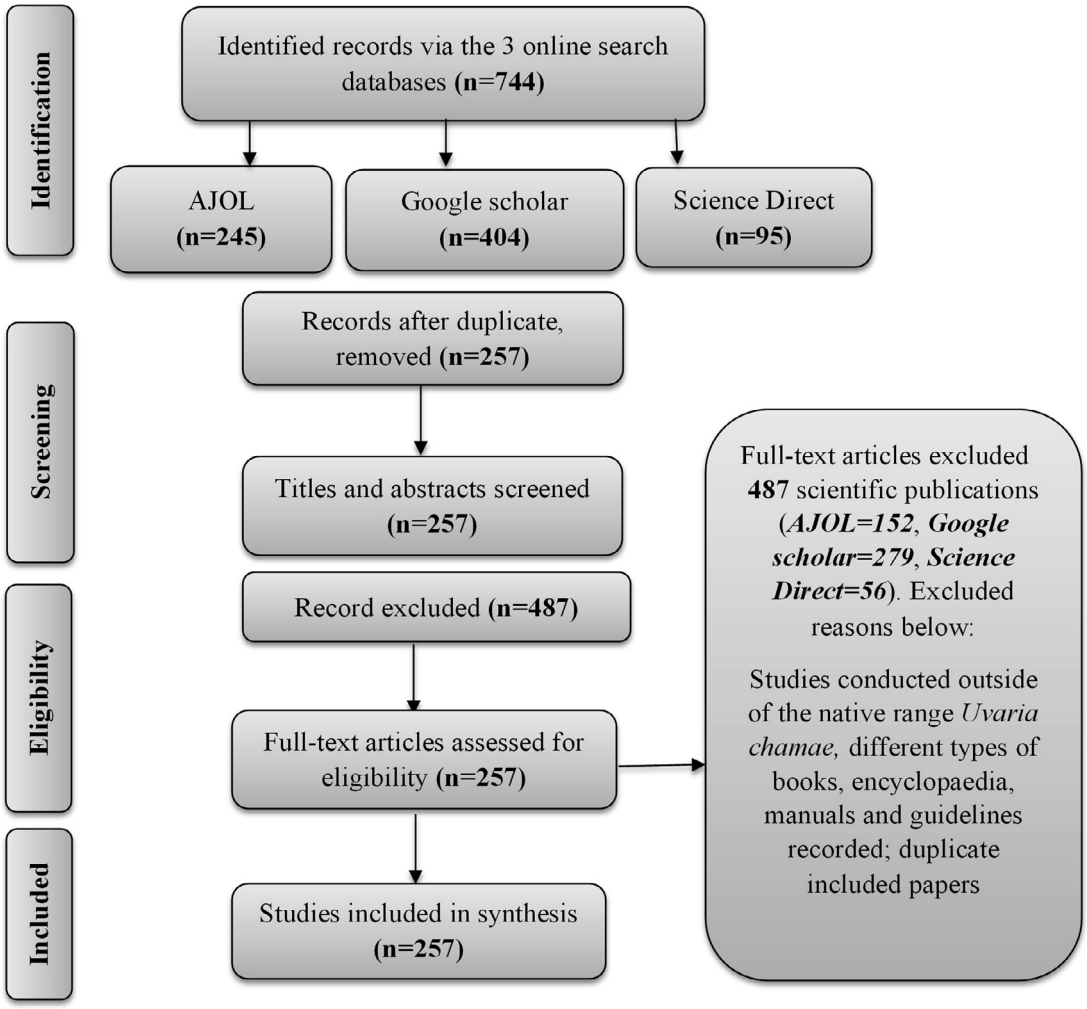

Fig. 1. Diagram showing the selection of 257 studies included in the systematic review on *U. chamae*.

and Cote d'Ivoire (n = 18) (Fig. 3b). Furthermore, the selected papers (257) on *U. chamae* focused mainly on the uses made of the species and to some extent on its botanical description and structural characteristics. Similarly, there were few studies on the taxonomy and ecology, botany, potential threats, and conservation status of the species. In addition, morphological and genetic diversity, shrub growth productivity and propagation, socioeconomic importance, reproductive biology, environmental conditions and ecophysiological aspects of the species are poorly documented (Fig. 4). All these aspects are crucial for the sustainable management of the species.

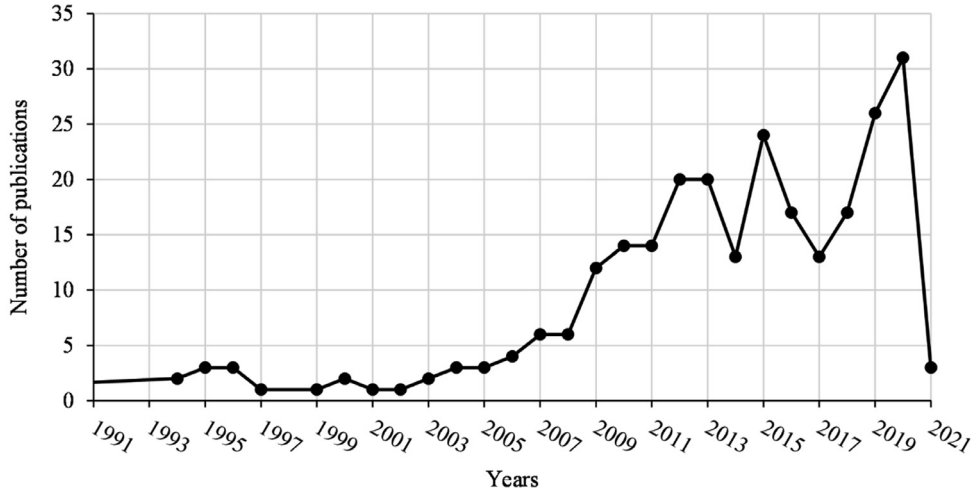

Fig. 2. Temporal variation in the number of publications on *U. chamae* along its native distribution range.

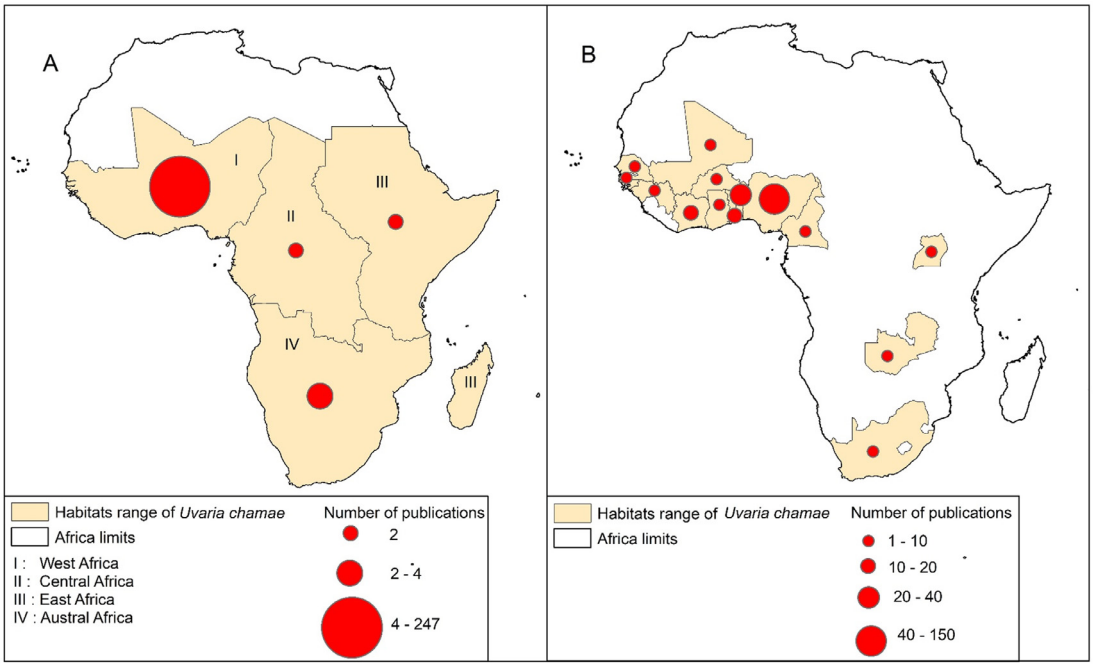

Fig. 3. A. Spatial distribution of number of recorded publications across the sub-regions covering the native distribution range of *U. chamae*, **B.** spatial distribution of number of recorded publications across countries forming the native distribution range of *U. chamae*.

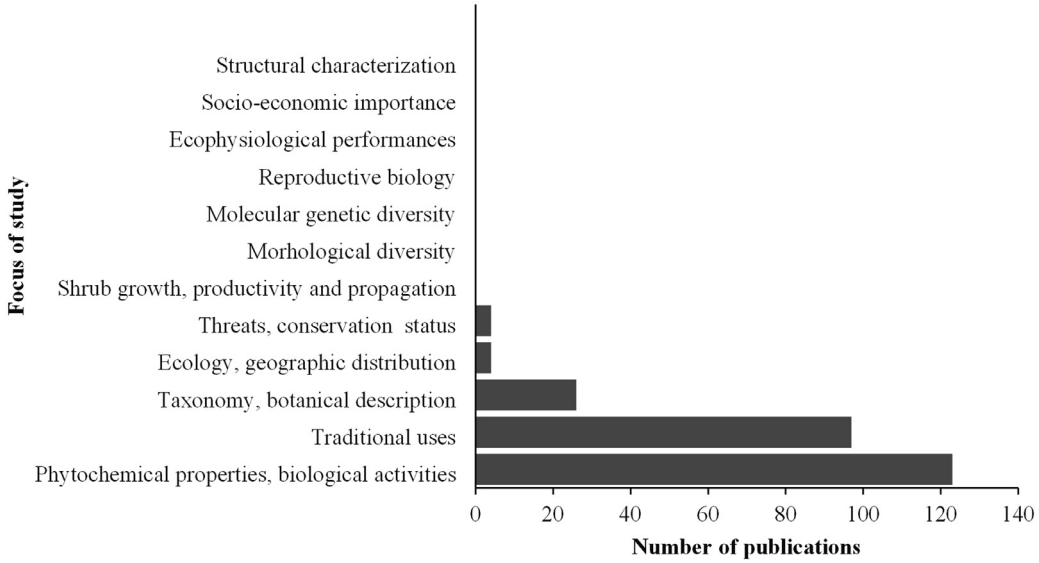

Fig. 4. Comparison of the number of publications following study focus on *U. chamae* across its native distribution range in Africa.

4. Discussion

4.1. *Temporal trends of the studies on* U. chamae

Globally, little documentation on *U. chamae* is recorded from 1991 to 2008. Nevertheless, issues related to traditional uses, biological activities and phytochemical properties have attracted great interest among scientists in the last decade due to their importance in the field of traditional medicine in sub-Saharan Africa; reflecting the growing research interest on the species in Africa. This trend corroborates a previous study by Adejumo et al. (2010) who reported that the roots of *U. chamae* were commonly used in traditional medicine for the treatment of sickle cell disease (SCD) in Nigeria. Similarly, Olumese et al. (2016) mentioned many other traditional uses of *U. chamae* in the treatment of diabetes, and other related diseases worldwide. The implications of the findings would foster new research perspectives for the domestication, conservation and sustainable use of the species.

4.2. *Spatial trends in publications on* U. chamae *in Africa*

Our results showed that 95.33 % of the publications came from West Africa, suggesting a greater research effort on *U. chamae* in this sub-region compared to other ones. More specifically, 89.10 % of the retained papers came from Nigeria, Benin, Cote d'Ivoire, Guinea and Togo. This trend could be explained by the wide range of species'

Fig. 5. A, B. Shrubs of *U. chamae* from wild habitats in Agbangnizoun district of Benin; **Source:** Daï photo (July, 2021).

uses especially in terms of traditional medicine, biological activities and phytochemical properties in these areas. Indeed, the majority of publications highlighting the biological activities, phytochemical properties and medicinal uses of *U. chamae* came from Nigeria (58.75%). This global trend observed among the recorded publications in West Africa could be explained by the multiple domestic uses (Olumese et al., 2016). For example, most of the publications recorded in West Africa have already reported its medicinal importance (Omajali et al., 2011), biological activities (Suba et al., 2004), phytochemical properties (Okwu and Iroabuchi, 2009; Abu et al., 2018), and food uses (Iwu, 1993; Bongers et al., 2005). Therefore, scientific research on the species in West Africa should also focus on other aspects such as: morphological diversity, ecology and geographical distribution, molecular genetic diversity, ecophysiological performance, socio-economic importance, growth, productivity and spread of trees, structural characterization, threats and conservation status of the species. However, few publications were gathered on the species in Austral Africa (09), Central Africa (02) and Eastern Africa (01). This could be probably due to the fact that research is oriented by the knowledge and use of the species. This knowledge and use vary between sub-regions of Africa, according to ethnic differences and the dynamics of transferring knowledge from generation to generation and the species' availability. Secondly, it may also be due to the fact that *U. chamae* is more distributed and abundant in West Africa compared to other sub-regions. North Africa recorded a very low number of publications, the limited distribution of the species in this sub-region could be the reason for its reduced research interest in this sub-region, as the genus *Uvaria*, family Annonaceae, is distributed in the tropical regions of Africa, Australia and the Pacific Islands (Muriel et al., 2011). It is crucial for scientists to address policies for sustainable management of the species with conservation and domestication actions needed to ensure the success of *U. chamae* domestication and cultivation as a new crop to alleviate poverty and improve the livelihoods in rural African communities.

4.3. Ecology and geographic distribution

U. chamae, commonly known as "finger root" or "bush banana"; was recorded in Ghana, by Palisot de Beauvois (Mugnier, 2008). It is a climbing shrub found in both wet and dry tropical forests of West and Central Africa (Abu et al., 2018; Bongers et al., 2005). It is widely distributed in parts of Asia, South America and Australia (Okwu and Iroabuchi, 2009). The species occurs in Senegal, Guinea, Mali, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Benin, Nigeria, Central African Republic and Democratic Republic of Congo (Mugnier, 2008). It is often found in the gallery forests of the Guinean and Sudanese savannas, in significant numbers compared to other species on rocky soils, but also on slightly cooler soils (in the lowlands and valleys) of Senegal, Cameroon and Democratic Republic of Congo (Mugnier, 2008). *U. chamae* is usually found in Benin savannas (Fachola et al., 2019). In Benin, it is still wild and established through savannahs, gallery forests, groves and fallows (Fig. 5), where it remains underutilized (Akouègninou et al., 2006). For example, the species occurs at the station located along the Okpara' river close to the road connecting the Oké-Owo village to Nigeria in a vegetation composed of *Lecaniodiscus cupanoides, Napoleonea vogelii* (Yabi et al., 2017). It is commonly found, at the water's edge in swamp forests with *Alchornea cordifolia, Dracaena arborea, Anthocleista vogeliana, Mussa endaiserteana, Mitragyna stipulosa)* (Arbonnier, 2004; Bongers et al., 2005; Abu et al., 2018). *Uvaria chamae* has been identified in the underwood of the *Acacia auriculiformis* plantation, occupying an area of several hectares in southern-Benin in association with *Adenia lobata, Chassalia kolly, Olax subscorpioidea, Rytiginia umbellulata, Agelaea pentagyna, Diospyros tricolor* (Tossou et al., 2012). The species is found in the form of climbers in the underwood of the Badenou forest in Côte d'Ivoire in association with other lianas such as: *Opilia amentacea* (Opiliaceae), *Saba senegalensis* (Apocynaceae), generally in clumps (Gboze et al., 2020). *U. chamae* is adapted to the tropical ferruginous soils in phytocenoses with *Reissantia indica* and on lianescent synusis with *Reissantia indica* on tropical ferruginous soils with well drained silty texture (Gangnibo et al., 2014).

4.4. Taxonomy and botanical description of U. chamae

4.4.1. Taxonomy

U. chamae belongs to the Annonaceae family. The Annonaceae is a large pantropical family including 135 genera and 2500 species of flowering trees and climbing shrubs (Chatrou et al., 2004; Zhou and Saunders, 2009). The genus *Uvaria* located in the LBC, is one of the largest paleotropical genera in the family (Zhou and Saunders, 2009), with 190 species of climbing plants or scandal shrubs in the humid tropics of Africa, Madagascar, continental Asia, Malaysia, northern Australia and Melanesia (van Heusden, 1992; Zhou and Saunders, 2009). The generic name Uvaria was first published by Linnaeus in 1753, with the description of two species, *U. zeylanica L.* and *U. japonica L.*; the former species is the type of the generic name, while the

Fig. 6. Fruits of *U. chamae*, **Source**: Daï photo (August, 2021).

latter is now recognized as a Kadsura species (Saunders, 1998; Zhou and Saunders, 2009). Synonyms of *U. chamae* have been described as follows: *Unona macrocarpa* DC, *Uvaria cristata* R. Br., *Uvaria cylindrica* Schumacher. Thonn, *Uvaria echinata* A. Chev., *Uvaria nigrescens* Engl. Diels, *Xylopiastrum macrocarpum* (DC.) Roberty (Lim, 2012).

4.4.2. Botanical description of U. chamae

U. chamae is an evergreen shrub that reaches a height of 3.6 to 4.5 meters. Its stem is dark brown, the branches of the sinuous species are rusty-pubescent and become glabrous. Its leaves when crushed give off a peppery smell. The fruits of the species have simple structures and are alternately arranged (Fig. 6). The fruits are briefly petiolate, leathery, elliptic oblong or oval, the apex obtusely pointed. The obtuse base is slightly cordate, with tiny stellate hairs becoming glabrous with age and the midrib is imprinted above with tiny hairs on the midrib of the lower surface, 9-13 pairs of laterals and entire with a slightly wavy margin. The leaves are lanceolate with a whole blade and clear veins. Their tops are cumulated with a glabrous vestiture (Orwa et al., 2009; Lim, 2012; Anowi and Ekwueme, 2019). The species is widely branched with broad, sweet, aromatic leaves (Okwu and Iroabuchi, 2009). The flower is 2.20 to 2.5 cm in diameter, greenish brown, bisexual, in clusters of 2 to 5 usually axillary flowers with a more or less hemispherical receptacle (Orwa et al., 2009; Anowi and Ekwueme, 2019). The flowers are usually solitary or grouped in inflorescences (pauciflores or clusters), terminal, extra-axillary or oppositive. They are most often hermaphrodite. The flower has a perianth in three cycles: (3S + (3 + 3) P). Its calyx is brownish green, tomentose, three valved and conical sepals located near the base with greenish beige petals, they are usually six, distinct, with three outer ones often larger and differentiated from the inner ones, slightly imbricated (Orwa et al., 2009; Lim, 2012; Linde and Jonas, 1999). Stamens are usually numerous, packed in a ball or disk configuration, distinct, rust-tomentose carpels, numerous (Orwa et al., 2009; Anowi and Ekwueme, 2019). Fruit carpels are 20 or fewer, rusty-pubescent, oblong, tenebrous, on stipes, sometimes rough, with blunt, irregularly spaced protrusions. The fruits appear in yellow finger-shaped clusters when they reach maturity. The fruits of the species have a sweet aril that contains the seeds. They can remain on the shrub for a long period during the dry season. Seeds are few in number, more or less compressed, shiny and light brown (Mugnier, 2008; Orwa et al., 2009).

4.5. Traditional uses of U. chamae

4.5.1. Food uses

U. chamae is identified as providing multiple goods and services for rural communities (Fig. 7). The tender species' leaves are eaten as vegetables, while the ash from its stem serves as a salt substitute in food. Its fruits are used in the beverage industry to flavor foods and are greatly consumed (Ambé, 2001; Bongers et al., 2005). The seeds of the species are used in the preparation of soup (Mapongmetsem et al., 2012).

4.5.2. Medicinal uses

U. chamae is identified as a key shrub used in traditional medicine throughout its native range. It is widely used in the treatment of diabetes worldwide (Olumese et al., 2016). The leaf juice is applied to wounds, sores, ulcers and cuts while the leaf infusion is used to treat injuries, swellings, ophthalmia irritis and conjunctivitis. The root-decoction is used as a purgative and lotion, for the treatment of piles, menorrhagia, epistaxis, hematuria and hemolysis (Omajali et al., 2011; Olumese et al., 2016). In folk medicine, extracts of the root, bark and leaves are used to treat gastroenteritis, malaria fever, vomiting, diarrhea, wounds, sore throat and inflamed gums (Okwu, 2003; Olumese et al., 2016). The species' bark is used for the treatment of fibroids in Nigeria (Adebisi, 2019). The leaves of *U. chamae* are used as antimalarial in Nigeria (Idu et al., 2010). According to Egunyomi et al. (2009), the roots of *U. chamae* and *Plumbago zeylanica* are among the constituents that are used in the manufacture of a traditional recipe for the treatment of sickle cell anemia. The species is used to treat fevers and has antibiotic properties (Bongers et al., 2005). Its roots are used against anemia in Benin (Adomou et al., 2012). *U. chamae* is used in the treatment of female infertility, cough, enteralgia, edema (Ouattara et al., 2016). The species' roots in decoction are used

Fig. 7. Traditional uses of *U. chamae* in Africa: **A, B.** the ripe fruits spread out to be sold to the consumers, **C.** branches of the species used to make a granary for agricultural products' conservation, **D.** the stems used as firewood, **E.** the cutting of the roots to be sold on the market as herbal tea, **F.** root attachments sold on the market in Benin. **Source:** Daï photo (August, 2021).

against inflammations in Benin (Kpodji et al. 2019). Leaf sap is used to treat wounds and sores, leaf infusions is used as eye wash and leaf decoction as febrifuge (Adelodun et al., 2013). The species root is used to treat malaria and infection in Benin (Allabi et al., 2011). The root crushed and boiled in water or palm wine as decoction or macerated is used in the treatment of hemorrhoid, diarrhoea, jaundice, and bleeding (Ajibesin et al., 2008). Leaves and bark boiled are taken against malaria (Uzodimma, 2013). The product from the root of *U. chamae* cut into bits, wash thoroughly and boil with lemon fruit treat cervical (Afolayan et al., 2020**)**. The root of *U. chamae* with palm wine and small amount of water in infusion is used to treat the benign prostatic hyperplasia (BPH) (Ofeimun and Temitope, 2020). The species' root in decoction is used against amenorrhea, hyperprolactinemia (Sharaibi et al., 2014). Blood clotting in women during childbirth is treated with the root bark and stem bark of *U. chamae* (Shomkegh et al., 2016). The species is described as having a good potential in the treatment of typhoid fever in Benin (Dougnon et al., 2018). Stem, leaves, bark in decoction or maceration are used as antimalarial in Nigeria (Oladeji et al., 2020). In addition, jaundice, yellow fever, sores, febrifuge, purgative are treated with the root and leaves of *U. chamae* (Olowokudejo et al., 2008). Root-bark of the species in poultice treats venomous bites/stings, swollen legs (snake, scorption) (Thomas and Bamidele, 2020). Sexual weakness and infection are treated with the species' root (Afanyibo et al., 2018). Etukudo (2003) mentioned that the root is used in the treatment of nose bleeds, heart disease (lung, bronchus), hematuria and fever. The natural antibacterial and antioxidant properties of the species are increasingly important in the prevention and treatment of heart cancer, inflammatory and cardiovascular diseases (Vârban, 2009). Flavonoids extracted from *U. chamae* roots protect against allergies, platelet aggregation, microbes, ulcers, hepatoxins, viruses and tumors (Okwu and Omodamiro, 2005; Farquar, 1996). These same flavonoids extracted from the roots of *U. Chamae* regulate menstruation in women, prevent conception and induce birth or abortion of a child, lower the clothing in the blood and even act as a decongestant. In addition, some of these flavonoids act as a potent protective agent against inflammatory disorders (Okwu and Iroabuchi, 2009). Similar anti-inflammatory properties have been reported on *Elephantorrhiza elephantina* and *Pentanisia prunelloides* in the treatment of degenerative diseases in South Africa (Moteetee et al., 2019). The leaves of *U. chamae* are used in Burkina Faso to treat leprosy and asthenia (Ouôba et al., 2006). These leaves are also used as a tonic in Nigeria. The roots, branches, and leaves of *U. chamae* are used in Guinea-Bissau to treat the ailments including intestinal problems, wounds, skin inflammation, burns, coughs, respiratory diseases, bites, poisoning, mental, neurological disorders, and hemorrhoids (Catarino et al., 2016). The stems are used in the treatment of diabetes in pregnant women (Fah et al., 2013). In Togo, the decoction of species' roots has been used to treat liver disease (Kpodar et al., 2016). The leaves, stem bark of *U. chamae* are used in Nigeria to treat malaria (Iyamah and Idu, 2015). The species' root infusion with native pepper in gin is used to treat severe abdominal pain in Ghana. Its root with Guinea grains is used in application to the fontanelle for cerebral diseases. The root has the reputation of being the "medicine of the rich" and is taken in conditions of weariness and senescence by the Fulai people of Senegal. In addition, the root is used to prevent miscarriage. It is also considered as a "female medicine" because it is used against the amenorrhea, against the pains of the childbirth in Togo, one gives a decoction of the root. In Côte d'Ivoire, it is used for the treatment of jaundice. In Nigeria, the bark of the root is used for the treatment of bronchitis, gonorrhea. It is also used against catarrhal inflammations of mucous membranes (Oluremi et al., 2010).

4.5.3. Other uses

The roots of the species have a widespread reputation (Iwu, 1993). The yellow coloration of the root of the species is widely used to dye fabrics (Fig. 8); this color is also useful in cosmetics (Igoli et al., 2005).

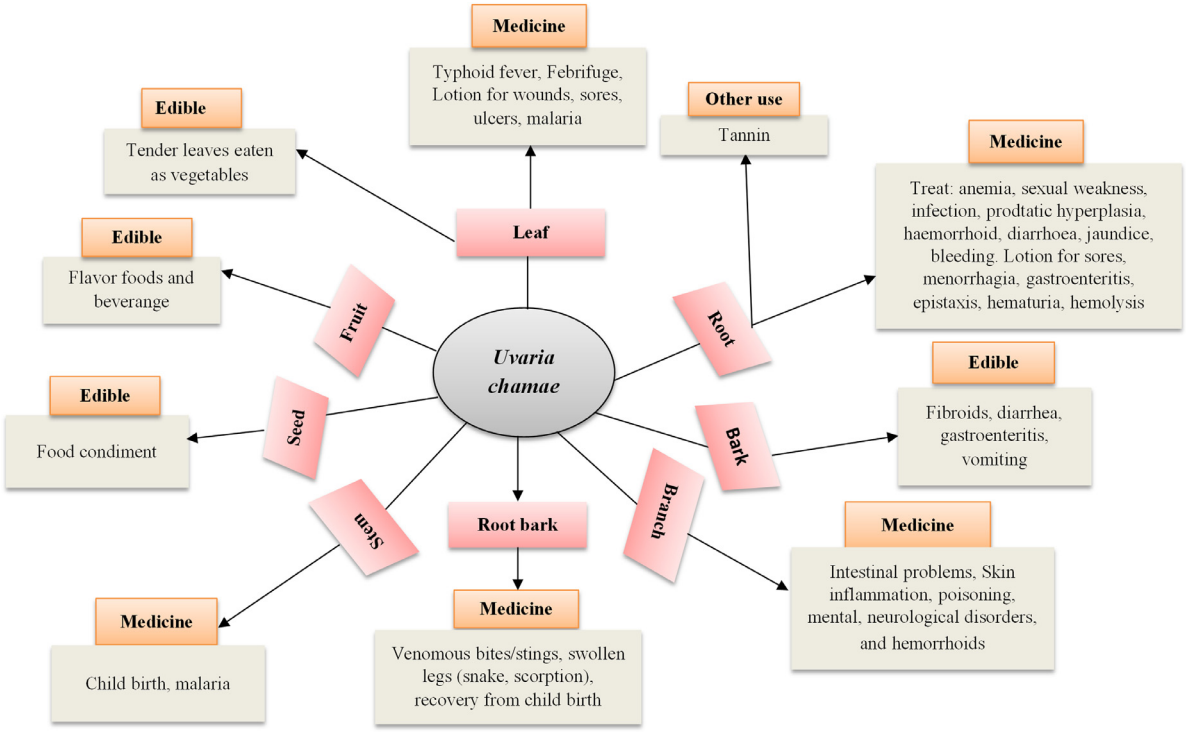

Fig. 8. Overview of traditional uses from different parts of *U. chamae* in Africa.

The stem bark is used as an alternative rope for tying firewood (Uzodimma, 2013).

4.6. Phytochemical properties and biological activities

4.6.1. Phytochemical properties

The species contains certain phytochemicals. Indeed, the roots of *U. chamae* contain: alkaloids, tannins, flavonoids, reducing sugars, quinone derivatives, leucoanthocyanins, terpenes/terpenoids, saponins, essential oils but do not contain glycosides (Avaligbe et al., 2012; Emeka et al., 2015; Abu et al., 2018). The stem bark contains: glycosides, saponins, tannins, flavonoids, reducing sugar (Ebi et al., 1999; Oluremi et al., 2010) but not the alkaloids. Its leaves are composed of alkaloids, saponins, tannins, flavonoids, terpenes / terpenoids, essential oils (Borokini and Omotayo, 2012; Moukimou et al., 2014). As for seeds, they contain flavonoids (Basil, 2017). The phytochemical screening of *U. chamae* revealed the presence of alkaloids, tannins, flavonoid, oxalate, saponins and cyanogenic glycosides (Olumese and Onoagbe, 2017).

4.6.1.1. Essential oils. The root oil of *U. chamae* contains a number of oxygenated benzylbenzoate and ether derivatives (Abu et al., 2018; Ayedoun et al., 1999).

4.6.1.2. Flavonoids. Flavonoids found in roots of *U. chamae* protect against allergies, platelet aggregation, microbes, ulcers, hepatoxins, viruses and tumors (Farquar, 1996; Okwu and Omodamiro, 2005).

4.6.2. Biological activities

4.6.2.3. Antidiabetic activity. The extract of *U. chamae* has anti-diabetic activity (Emordi et al., 2016). In addition, Suba et al. (2004) reported that tannin has anti-diabetic activity. Many plants containing flavonoids have been used for the treatment of diabetes (Choi et al., 1991; Hassig et al., 1999). The species possesses the considerable antimalarial activity (Okokon et al., 2006).

4.6.2.4. Antimicrobial activity. The stem bark of *U. chamae* has antimicrobial activity (Ebi et al., 1999; Lim, 2012). The leaf extract of *U. chamae* (linalool) has antimicrobial activities (Peana et al., 2003). Several subfractions, containing glycosides (8, 11-15) and tannins (18), have shown activity against a number of microorganisms, being in some cases more active than penicillin G and chloramphenicol, several extracts of the species have shown antibacterial activity in vitro (Ogbulie et al., 2007; Lim, 2012).

4.6.2.5. Antioxidant activity. The high presence of phenolic compounds in ethanol extracted from *U. chamae* could be responsible of the species antioxidant (Kone et al., 2015). Flavonoids are a group of phytochemicals that exert high antioxidant activity against superoxide radical (Hertog et al., 1993).

4.6.2.6. Cytotoxic activity. *U. Chamae* contains essential oils, alkaloids, flavonoids, which have cytotoxic activity (Bhawna and Kumar, 2009). The ethanolic extract of *U. chamae* has in-vivo activity against P-388 lymphocytic leukemia (PS) in mice and against human nasopharyngeal carcinoma derived cells (Lasswell and Hufford 1977).

4.6.2.7. Antivenom activity. According to Abu et al. (2018), the methanolic extract of *U. chamae* has a potential to neutralize some biological effects of *Naja nigricollis* venom. Thus, several chemical constituents such as alkaloids, flavonoids, glycosides and tannins have also been reported for their anti-snake venom activity (Moreno et al., 1993; Abu et al., 2018).

4.6.2.8. Insecticidal activity. Stem bark extracts of the species in the form of powder and ethanol are used during grain storage thus ensuring food security, profit maximization and availability of seeds for the next planting season without being damaged by insect

species. This is probably due to the fact that the species contains high concentration of steroids and terpenes (Negbenebor et al., 2018).

4.6.2.9. Antiparasitic activity. Extracts derived from the stem and root barks of *U. chamae* have antiparasitic activity against *Trypanosomia brucei* (Fall et al., 2003).

4.6.2.10. Antimalarial activity. Leaf and fruit extracts have better chemosuppressive and curative during antimalarial activity (Fig. 8), supporting their folkloric uses and secondary metabolites (Abu et al., 2018; Adepiti et al., 2013). *U. chamae* is traditionally used as a remedy for malaria in Nigeria (Lim, 2012).

4.6.2.11. Anti-inflammatory. Okwu and Iroabuchi, (2009) have already demonstrated the anti-inflammatory activities of *U. chamae*. Similarly, Temidayo et al. (2016) reported the anti-inflammatory properties of the species.

4.7. Threats and conservation status

The available literature on the species reveals a limited amount of work on the threats and conservation status of the species in sub-Saharan Africa. Indeed, to our knowledge, only Benin and Burkina Faso have briefly addressed these aspects of the species. It should therefore be noted that *U. chamae* is a species used by rural communities and that its uncontrolled exploitation constitutes a major threat to its decline. For example, in Burkina Faso, livestock graze on the species' natural regeneration (suckers and seedlings) preventing the survival of its population (Gnoumou and Adouabou, 2021). Similarly, the increasing pressure on *U. chamae* due to overexploitation of its roots does not guarantee the sustainability of the species in its natural habitats (Fachola et al., 2019). Therefore, according to Lawin et al. (2016), the species is threatened and its conservation in farmlands is the only measure adopted by rural communities. In southern Benin, *U. chamae* has been mentioned as a threatened species. However, for the sustainable management of the species, no protective measures are yet adopted by the local population (Djego et al., 2011).

4.8. Knowledge gaps and future prospects

Uvaria chamae is a species of great medicinal importance (Olumese et al., 2016). But unfortunately threatened in its natural habitat through uncontrolled harvesting of its roots by the local population in order to satisfy their needs (Fachola et al., 2019). The species is mostly used in Nigeria, Benin, Côte d'Ivoire, Guinea and Togo in medicine and to a lesser extent in food uses. In spite of this, *U. chamae* is poorly documented and its native range is becoming increasingly restricted because the species faces increasing anthropogenic pressures (Fachola et al., 2019; Gnoumou and Adouabou, 2021). As the species is threatened in its natural habitat, in the coming years if nothing is done for its domestication and conservation, the populations of the species may disappear completely. It is therefore important to put in place strategies for its domestication in its geographical range in general and in particular in sub-Saharan African countries. In addition, several gaps in knowledge about *U. chamae* in Africa have been highlighted in this review. We noted a heterogeneous and uneven distribution of publications on the species in its range. Our results are congruent with the previous findings and support the hypothesis that the number of publications on plant resources is greatly dependent on their importance, availability and conservation status (Houndonougbo et al., 2020). Therefore, in this review, several gaps were recorded in line with the domestication and conservation aspects of bush banana. These gaps include morphological diversity, molecular genetic diversity, shrub growth, productivity and propagation, socioeconomic importance, reproductive biology, ecophysiological performances. Identification of these gaps is very useful for the implementation of further actions that must be carried out for the development of a management plan of *U. chamae*. However, in the perspective of the sustainable management of *U. chamae*, many other studies should be conducted for illuminating the domestication potentials and conservation measures of the species in Africa. More specifically:

1. There is a lack of knowledge regarding the geographical distribution and its suitable habitats in line with environmental factors driving its distributional ecology. This is crucial for decision-making about identification of the current and future suitable habitats for domestication and conservation of bush banana. It will therefore be necessary to dissect the ecological mechanisms underlying its spatial distribution and abundance in Sub-Saharan Africa;
2. Very few studies have addressed the morphological variability of the species in Africa. It is important to characterize the ecophenotypic variation of *U. Chamae* in its range and to highlight how this variation is related to the environment;
3. Some studies have pointed out that populations of *U. Chamae* are declining due to increasing anthropogenic and ecological pressures in the tropics. Especially the overexploitation of the species through root removal and utilization have a negative impact on the reproductive performance of the species.
4. However, there is no long-term research on the population dynamics of the species and how it responds to different disturbances that would allow us to have information on the life history of the species, which could be useful for planning its conservation actions.
5. Remarkably, little information is available on the biochemical properties of species' fruits. Thus, the biochemical characterization of its fruits will add value to the species potential for human nutrition (Chadare et al., 2008). Similarly, biochemical analyses of the fruits will pave the way for genetic studies and accelerate the identification of morphological traits in addition to selection of the best morphotypes for cultivation of bush banana.
6. There is little information on the economic contribution of *U. chamae* to rural household incomes in sub-Saharan Africa. Previous studies have indicated that the NTFP trade contributes significantly to rural livelihoods through income generation. It would be crucial to conduct surveys to determine the contribution of *U. chamae* to household income in relation to other sources of income in local communities in Africa.
7. There are few studies on the improvement of genetic resources related to the selection of wild morphotypes of *U. chamae*. This is a potential new research opportunity for characterizing *U. chamae* germplasm for further domestication initiatives.
8. Little is also known about the ecophysiological performances of *U. chamae* despite its ability to grow spontaneously in fallows, crop fields and savannas in Africa. It is therefore important to study the physiological performance of the species against biotic and abiotic factors in order to select the best climate-resilient cultivars that could be used in further breeding programs.
9. There are few studies on the production and harvesting of species' fruits along a climatic gradient. It would be important to evaluate the yields and the dynamics of the natural stands for the planning of domestication and conservation actions of *U. chamae*.
10. There is a lack of information on the biological reproduction of the species. It is necessary to understand the modes of biological reproduction of the species for the implementation of domestication strategies.

5. Conclusion

U. chamae is a neglected and underutilized multipurpose shrub in tropical Africa. It has several benefits for the population and has a great potential for use as a traditional medicine. For example, the root of the species is used to treat many ailments in traditional medicine. However, the conservation of the species will face difficulties if research and information generation is lacking. In addition, knowledge of the species' range, morphological variability, genetic and environmental factors affecting morphological traits, and intraspecific variation of the species remains unknown. This review identifies relevant research gaps and further provides recommendations which, if adopted, could improve knowledge on the species to enhance its domestication process.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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