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Chromolaena odorata invasion in Guinea-Bissau (West Africa): first records and trends of expansion

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Abstract

The Siam weed, *Chromolaena odorata* (L.) R. M. King & H. Rob. (Asteraceae), is recognized as one of the world's worst tropical weeds. It is a perennial herb or shrub native to the neotropics that has become invasive across the tropical regions of Africa, Asia and Oceania. The species was introduced in 1937 in Nigeria and later spread to neighboring countries. Its presence and effects have been documented in the upland zones of almost all West African countries. Although, until the present study, the species had not been recorded in Guinea-Bissau, its presence in the country was very likely. In this work we document, for the first time, the invasion of Guinea-Bissau by *C. odorata,* assessing its present distribution and reporting effects, local uses and common names. Dispersal trends, potential consequences of its expansion and recommendations for management and control are also presented.

Key words: invasive alien species, biological invasions, fallow land, shifting agriculture, Siam weed

Introduction

Chromolaena odorata (L.) R. M. King & H. Rob. (=*Eupatorium odoratum* L.) (Asteraceae: Eupatorieae) is native to the warmest parts of southeastern USA, Mexico, the Caribbean, Central America, and tropical South America. This species has become an important invasive weed throughout the tropical regions of Africa, Asia and Oceania (Muniappan et al. 2005; Zachariades et al. 2013).

In West Africa, the species was accidentally introduced in 1937 in Nigeria through seeds of *Gmelina arborea* Roxb. imported from Sri Lanka (Ivens 1974), and from there it spread to neighboring countries. Presently, *C. odorata* is documented in almost all West Africa countries, from Senegal and Gambia in the north to Nigeria and Cameroon in the south. Its dissemination was largely due to human activities and migration movements commonly driven by economic reasons and/or by local traditions and practices, as well as other related anthropogenic factors (Uyi and Igbinosa 2013).

Siam weed is a ruderal plant species that thrives in sunny and disturbed habitats, such as fallow lands, roadsides and cropped land, and can easily invade open spaces (see the review by Zachariades et al. 2009). In heavily disturbed environments it effectively outcompetes crops and other plants, and may become the dominant species. In West Africa, it is a major weed both in young tree crop plantations and in annual crops, and can also invade pasture land. It has been reported to decrease agricultural productivity and to increase management costs at both subsistence and commercial scales (Prasad et al. 1996).

As reported for several African countries, the invasiveness of Siam weed is particularly severe in young fallow lands (i.e. with fallow periods shorter than 5 years) and light may be the major factor regulating population size (Witkowski and Wilson 2001). In slash-and-burn systems with long fallow periods, the weed abundance decreases sharply as the succession proceeds (e.g. after the 5th year) (Kushwaha et al. 1981). However, in these systems, the shortening of fallow periods can favor the encroachment of *C. odorata.* The invasive success of *C. odorata* is thought to depend upon a combination of factors such as high reproductive capacity, high growth and net assimilation rates, the capacity to suppress native vegetation through competition for light and allelopathy, and its ability to grow in a wide range of soil types and climatic conditions (Muniappan et al. 2005; Uyi and Igbinosa 2013). Likewise, the lack of natural enemies can contribute to explain the dense infestations outside its native range.

The negative impacts of plant invasions in Protected Areas were addressed by Foxcroft et al. (2017), who considered the impacts on species and communities, on ecosystem properties, and on biogeochemistry and ecosystem dynamics, as the most important ones. Even though little research has been carried out in Africa's Protected Areas, the available work reveals that the selected biodiversity indicators and other ecosystem properties are being impacted upon (Foxcroft et al. 2013). In addition, according to Macdonald and Frame (1988), Siam weed invasion can have disastrous consequences for nature reserves, particularly those with anthropogenic savannas.

Several methods are used in attempting to control *C. odorata*'s invasion (Van Gils et al. 2004; Zachariades et al. 2009). In some West African countries farmers use slash-and-burn, followed by frequent hoeing and uprooting. Despite herbicides may prove to be effective, they are not cost-effective, especially under the low resourceful farming systems that prevails in these countries. In fact, the applied control methods are generally unsuccessful to halt the spread of the weed, due to its rapid attainment of reproductive maturity, its ability to regenerate rapidly, the large production of wind-dispersed seeds and a short-term persistent seed bank (Witkowski and Wilson 2001). Likewise, Van Gils et al. (2004) proved that

once Siam weed is established, its control by conventional methods is very difficult. Even though it can be easily killed by herbicides, mechanical, or cultural means, and by using integrated control and management strategies, the spread of the weed has not been stopped in South Africa. Zachariades et al. (2009) recommend the use of biological control to reduce its impact. The use of natural enemies of *C. odorata,* namely insects, is considered an alternative tool for long-term sustainable management of Siam weed (Uyi and Igbinosa 2013; Uyi et al. 2014).

Two biotypes of *C. odorata* are recognized in Africa: the Asian/West African biotype is spreading from tropical West and Central Africa, and the Southern African biotype from southeastern Africa (Zachariades et al. 2013; Shao et al. 2018). The Asian/West African biotype was predicted to invade areas in the Old World with a minimum annual rainfall of 1200 mm, but this biotype has been shown to have a considerably lower limit (McFadyen and Skarratt 1996; Kriticos et al. 2005). According to McFadyen and Skarratt (1996) and Raimundo et al. (2007), the potential distribution of the species in West Africa coincides with the currently invaded area, suggesting that the climatic limits for the species have been reached.

The occurrence of Siam weed is confirmed in Guinea-Bissau's neighboring countries but until now not in the country (Uyi and Igbinosa 2013). Lisowski (2009) records the occurrence of *C. odorata* in the Republic of Guinea and Zachariades et al. (2013), based on a personal communication, report the presence of the species in Senegal.

Regarding Guinea-Bissau, no records have been made until now, despite the extensive field surveys carried out in the country for the last two decades, under the scope of different projects, by two of the authors of this work (Catarino and Indjai). Given the small size of the country, the territorial continuity and the presence of the species in the surrounding countries, the occurrence of Siam weed in Guinea-Bissau was very likely, as suggested by Zachariades et al. (2013).

The objective of this work is to assess Siam weed present distribution in Guinea-Bissau. Dispersal trends, potential consequences of its expansion and recommendations for management and control are also presented.

Materials and methods

Study site

Guinea-Bissau is located in the Northern Intertropical Zone of West Africa, between 10° 59′–12°20′ North and 13°40′–16°43′ West and has a surface area of 36 125 km^2. It is bordered by the Republic of Senegal to the North, the Republic of Guinea to the East and South and by the Atlantic Ocean to the West (Figure 1).

The climate in the country is tropical sub-humid, with a mean annual temperature around 26.5 °C and two seasons: the dry season, which runs

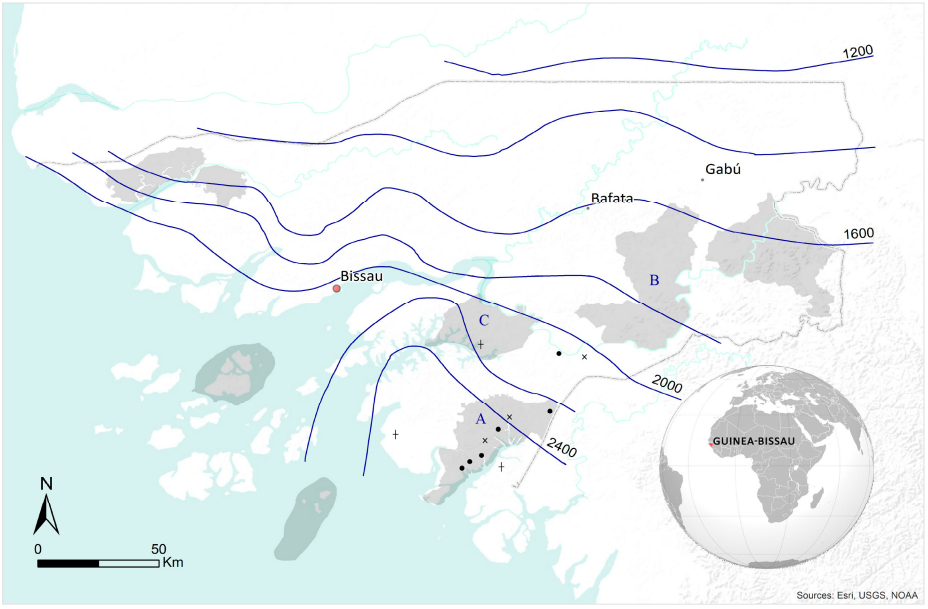

Figure 1. Map of Guinea-Bissau with the known distribution of *C. odorata* in the country. Isohyets' values are in mm/year. Protected areas are indicated as shaded areas. A – Parque Nacional de Cantanhez; B – Parque Natural de Dulombi; C – Parque Natural das Lagoas de Cufada. ● Author's records; × Herbarium vouchers; ┼ Third-person records.

from November to May, and the rainy season, usually from June to late October. The annual rainfall is the climatic factor showing the largest variation across the country, decreasing from 2400–2600 mm in the southwest to 1200–1400 mm in the northeast (Machado 1972).

Forest vegetation in upland zones is composed mainly of woodlands and savanna woodlands, as well as palm groves and some patches of dry Guinean forest in the southwest of the country. However, as a consequence of human intervention, mainly by fire and shifting agriculture, the more common vegetation types in the country are secondary formations such as derived savannas and fallow land (Catarino et al. 2008).

The smallholder agriculture is prevalent in the country and the agricultural extension services are not effective in supporting farmers. Two main crops and agricultural systems largely shape the agricultural practices in Guinea-Bissau upland areas. Rice is the staple food and is cropped both in paddy fields and in slash-and-burn systems in cleared old fallow lands and woodlands, savanna woodlands and forest patches. On the other hand, cashew (*Anacardium occidentale* L.) is the main cash crop and greatly expanded over the last decades (Monteiro et al. 2017). The cashew orchards are established as agroforestry systems in the first 3 to 4 years, consociated with upland rice and other annual crops and then evolve to dense monospecific orchards (Catarino et al. 2015).

Data collection

Chromolaena odorata was noted for the first time during a fieldwork campaign held in January 2018 in the Parque Nacional de Cantanhez

(PNC, Cantanhez National Park), in southern Guinea-Bissau. A voucher was collected and identified at LISC herbarium (*Catarino 2451*). A second fieldwork campaign was done in May 2018. Having identified the species and being aware of its invasive character, a panel with photos of the plant was made and shown to community leaders in villages at PNC, as well as to community representatives and local authorities during a meeting of the Management Council of Parque Nacional de Cantanhez held on the 4th and 5th of May 2018 at Iemberém. Also, local authorities and representatives of other protected areas in the country participating at the Parque Nacional de Cantanhez Management Council were asked to identify and report the presence of Siam weed in other regions of the country. Two additional herbarium vouchers were collected in different places (*Catarino 2470* and *2477*) and a photographic record was made, whenever possible with geo-referenced photos. The information obtained is presented in Supplementary material Table S1.

Results and discussion

Although the invasion by Siam weed had already been documented in surrounding countries, namely Senegal and Republic of Guinea, there were no records of it in Guinea-Bissau until now. Indeed, the species was not recorded in the country neither in the checklist of the vascular flora of Guinea-Bissau (Catarino et al. 2008) nor in the comprehensive guide of the flora of Parque Nacional de Cantanhez (Malaisse 2010). Moreover, no record can be found for the country in the GBIF facility (www.gbif.org) and no specimens were saved at the Tropical Research Institute herbarium (LISC) in Lisbon, where the world's largest collection of Guinea-Bissau plant specimens is held.

Here, we provide the first evidence of the Siam weed occurrence, distribution and potential effects in Guinea-Bissau (gathered data summarized in Table S1). Some aspects of the species in southern Guinea-Bissau are illustrated in Figure 2 and Supplementary material Figure S1.

Date and place of introduction

According to the information obtained, the species was noted for the first time in 1998 at Gandembel, a village in Parque Nacional de Cantanhez close to the Republic of Guinea border, and in 2003 at Amindara, approximately 25 km apart. Its expansion in Guinea-Bissau appears to have begun in the southwest of the country, at the border with the Republic of Guinea, and to have proceeded northwards. As the species had been recorded in the Republic of Guinea several years earlier, it is likely that this country is the source of the invasion. The form of introduction, according to the collected information, was through seeds that would have been wind-dispersed.

Figure 2. Some aspects of *Chromolaena odorata*'s invasion of southern Guinea-Bissau. A – Invasion of a young fallow land by Siam weed. B – shoot with leaves; C – flowering plant; D – fruiting plant. The bar length in B corresponds to 20 mm. Photographs by L. Catarino.

Biotype

As expected (Zachariades et al. 2013; Shao et al. 2018), the Asian/West African biotype, characterized by pale blue-lilac flowers and fairly hairy leaves (Zachariades et al. 2009), is the one occurring in Guinea-Bissau.

Ecology and phenology

The species germinates abundantly during the rainy season (June to October) and grows quickly. The flowering period runs probably from late December to February and the fruiting season from March to May. It develops in disturbed and open environments, namely in young fallow land, cropped

land, and along roadsides; plants can attain 4 to 5 m of height. The aerial stems seem to dry up in the dry season but, according to available sources, the species can re-sprout in the wet season (Muniappan et al. 2005).

Present distribution and future trends

So far, *C. odorata* was recorded only in southwestern Guinea-Bissau. However, all the territory seems suitable for this species, given its rainfall regime (usually over 1200 mm/year), and it is likely that it will invade the rest of the country. The occurrence of Siam weed is confirmed in Parque Nacional de Cantanhez and was detected at the Parque Natural das Lagoas de Cufada. In the near future, it is probable that it will spread to Parque Natural de Dulombi (Figure 1).

Local names

Several local names were recorded in southern Guinea-Bissau for *C. odorata* and some have meanings related to the introduction period or the effect of the weed (Table S1). The most used vernacular name appears to be *punguém*, in Fulani language, but *kikalaporele* was also referred in the same language, as well as *urnene*, in Sosso language. None of these names have meanings, unlike the various names mentioned in Guinea-Bissau's Creole: *toma-conta* means that the species quickly occupies the space available and *pó-nobo* refers to a newly recorded plant. The names *malam-bacai* and *nhamadjo* are related to two Guinean politicians: the first evokes the similarity between the inflorescence of *C. odorata* and the traditional hat of the former President Malan Bacai Sanha (2009–2012); the second seems related to the expansion of the plant during the time Manuel Serifo Nhamadjo was Acting President of the Republic (2012–2014).

Reported effects

According to the consulted village leaders, though the presence of Siam weed was noted for more than a decade, only in recent years did it expand and become problematic. Most of the village leaders and local authorities were not much concerned about the consequences of the invasion by *C. odorata*. In most cases the species is said to be invasive in young fallow lands, hampering land clearing. However, in the last few years it has been noticed to constraints the growth of other plant species and it is thus becoming troublesome for several crops.

Local uses

Heated leaves have been reported to help treating colds and young leaves, with a pleasant smell, are used to aromatise the houses. It was also referred that the roots act as a sexual stimulant for men.

C. odorata in Guinea-Bissau's Protected Areas

The presence of Siam weed is confirmed in Parque Nacional de Cantanhez and was also mentioned in the Parque Natural da Lagoas de Cufada (see Figure 1). In Parque Nacional de Cantanhez, where the invasion seems to have begun, the impact on young fallow lands and other sunny and disturbed places is notorious (Figure 2). The harmful effect of *C. odorata* in natural ecosystems is well documented (Foxcroft et al. 2013) and the invasion can have serious consequences for nature reserves, particularly on anthropogenic savannas (Macdonald and Frame 1988). As this is the case of most savanna woodlands in Guinea-Bissau's Protected Areas, the concerns about the potential consequences of this invasion on biodiversity and ecosystem integrity and livelihoods of local populations are justified.

Prospects for management and control of *C. odorata* in Guinea-Bissau

C. odorata is currently invading the Guinea-Bissau territory from the south northwards, yet, apparently still in an early phase. As all the country is suitable for the Asian/West African biotype, all the territory is vulnerable to invasion by Siam weed. In order to prevent its expansion and avoid harmful consequences as much as possible, it seems advisable to act in three main aspects: 1) to alert the competent authorities as well as the rural communities to the potential consequences of the invasion by *C. odorata* and make people aware of the damages at ecological and agricultural levels; 2) to monitor the distribution of the weed in the country and follow up its expansion; and 3) to search for, identify and select the most appropriate control measures, draw up a control program for *C. odorata* and find the necessary resources for its implementation.

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References

Catarino L, Martins ES, Pinto-Basto MF, Diniz MA (2008) An annotated checklist of the vascular flora of Guinea-Bissau (West Africa). *Blumea* 53: 1–222, https://doi.org/10.3767/000651908X608179

Catarino L, Menezes Y, Sardinha R (2015) Cashew cultivation in Guinea-Bissau – risks and challenges of the success of a cash crop. *Scientia Agricola* 72: 459–467, https://doi.org/10.1590/0103-9016-2014-0369

Foxcroft LC, Pyšek P, Richardson DM, Genovesi P, MacFadyen S (2017) Plant invasion science in protected areas: progress and priorities. *Biological Invasions* 19: 1353–1378, https://doi.org/10.1007/s10530-016-1367-z

Foxcroft LC, Witt A, Lotter WD (2013) Icons in peril: invasive alien plants in African protected areas. In: Foxcroft LC, Pyšek P, Richardson DM, Genovesi P (eds), Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht, pp 117–143, https://doi.org/10.1007/978-94-007-7750-7_7

Ivens GW (1974) The problem of *Eupatorium odoratum* L. in Nigeria. PANS 20: 76–82
Kriticos DJ, Yonow T, McFadyen RC (2005) The potential distribution of *Chromolaena odorata* (Siam weed) in relation to climate. *Weed Research* 45: 246–254, https://doi.org/10.1111/j.1365-3180.2005.00458.x
Kushwaha SPS, Ramakrishnan PS, Tripathi RS (1981) Population dynamics of *Eupatorium odoratum* in successional environments following slash and burn agriculture. *Journal of Applied Ecology* 18: 529–535, https://doi.org/10.2307/2402414
Lisowski S (2009) Flore (Angiospermes) de la République de Guinée. Premiére Partie (Texte). Scripta Botanica Belgica 41, 517 pp
Macdonald IAW, Frame GW (1988) The invasion of introduced species into nature reserves in tropical savannas and dry woodlands. *Biological Conservation* 44: 67–93, https://doi.org/10.1016/0006-3207(88)90005-5
Machado JSS (1972) Balanço hídrico da Província da Guiné. Boletim Cultural da Guiné Portuguesa 27: 753–779
Malaisse F (2010) Guide Floristique du Parc National de Cantanhez (Guinée-Bissau). Instituto Marquês de Valle Flor, Lisboa / Acção para o Desenvolvimento, Bissau, 530 pp
McFadyen RC, Skarratt B (1996) Potential distribution of *Chromolaena odorata* (Siam weed) in Australia, Africa and Oceania. *Agriculture, Ecosystems & Environment* 59: 89–96, https://doi.org/10.1016/0167-8809(96)01035-3
Monteiro F, Catarino L, Batista D, Indjai B, Duarte MC, Romeiras MM (2017) Cashew as a high agricultural commodity in West Africa: insights towards sustainable production in Guinea-Bissau. *Sustainability* 9: 1666, https://doi.org/10.3390/su9091666
Muniappan R, Reddy GVP, Lai P-Y (2005) Distribution and biological control of *Chromolaena odorata*. In: Inderjit (ed), Invasive Plants: Ecological and Agricultural Aspects. Birkhäuser Verlag, Basel, pp 223–233, https://doi.org/10.1007/3-7643-7380-6_14
Prasad UK, Muniappan R, Ferrar P, Aeschliman JP, de Foresta H (1996) Proceedings of the third international workshop on biological control and management of *Chromolaena odorata*, Abidjan, Côte d'Ivoire, November 1993. Publication No. 202, Agricultural Experimental Station, University of Guam, USA, pp 1–213
Raimundo RLG, Fonseca RL, Schachetti-Pereira R, Peterson AT, Lewinsohn TM (2007) Native and exotic distributions of Siam weed (*Chromolaena odorata*) modelled using the genetic algorithm for rule-set production. *Weed Science* 55: 41–48, https://doi.org/10.1614/WS-06-083.1
Shao X, Li Q, Lin L, He T (2018) On the origin and genetic variability of the two invasive biotypes of *Chromolaena odorata*. *Biological Invasions* 20: 1–14, https://doi.org/10.1007/s10530-018-1677-4
Uyi OO, Igbinosa IB (2013) The status of *Chromolaena odorata* and its biocontrol in West Africa. In: Zachariades C, Strathie LW, Day MD, Muniappan R (eds), Proceedings of the eighth international workshop on biological control and management of *Chromolaena odorata* and other Eupatorieae, Nairobi. ARC-PPRI, Pretoria, 1–2 November 2010, pp 86–98
Uyi OO, Ekhator F, Ikuenobe CE, Borokini TI, Aigbokhan EI, Egbon IN, Adebayo AR, Igbinosa IB, Okeke CO, Igbinosa E, Omokhua GA (2014) *Chromolaena odorata* invasion in Nigeria: A case for coordinated biological control. *Management of Biological Invasions* 5: 377–393, https://doi.org/10.3391/mbi.2014.5.4.09
Van Gils H, Delfino J, Rugege D, Janssen L (2004) Efficacy of *Chromolaena odorata* control in a South African conservation forest. *South African Journal of Science* 100:251–253
Witkowski ETF, Wilson M (2001) Changes in density, biomass, seed production and soil seed banks of the non-native invasive plant, *Chromolaena odorata*, along a 15-year chronosequence. *Plant Ecology* 152: 13–27, https://doi.org/10.1023/A:1011409004004
Zachariades C, Day M, Muniappan R, Reddy GVP (2009) *Chromolaena odorata* (L.) King and Robinson (Asteraceae). In: Muniappan R, Reddy GVP, Raman A (eds), Biological control of tropical weeds using arthropods. Cambridge University Press, Cambridge, pp 130–162, https://doi.org/10.1017/CBO9780511576348
Zachariades C, Janse van Rensburg S, Witt ABR (2013) Recent spread and new records of *Chromolaena odorata* in Africa. In: Zacharides C, Strathie LW, Day MD, Muniappan R (eds), Proceedings of the eighth workshop on biological control and management of *Chromolaena odorata* and other Eupatorieae, Nairobi. ARC-PPRI, Pretoria, 1–2 November 2010, pp 20–27

Supplementary material

The following supplementary material is available for this article:

Table S1. Summary of available data on the status of *Chromolaena odorata* expansion in Guinea-Bissau.

Figure S1. Set of geo-referenced photos documenting *C. odorata* presence in southern Guinea-Bissau. A – Mature plant at the edge of a path, Iemberém, 4 May 2018, 11.2308N; 15.0361W; B – Dehiscent inflorescence, Gandembel, 3 May 2018, 11.3667N; 14.8005W; C – Patch of *C. odorata* at Tubandim, 4 May 2018, 11.1917N; 015.1322W; D – Fruiting branch in fallow land at the forest edge, Cabante, 4 May 2018, 11.1561N; 15.1322W; E – Vegetative plants in young fallow land, Contabane, 6 May 2018, 11.5625N; 14.6753W. Photographs by L. Catarino.

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