South African Journal of Botany 118 (2018) 1–10

Contents lists available at ScienceDirect

South African Journal of Botany

journal homepage: www.elsevier.com/locate/sajb

Regeneration ecology of the climber *Flagellaria guineensis* (Flagellariaceae) in the Transkei Coastal Forests, South Africa

N. Tshaduli [a,b,*], C.J. Geldenhuys [a], P.W. Chirwa [a]

[a] Forest Postgraduate Programme, Department of Plant & Soil Sciences, University of Pretoria, South Africa
[b] PO Box 193, Tshilwavhusiku, Limpopo 0938, South Africa

ARTICLE INFO

Article history:
Received 26 November 2017
Received in revised form 19 May 2018
Accepted 29 May 2018
Available online xxxx

Edited by Stefan Siebert

Keywords:
Climbing bamboo
Culm
Forest stand condition
Phenology
Regeneration

ABSTRACT

Earlier studies showed that local people benefit by harvesting culms of the "climbing bamboo" *Flagellaria guineensis* from Transkei Coastal Forests in South Africa. However, little is known about the regeneration ecology of this species that often forms tangles in forest stand conditions. This study assessed the regeneration ecology of *F. guineensis* in different forest stand conditions (forest gaps and edges, and closed canopy stands). Intensity ratings were applied to determine the monthly phenological states, i.e. presence and amount of phenological stages in Bulolo and Mtambalala Forests. Relatively few flowers and fruits were seen; in Mtambalala only during the rainy season and in Bulolo during the rainy and dry seasons. Regeneration (seedlings, shoots from rhizomes and at growing tips) was constant during the 12-month study period in both forests. This suggested that during the study period, this climbing bamboo was in an active vegetative growth stage but not in a reproductive stage. Culm development in forest stand conditions in Mnenga, Mtambalala and Manubi Forests showed significant differences ($P \leq 0.05$) in cluster diameter, culm diameter and culm length but not in the number of culms per cluster ($P > 0.05$). Mean cluster and culm diameters were highest in Manubi (185.5 and 1.0 cm) and lowest in Mnenga (64.1and 0.8 cm). The longest culms were recorded in Manubi (11.1 m). Culm diameter and length differed significantly ($P \leq 0.05$) between forest stand conditions, but not cluster diameter and culm numbers ($P > 0.05$). Culm numbers were not significantly related to cluster diameter; similarly culm length was not related to culm diameter. Flowering and fruiting of *F. guineensis* differed between seasons and sites, and culm development is influenced by forest stand conditions and differed between forests. Recommendations for more sustainable harvesting of culms for basket-making included focusing on tangles in tree crowns to be harvested during the dry season with minimal flowering or fruiting, further studies on growth of seedlings and shoots into the forest canopy, and productive cultivation of this climbing bamboo outside the forest.

1. Introduction

Culms (stems) of the 'climbing bamboo' *Flagellaria guineensis* Schumach (locally known as Ugonothi) in the South African coastal forests, are harvested for basket-making. The species regenerates both from seed (as product of flowering and fruiting) to maintain genetic variation, and vegetatively to ensure persistence in a site. The question is: How would an understanding of the phenological stages of flower, fruit, shoot and seedling formation, help towards sustainable harvesting of the species from the forests?

Flagellaria is a genus in the bamboo-like family Flagellariaceae (order Poales). It is not a bamboo (Poaceae family) but it is a climbing evergreen perennial plant and the stems resemble a slender bamboo, and hence-forth, in this paper, it will be called a climbing bamboo, as it is generally called in the literature. The genus consists of four or more species, including *F. guineensis* and the closely related *F. indica*. *Flagellaria guineensis* occurs in the tropical and subtropical forests of mainland Africa (Baldwin and Speese, 1957; https://www.prota4u.org/database/protav8.asp?g=pe&p=Flagellaria+guineensis+Schumach. 2018). Some bamboos and climbing bamboos occupy a dominant position in the understory of temperate and subtropical forests (Kleinhenz and Midmore, 2001; Giordano et al., 2009). The persistence of this climbing bamboo is sustained by the development of new shoots and culms. The shoot is the new growth from the dense root rhizome system (Muller and Rebelo, 2010) that develops into a culm, i.e. the individual bamboo-like stem (Kigomo, 2007). In the case of the climbing bamboos, the developing culms may climb by various means from ground level under the forest canopy to the top of the host trees. The changing light conditions may determine the successful flowering-fruiting behaviour of the species.

* Corresponding author at: PO Box 193, Tshilwavhusiku, Limpopo 0938, South Africa.
E-mail address: lynettendivhuwo@yahoo.com (N. Tshaduli).

https://doi.org/10.1016/j.sajb.2018.05.026
0254-6299/

Many of the trees in tropical and subtropical forests are colonized by woody climbers or lianas (Campanello et al., 2012). Such climbers need a support structure, such as other plants and specifically trees, to reach the canopy, and where the canopy is low, more climbers enter the host-tree canopy vertically (Balfour and Bond, 1993). Climbing bamboos act in a similar way. Their culms are slender, solid and composed of well-demarcated nodes and internodes, a factor that makes them different from other climbers and from other bamboos because of their need for support from host trees. When high supports are lacking, the bamboo *Chusquea abietifolia*, for example, succeeds very well in climbing over low shrubs (Seifriz, 1920). Forest trees in the Transkei Coastal Forests, Eastern Cape, South Africa, are colonized by *F. guineensis*. This climbing bamboo requires support from host trees to grow vertically and to reach the canopy.

Many woody bamboos are typical examples of invasive or pioneer plants, having many attributes of successful pioneers (Lima et al., 2012). Lianas often increase in density when the forest canopy is disturbed (Lowe and Walker, 1977), which relates to better light conditions. They develop dense tangles on forest margins (Williams-Linera, 1990), forest gaps and disturbed sites (Campanello et al., 2012). In large open sites, the growth habit of the *Chusquea* bamboos is more arched and the culms of the different clumps are intermingled, forming an impenetrable thicket; passage is only possible by creeping below or climbing over the culm mat (Widmer, 1998). Young *F. indica* plants cannot survive under full sun exposure and requires shade in order to grow. However, adult plants are known to be strongly light-demanding (heliophytic) (Rabenantoandro et al., 2007).

The reproductive success of a plant depends on its flowering time being adapted to the environment in which it grows (Ramanayake, 2006). Patterns of bamboo regeneration through the production of new seedlings can be influenced by forest canopy conditions (Taylor et al., 2004). Forest canopy density has a strong influence on bamboo regeneration from seed. Some bamboos are monocarpic, which means that they flower once and then die, with masses of seedlings establishing, but it may take many years for the seedlings to develop into mature plants (Taylor and Qin, 1993). This behaviour has not been recorded for *F. guineensis*.

The culms of Ugonothi in the South African coastal forests are extensively used for basket-making (Cawe and Ntloko, 1997; Cawe, 1999; Cawe and Geldenhuys, 2007). It plays a significant role in local income of rural people around Port St Johns (Cawe and Ntloko, 1997) and the plant has many uses in other parts of the continent (Bosch, 2010). In the Port St Johns area, it is sold in bundles, locally called head loads (Cawe and Geldenhuys, 2007). This raised concerns over the sustainability of such harvesting. The current study was motivated by the concerns that foresters have about the suppressing appearance of *F. guineensis* on the canopy of its host trees along forest edges, as a possible indication of unsustainable harvesting of this species. *Flagellaria guineensis* appeared to be shading the canopy of adult trees on the forest edge. However, the culms also produce the flowers and fruits that would ensure maintenance of the genetic pool of the species. This requires a good understanding of the critical life history stages of flower, fruit, shoot and seedling formation, to ensure sustainable harvesting of the species from the forests. In the case of the forest fern *Rumohra adiantiformis*, harvested for its leaves (fronds) for the florist industry, it was critical to synchronise frond harvesting with specific phenological stages in frond development (Geldenhuys and Van der Merwe, 1988). The study of plant phenology involves the observation, recording and interpretation of the timing of such life history events (Fenner, 1998). The switch to flowering is the most important event in the life cycle of a plant, signaling its commitment to set seed, ensuring survival of the species (Ramanayake, 2006). In bamboos, the duration of the vegetative phase and switch to flowering varies according to the species (Ramanayake, 2006).

The main aim of this study was to assess the regeneration ecology of *F. guineensis* in the Transkei Coastal Forests in the Eastern Cape Province of South Africa. The specific objectives were: (1) To describe the phenological stages of flowering, fruiting and regeneration of the species; and (2) To compare the development patterns of the shoots and culms between different forest stand conditions such as forest edges (margins), forest gaps and mature forest stands. The following questions were addressed: (1) What are the phenological patterns of flowering, fruiting, shoot development and seedling production in the species over one year? (2) How and under what conditions do the seedlings establish and grow? (3) What is the nature of the rootstock from which the plant develops new shoots? (4) How does development of the plant vary between forest edges (margins), forest gaps and mature, closed-canopy forest? (5) How do the shoots climb into a tree if they continuously start at ground level?

2. Materials and methods

2.1. Study forests and species

The study was conducted in four forests along the Wild Coast of the Eastern Cape: Bulolo Forest (31°8′36.25″ S, 29°30′58.55″ E; 6–100 m above sea level or asl), Mnenga Forest (31°36′27.94″ S, 29°34′33.96″ E; 80–125 m asl), Mtambalala Forest (31°32′57.22″ S, 29°36′19.99″ E; 50–125 m asl) around of Port St Johns, and Manubi Forest (32°26′34.83″ S, 28°35′42.02″ E; 100–200 m asl) north of East London (Fig. 1). Rainfall is usually >700 mm per year and is more prevalent during summer. Total monthly rainfall during the study period was obtained from the Silaka Nature Reserve near Port St Johns, close to the Bulolo Forest (Fig. 2), showing two dry periods between May to August and January to February, and two rainy seasons between March to April and September to December. The area along the coast has a moderate climate with mean minimum temperature of 17 °C and a mean maximum of 20 °C (Von Maltitz et al., 2003). The geology is mainly sandstone outcrops, syenitic granites and rhyolites, and the soils are generally less acidic and medium to coarse-grained (King, 1940; Von Maltitz et al., 2003).

The Transkei Coastal Forests (Von Maltitz et al., 2003; Mucina, 2018) are characterized by low to high canopies (10–30 m) with a smooth to uneven surface, but relatively closed. Stand structure comprises three distinct strata, restricting light penetration onto the forest floor: a tree stratum of canopy trees, with a well-developed sub-canopy tree stratum with seedlings and saplings, and a poorly developed herb layer (King, 1940; Geldenhuys and Rathogwa, 1995; Cawe and Geldenhuys, 2007). The forests are found on sloping coastal platforms as well as steep scarps in deeply incised valleys. The tree and climber species vary in importance in different forests in this coastal zone. Common tree species include *Buxus macowanii*, *Buxus natalensis*, *Drypetes gerrardii*, *Englerophytum natalense*, *Harpephyllum caffrum*, *Heywoodia lucens*, *Millettia grandis* and *Ptaeroxylon obliquum*. Herbaceous climbers include *Flagellaria guineensis* and *Thunbergia alata*. Common shrubs and scramblers include *Scutia myrtina*, *Grewia occidentalis* and *Eugenia natalitia* (Von Maltitz et al., 2003; Mucina and Geldenhuys, 2006).

Flagellaria guineensis in these coastal forests is woody with sympodial rhizomes and is patchily distributed. Leaves are distichous, with the leaf apex extending into a simple, involutely coiled tendril that clings to all available host trees for support. The plant regenerates from both seed and rhizome shoots (Fig. 3).

2.2. Data collection

2.2.1. Flowering, fruiting and growth phenology

Phenological observations were confined to the Bulolo and Mtambalala Forests due to logistical constraints during this short-term study. In each forest, 30 observation spots (one bamboo cluster) were selected, 10 m apart, with 10 spots in each of the three forest stand conditions: Forest edge E (exposed to the sun during the morning, i.e. east or south, with cooler conditions), Forest edge W (exposed to the sun