



DIMORPHIC TRAITS OF FEMALE *GARCINIA KOLA* (HECKEL) TREE: CASE STUDY IN THE RAINFOREST-MANGROVE AREA OF ONNE RIVER STATE

Okonkwo, H. O^{1*}, Omokhua, G. E²., and Chima, U. D².

¹Swamp Forest Research station Onne, Forestry Research Institute of Nigeria.

²Dept of Forestry and Wildlife Management, Faculty of Agriculture, University of Port Harcourt

*Corresponding author: Email: richychrist4ever@gmail.com and onyeb24@yahoo.com. Phone: 07032213189

Abstract

Sexual dimorphism and reproductive allocation studies often require the knowledge of the dimorphic traits required to *differentiate the sexes especially at seedling stage*. A study was therefore designed to investigate the dimorphic traits of female *Garcinia kola* in the rainforest-mangrove area of Onne, Rivers state. Three (3) female trees that have been observed to flower regularly for three years were randomly selected for the study: a total of 100 inflorescence was randomly collected from the crown of each tree and 500 flowers randomly assessed within the period of four (4) flowering seasons: floral sex assessment was done visually and with a hand magnifying lens. Three (3) flowering twigs were randomly collected from the crown of each tree and twenty-seven (27) reproductive and vegetative traits assessed per tree. Traits were subjected to principal component analysis (PCA) to understand the combination of traits most relevant for sexual differentiation of the female tree. Five (5) principal components with eigen Value greater than 1 were extracted. Component one explained 39% of the variation, component two 29%, component three 11%, component four 9%, and component five 4%; communality for almost all the factors was close to 1 indicating high level of relationship between factors. Each of the components provides an insight into the combination of traits that are important to the estimation of floral dry weight, vegetative dry weight, reproductive allocation and sexual differentiation of the tree.

Keywords: components, sexual, traits, vegetative, reproductive.

Introduction

Investigating correlations among dimorphic floral traits may provide insights into how selection shapes patterns of dimorphism in dioecious and monoecious populations (Yakimowski *et al.* 2010). Patterns of dimorphic behaviour in plants are important to the understanding of reproductive behavioural and evolutionary studies but equally needed for early differentiation of seedling gender in the nursery particularly in dioecious species. Dimorphic traits that are identifiable or pronounced at early stage are required to separate the sexes at an early stage.

Sexual dimorphism studies related to plant sex mediated response to resources such as light and nutrients or growth rate and dry weight can be of great help in finding the combination of dimorphic traits needed to early plant gender differentiation in the nursery. For example, Tonnabel *et al.* (2019) investigating sex-specific selection on plant architecture through 'budget' and 'direct' effects in experimental populations of a wind-pollinated herb *Mercurialis annua* documented some correlations of dimorphic traits such as high-density planting favouring male sex selection while low density favoured female sex selection. The particular response of different species to sex selection at low and high-density planting nevertheless needs to be investigated as plants respond differently to different environmental niches (Delph, 1996). This divergent dimorphic behaviour of different sexes has been reported by some authors; males trees sometimes are smaller in size in (Delph, 1999), show lesser natural defence (Avila-Sakar and Romanow 2012), and express lower rates of gas exchange and lower water-use efficiency (Dawson and Geber 1999) in comparison to females while sometimes male and female trees different in longevity (Delph, 1999).

Morphological differences between male and female trees could arise due to the variations in the physiological requirements for the fulfilment of the particular sex function (Downhower 1976; Freeman *et al.* 1976; Harris and Pannell 2008). For example, female trees in preparation for their reproductive function of fruit and seed production may acquire vegetative traits that enable the deployment of carbon and water (Obeso 2002; Burd 1994; Dawson and Geber 1999). Sexual dimorphism could also arise due to the variation in the type of resources required for the different sex functions which in turn results in the acquisition of morphological traits that enhance the harvesting of the resources (Conn and Blum 1981; Zimmerman and Lechowicz 1982; Lovett-Doust *et al.* 1987; Dorken and Barrett 2004; Herlihy and Delph 2009; Harris and Pannell 2008; Teitel *et al.* 2016; Tonnabel *et al.* 2017). There is also the element of sexual dimorphism arising due to sexual or fecundity selection or even heredity (Delph and Ashman 2006; Delph *et al.* 2011; Moore and Pannell 2011). There is therefore the need to investigate the combination of traits that can help to separate the sexes at the early nursery stage especially for dioecious and subdioecious species. A study was therefore designed to investigate the dimorphic traits of female *G. kola*.

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The study was conducted at the Swamp Forest Research station, of the Forestry Research Institute of Nigeria. The area is located on Latitude 4°42' - 10°32' N and Long. 7°10' - 32°46' E, with 2400 mm mean annual rainfall, relative humidity 78% in February (dry season) and 89% in July (rainy season), mean annual temperature 27°C in February and 25°C in July, soils are ultisols derived of coastal sediments, highly acidic (pH 4.4), with low fertility, and classified as siliceous, isohyperthermic, typic paleudult, usually deep, chemically poor, well drained with good physical properties. The vegetation is a rainforest-mangrove transition forest zone.

In this preliminary study three (3) female trees that have been observed to flower regularly for three years were randomly selected for the study: a total of 100 inflorescence was randomly collected from the crown of each tree and 500 flowers randomly assessed within the period of four (4) flowering seasons: floral sex assessment was done visually and with a hand magnifying lens.

Three (3) flowering twigs were randomly collected from the crown of each tree and the following twenty seven (27) reproductive and vegetative traits assessed per tree: number of twig per branch (counted), twig length (cm), number of leaf per twig (counted), inflorescence length (cm), inflorescence width (cm), number of flower bud per inflorescence (counted), leaf length (cm), leaf width (cm), petiole length (mm), petiole width (mm), number of inflorescence per twig (counted), total number of branches per tree (counted), branch diameter (mm), pedicel length (mm), pedicel width (mm), sepal length (mm), sepal width (mm), petal length (mm), petal width (mm), stigma length (mm), stigma width (mm), style length (mm), style width (mm), ovary length (mm), reproductive allocation (%), floral dry weight (g), and vegetative dry weight (g): measuring instruments used were veneer calliper and ruler graduated in millimetre and centimetre respectively. Twig was separated into floral parts (flowers, and inflorescences) and vegetative parts (leaves and stem) and air-dried at ambient temperature until constant weigh was achieved. Data was analysed with the aid of principal component analysis (PCA). Reproductive allocation (RA) was calculated viz (Shivannah and Tandon 2014):

$$RA = \frac{\text{Floral dry weight}}{\text{Vegetative dry weight}} \times 100 \text{ -----} 1$$

Results and discussions

Using Kaiser rule (Johnson and Wichern, 1982) five (5) principal components with eigenValue greater than 1 (fig. 1) were extracted. Component one explained 39% of the variation, component two 29%, component three 11%, component four 9%, and component five 4%; communality for almost all the factors was close to 1 indicating high level of relationship between factors (table 1). Each of the components provides an insight into the combination of factors that that are important to the estimation of floral dry weight, vegetative dry weight, reproductive allocation and sexual dimorphic characters of the tree.

Component one showed a significant high loading of reproductive allocation, vegetative dry weight, and floral dry weight along-side factors such ovary length, style length and width, stigma length and width, petal length and width, sepal length and width, pedicel width, number of twigs per branch, petiole width, number of inflorescences per twig and branch diameter: Component two shows a significant high loading of reproductive allocation along-side factors such as ovary and style length, petal length and width, sepal length and width, pedicel length and width, number of twigs per branch, number of inflorescences per twig, twig length, number of leaves per twig and inflorescence width: Component three showed significant high loading of branch diameter and total number of branches along-side factors such as petiole length, inflorescence width, twig length and number of leaves per twig: Component four showed significant high loading of petiole length and width along-side factors such as number of flower bud per twig, inflorescence length and width, and number of leaves per twig; while, component five showed high significant loading of branch diameter along-side factors such as leaf length, width, and inflorescence width (Table 1). While components one and two explained more of the combination of factors important to reproductive allocation estimation, components three, four and five relates more to sexual dimorphic characters of the tree.

Sexual dimorphism is a factor frequently associated with dioecious and subdioecious species (Delph *et al.*, 1996; Eckhart, 1999). In studying sexual dimorphism authors often use different floral and vegetative traits or factors. For example, Yakimowski *et al.* (2010) investigating floral dimorphism in plant populations with combined versus separate sexes measured factors such as total number of flowers per inflorescence, daily display size (number of flowers in anthesis), perianth diameter, and leaf mid-vein length of the subtending leaf to the inflorescence. Asouad *et al.* (1977) studied the reproductive capacities in the sexual forms of the gynodioecious species *Thymus vulgaris* using factors such as number of inflorescences per plant, length of styles, corolla size and total number of pollen grain found on the stigma. Understanding the combination of vegetative and floral traits that best differentiate the sexes in dimorphic populations is therefore a central issue in any study of sexual dimorphism (Delph 1996). This is because in plants sexual dimorphic features may not readily be identifiable (Harris and Pannell 2008; Renner 2014). Hence, plant reproductive biologists have been working to trace patterns of sexual differentiation in dimorphic populations. Sexual dimorphism has been traced to traits and behaviours such as flower size, time and duration of flowering, physiology, allocation of resources to vegetative, fruit, seed, pollen production, size of ovary and floral production etc (Bawa and Webb, 1983; Agrawal *et al.*, 1999; Mazer *et al.*, 1999; Venable and Lloyd, 2004; Vilas and Pannell 2011).

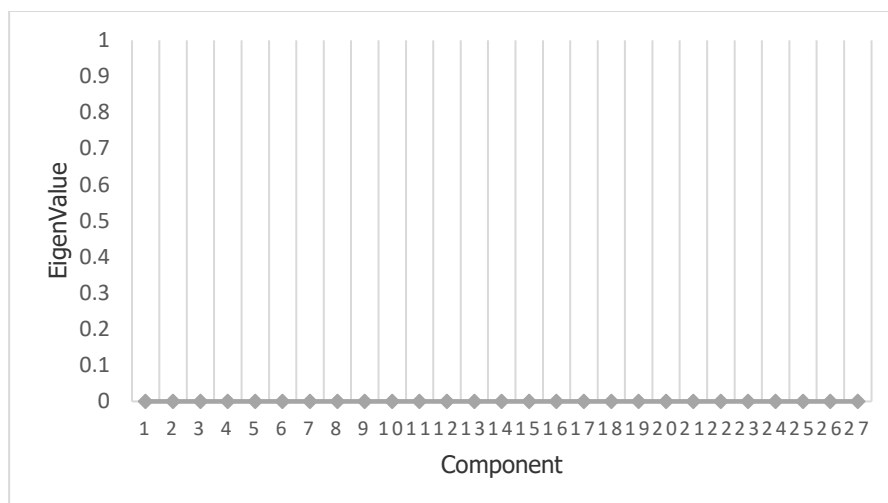


Figure 1. Components and eigen values

Table 1. Principal components extracted and percent variation explained, communality, and specific factor of variation.

Traits/ %	PC1 39%	PC 29%	PC3 11%	PC4 9%	PC5 4%	Comm	Specific
Twig Length	-0.184	0.434	0.803	-0.099	0.083	0.883	0.117
Leaf per Twig	-0.149	0.395	0.572	-0.491	0.147	0.769	0.231
Inflorescence length	-0.259	0.039	-0.284	-0.893	0.220	0.996	0.004
Inflorescence width	0.043	0.337	-0.685	-0.508	0.310	0.938	0.062
No of flower bud	0.284	0.016	0.102	-0.854	-0.036	0.822	0.178
Leaf Length	0.204	-0.447	-0.208	-0.006	-0.829	0.972	0.028
Leaf Width	0.291	-0.190	0.098	0.190	-0.885	0.949	0.051
Petiole Length	-0.027	-0.285	0.739	0.317	0.025	0.729	0.271
Petiole Width	0.445	0.245	-0.201	0.665	-0.038	0.741	0.259
Inflorescence per twig	0.612	-0.754	-0.037	0.040	-0.201	0.986	0.014
Twig per branch	0.590	0.682	0.066	-0.215	0.140	0.883	0.117
Number of branches	-0.096	-0.088	0.824	-0.145	0.040	0.719	0.281
Branch diameter	0.480	0.147	-0.555	0.148	-0.541	0.875	0.125
Vegetative dry weight	-0.954	0.183	0.075	-0.026	0.203	0.991	0.009
Floral dry weight	-0.963	-0.163	0.145	-0.069	0.116	0.993	0.007
Reproductive allocation	0.535	-0.742	-0.006	0.029	-0.202	0.879	0.121
Pedicle length	-0.177	-0.972	0.046	0.001	-0.104	0.989	0.011
Pedicle width	0.356	0.925	-0.062	0.009	0.069	0.991	0.009
Sepal length	0.356	0.925	-0.062	0.009	0.069	0.991	0.009
Sepal width	0.867	0.479	-0.098	0.040	-0.073	0.998	0.002
Petal length	0.356	0.925	-0.062	0.009	0.069	0.991	0.009
Petal width	-0.612	0.754	0.037	-0.040	0.201	0.986	0.014
Stigma length	-0.969	-0.171	0.099	-0.048	0.132	0.997	0.003
Stigma width	-0.969	-0.173	0.099	-0.048	0.132	0.997	0.003
Style width	-0.969	-0.172	0.099	-0.048	0.132	0.997	0.003
Style length	0.356	0.925	-0.062	0.009	0.069	0.991	0.009
Ovary length	-0.831	-0.543	0.096	-0.037	0.059	0.998	0.002

* Factor loading ≥ 0.3 = significant; Trait = vegetative and reproductive traits; % = percentage proportion of variation explained per component; PC = principal component; Comm = communality of variation of traits; Specific = variation unique to a trait.

Conclusion

Five (5) principal components with eigenValue greater than 1 were extracted. Component one explained 39% of the variation, component two 29%, component three 11%, component four 9%, and component five 4%; communality for almost all the factors was close to 1 indicating high level of relationship between factors. Each of the components provides an insight into the combination of traits that are important to the estimation of floral dry weight, vegetative dry weight, reproductive allocation and sexual differentiation of the female *G. kola* tree.

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