https://dx.doi.org/10.4314/ijs.v21i3.21

FRUIT CHARACTERIZATION AND PHYLLOTAXY OF FLUTED PUMPKIN FROM OSUN STATE, NIGERIA

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(Received: 28/3/2019; Accepted: 12/10/2019)

ABSTRACT

The study evaluated some fruit characteristics and phyllotaxy of *Telfairia occidentalis* with a view to determining which attributes relate to size and the usefulness of phyllotaxy in sex determination. Data obtained from fruits were correlated with fruit size parameters. Seeds were also germinated and the phyllotaxy of the seedlings recorded against their eventual sex. Fruit length was positively and significantly correlated with all fruit size parameters measured while circumference was positively and significantly correlated with only length and area. None of the fruit or seed parameters correlated with germination percentage. All fruit size characteristics except circumference showed a weak positive and significant correlation with Total Seed Number (TSN) per fruit. No phyllotaxy was associated with any sex and therefore, phyllotaxy cannot be used in identifying plant sex for this species. Fruit length with regard to shape is a very important attribute that relates to size of *Telfairia occidentalis* fruits.

Keywords: *Telfairia occidentalis*, Fruit size, Fruit shape, Attributes

INTRODUCTION

Fluted pumpkin (*Telfairia occidentalis* Hook. F), a member of the Cucurbitaceae plant family, is one of the most widely cultivated leafy vegetables in southern Nigeria (Odiaka *et al*., 2008). It is however now cultivated in almost all parts of the country (Akoroda, 1990a, Igbozulike, 2015). Fluted pumpkins are of great importance to many people in Nigeria because of the highly nutritious leaves and seeds (Badifu and Ogunsua, 1991; Giami and Isichei, 1999; Akwaowo *et al*., 2000; Fashina *et al.*, 2002; Giami *et al*., 2003; Agatemor, 2006; Akanbi *et al.*, 2007).

The plant derives its name from the morphology of the fruit which is fluted. Common names for the plant include Fluted gourd, Fluted pumpkin, and *Ugu*. The leaves are arranged spirally although at the seedling stage, other leaf arrangements have been observed. According to Okoli and Mbeogu (1983), at the seedling stage, some of the leaves are opposite but as the plant increases in size, the phyllotaxy becomes completely alternate. Ajayi *et al*., (2007a) reported three forms based on phyllotaxy at the first 4-5 nodes and indicated that the pattern of arrangement of the first two leaves may be a useful indicator of sex during early seedling development. This is important since sex of the plant cannot be ascertained until it begins to flower and this is a constraint to production since the female plants are preferred.

The size of fruits produced can be quite variable, but fruit attributes, particularly those related to size, are not clearly defined. Some research have addressed quantitative evaluations of *Telfairia occidentalis* fruit characteristics (Adeyemo and Odiaka, 2005; Chukwudi and Agbo, 2014), but generally, the objectives have been to assess the effect of seed and fruit sizes on growth or leaf and fruit yield. Researchers characterized the fruits in different ways. According to Todorova (2007), quantitative fruit characters – length, diameter, pericarp thickness, average weight and usable part are of great importance in describing fruits and genotypes (varieties), respectively. A fundamental question related to *T. occidentalis* fruit characteristics remain unanswered. What characteristics are associated with larger fruit? Do fruit components such as number of seeds per fruit stay constant with varying fruit size or do they change? Do large fruits have large number of seeds? The objectives of this study are to evaluate fruit characteristics in *T. occidentalis*, identify how the attributes relate to size and

investigate the usefulness of phyllotaxy and other morpho physiological traits in sex determination.

MATERIALS AND METHOD

Source of Materials

Fruits of *T. occidentalis* were obtained from subsistence farmers and markets in and around Ile-Ife, Osun state, Nigeria (Latitude: 7° 467' 0 N, Longitude: 4° 567 ' 0 E).

Data were obtained from 40 fruits. The data included such information as, length of fruit, circumference of fruit, number of seeds in fruit, weight of seeds, area and shape of fruits, endosperm colour and colour of seed. Shape of the fruits was calculated using the formula:
[length/diameter],
while fruit area was estimated using the equation for the area of an ellipse

[Area = {π x length (major axis) x breath (minor axis)}/4 (Where π = 3.1415)].

The seeds were then germinated and number of seeds exhibiting polyembryony per fruit was also documented. Fruit characteristics were then correlated with average weight of seeds and number of seeds per fruit.

In order to distinguish plant sex using morpho-physiological seed traits, twenty-five seeds each from four fruits of different known sources (Ife, Famia, Toro and Gbongan) were used. Data were obtained from them as indicated above. The seeds were germinated in pots and one week old seedlings were transferred to the field in progeny rows. From emergence, data such as: pigmentation on stem, petiole and tendrils, phyllotaxy (based on leave arrangement on first three nodes) and stem girth, on each seedling were recorded. Subsequently (after transplanting) plants were observed for plant sex and collected data were correlated with plant sex.

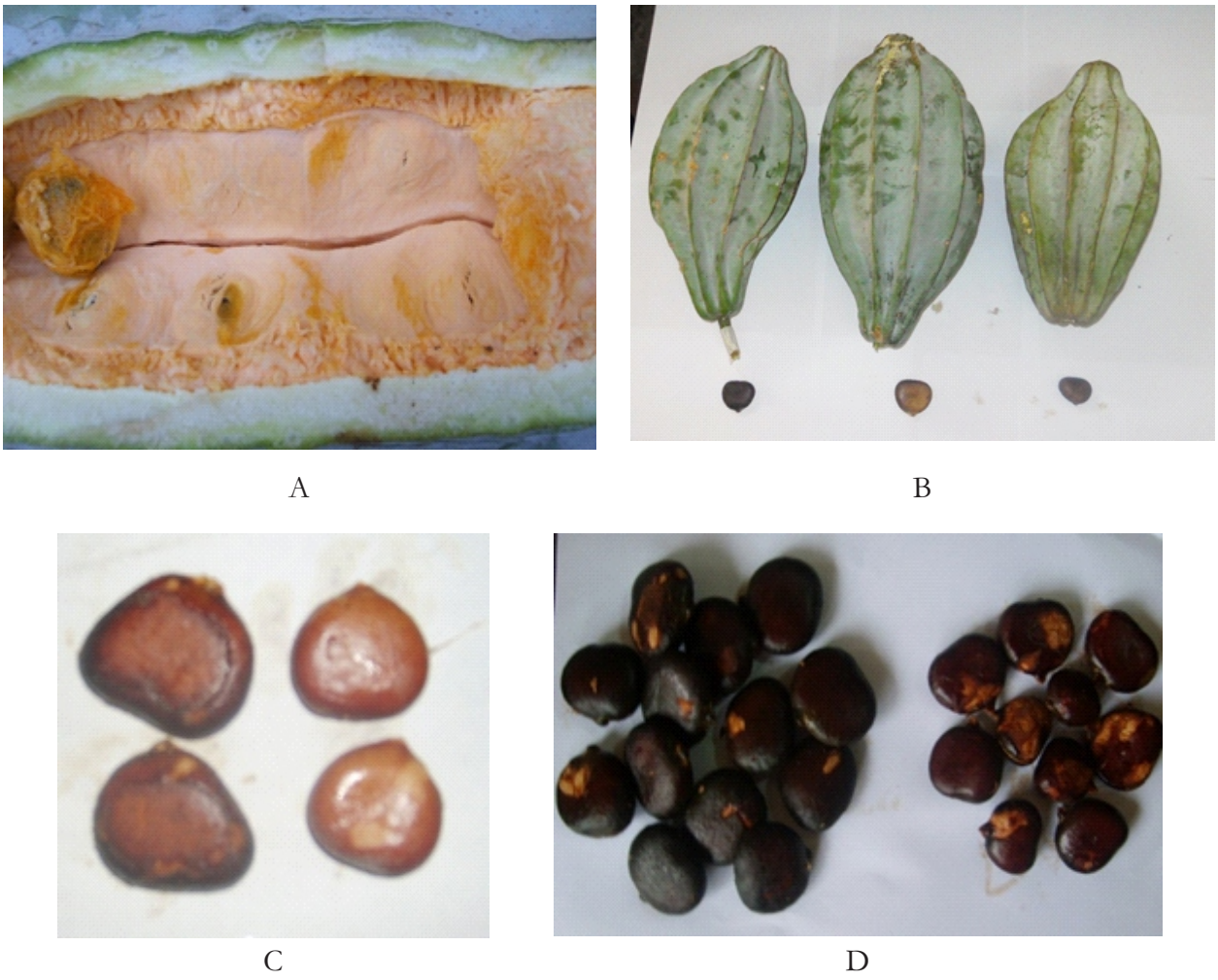
Statistical Analysis: Pearson's correlation coefficients and Spearman's correlation analysis were performed using SAS 9.0. Principal component analysis was carried out using PAST.

RESULTS

Of all the fruits sampled in this study, 77.5% had orange pulp, 7.5% peach, 5.0% yellowish cream and 10.0% yellow pulp (Plate 1). The seed colour was predominantly black. Brown seeds accounted for only 25.0% of the fruits sampled. Fresh seed weight per fruit ranged from 5.9 – 27.8 g. The length and circumference of each fruit ranged from 18.0 – 85.5 cm and 20.5 – 78.5 cm respectively. The mean number of seeds and the fresh weight per fruit based on the size of the fruit are shown in table 1.

Length (L) of fruit has a very strong correlation with Area of fruit (A), Shape (S) and ratio of length to circumference (L/C) while Circumference (C) is only correlated with Area. L has a weak correlation with Total Seed Number (TSN), Fresh Seed Weight (FSW) and Dry Seed Weight (DSW). Circumference on the other hand has no correlation with TSN but, has a strong correlation with FSW and DSW. The ratio of L/C has a very strong correlation with the shape of the fruit. TSN is also correlated with L/C, Shape and Area (Table 2).

Percentage polyembryony ranged from 0 - 30% per fruit and the cumulative percentage of seeds exhibiting polyembryony per fruit was 13.3 ± 2.3%, There was no correlation between percentage polyembryony and total number of seeds in a fruit or between fresh seed weight and number of polyembryonic seedlings and percentage polyembryony.



A B C D

Plate 1- Fruit and Seed Characteristics in *Telfairia occidentalis*
A: Orange pulp colour; B: Fruit shapes; C: Brown seeds; D: Black seeds

Table 1: The Mean Number of Seeds and Mean Seed Fresh Weight per Fruit based on different Fruit Size Classes

	SIZE				AREA			
Size Classes (cm)	**0 – 40**	**41 – 50**	**51 -60**	**61 – 90**	**0 – 600**	**601 – 1200**	**1201 – 1800**	**1801 – 2500**
Mean No of seeds based on length	56 ± 9.6 (n=8)	86 ± 9.1 (n=14)	85 ± 9.4 (n=12)	103 ± 13.3 (n=6)				
Mean seed No based on circumference	-	71 ± 16.6 (n=6)	79 ± 9.2 (n=15)	88 ± 7.2 (n=19)				
Mean No of seeds based on area of fruit					**60 ± 6.4** (n=4)	**77 ± 8.2** (n=20)	**92 ± 8.7** (n=11)	**103 ± 16.3** (n=5)
Mean fresh seed weight based on length	12 ± 1.4 (n=8)	11 ± 1.3 (n=14)	13 ± 1.1 (n=12)	18 ± 2.2 (n=6)				
Mean fresh seed weight based on circumference	-	10 ± 0.9 (n=6)	11 ± 1.2 (n=15)	15 ± 1.2 (n=19)				
Mean fresh seed weight based on area of fruit					**10 ± 1.2** (n=4)	**11 ± 1.0** (n=20)	**14 ± 1.3** (n=11)	**18 ± 2.6** (n=5)

Table 2: Pearson Correlation Coefficients between Fruit and Seed Characteristics of *T. occidentalis*

	L	C	L_C	Area	shape	TSN	FSW	DSW	SC	EC	%MC	G%
L		0.74**	0.65**	0.95**	0.65**	0.41**	0.37*	0.42**	-0.08	-0.12	0.04	-0.02
C			-0.01	0.85**	-0.01	0.23	0.53**	0.58**	0.01	-0.27	0.03	0.18
L_C				0.43**	1.00**	0.36*	-0.05	-0.05	-0.12	0.14	0.04	-0.24
Area					0.43**	0.36*	0.49**	0.58**	-0.08	-0.17	-0.00	0.08
Shape						0.36*	-0.05	-0.05	-0.12	0.14	0.04	-0.24
TSN							-0.37*	0.08	0.32*	-0.30	-0.47**	-0.21
FSW								0.59**	-0.13	-0.05	0.45**	0.22
DSW									0.05	-0.24	-0.41**	0.20
SC										-0.16	-0.18	-0.09
EC											0.20	0.18
%MC												0.04

*****Significant at 0.05 level of probability; ******significant at 0.01 level of probability

KEY

L - Length of fruit C - Circumference of fruit L /C – Ratio of Length to Circumference of fruit
TSN – Total Seed Number FSW – Fresh Seed Weight DSW – Dry Seed Weight G%- Germination Percentage
SC - Seed Color EC - Endosperm Color %MC - Percentage Moisture Content

The phyllotaxy observed in seedlings of *Telfairia* ranged from 1-7 based on leaf arrangement on the stem (Table 3A). Seedlings from fruits were analyzed for exhibition of phyllotaxy and phyllotaxy P2 (leaves alternate throughout) was found to be the prevalent type (Table 3B). No phyllotaxy was particularly associated with any sex. Sex did not correlate with pigment on stem or stem girth. Instead, it aligned with the prevailing girth or pigment. For example, most of the seedlings from Famia had small girth, therefore, the female plants from Famia all came from seedlings with small girth.

Only 15% of all the fruits utilized in this study contained unfilled seeds. They all belonged to the category of fruits with area above 1200 cm^2. The length of the fruit with the highest number of unfilled seeds (38) was 54 cm while the circumference was 59.8 cm (Table 4). The number of unfilled seeds in all other fruits with unfilled seeds ranged from 2 – 7 seeds.

Table 3A: Phyllotaxy observed in Seedlings of *Telfairia occidentalis*

Phyllotaxy	Description
P1	Leaves on first node opposite
P2	Leaves alternate throughout
P3	Multiple (that is, 3-4) leaves at second node
P4	Leaves on first node alternate, second node opposite and then back to alternate arrangement on third node.
P5	Leaves on first node alternate and the next 2 nodes opposite
P6	Multiple leaves at first node
P7	First and second nodes alternate and third node opposite.

Table 3B: Percentage Phyllotaxy types in observed Seedlings, Male and Female plants of *T. occidentalis*

Phyllotaxy	Seedlings from fruits %	Male %	Female %
P1	11± 1.2	17.5 ± 1.2	14.8 ± 0.9
P2	53 ± 8.5	47.5 ± 1.2	29.63 ± 1.5
P3	7.8 ± 0.5	5 ± 0.3	11 ± 0
P4	17.7 ± 0.8	20 ± 1.2	22.2 ± 0.6
P5	7.2 ± 0.9	7.5 ± 0.6	18.5 ± 0.9
P6	2.6 ± 0.4	2.5 ± 0.3	3.7 ± 0.3
P7	0.7 ± 0.2	0	0

Table 4: Fruit and Seed Characters of 40 *Telfairia occidentalis* Fruits

S/no	F. Length (cm)	F.Circum. (cm)	Length/ Circum.	Total seed no.	Fresh.seed weight.	Seed color	Endosperm color	Area (cm^2)	Shape
1	30.0	56.7	0.53	32	20.5	20	1	667.64	1.66
2	39.5	50.5	0.78	28	11.1	10	1	782.93	2.46
3	53.9	52.9	1.02	29	11.5	10	1	1119.14	3.20
4	60.0	63.0	0.95	83	19.1	10	1	1483.65	2.99
5	55.5	70.0	0.79	62	20.1	10	1	1524.86	2.49
6	40.5	72.0	0.56	50	15.2	10	1	1144.53	1.77
7	46.5	60.0	0.78	68	20.2	10	1	1095.08	2.43
8	85.5	72.5	1.18	118	13.1	10	1	2433.01	3.71
9	49.0	74.5	0.66	47*	18.8	10	1	1432.82	2.07
10	65.4	73.3	0.89	85*	18.0	10	2	1881.57	2.80
11	46.0	54.0	0.85	92	10.3	20	3	974.97	2.68
12	51.6	60.0	0.86	137	7.0	10	1	1215.18	2.70
13	42.0	51.3	0.82	83	6.2	10	1	.68	2.57
14	55.5	58.3	0.96	121	10.1	10	2	1269.99	2.99
15	18.0	20.5	0.88	48	10.0	10	3	144.83	2.76
16	40.1	60.2	0.67	92	7.4	10	1	947.50	2.09
17	54.0	59.8	0.90	98*	15.0	10	1	1267.46	2.84
18	63.2	78.5	0.81	49*	27.8	10	1	1947.27	2.53
19	52.0	67.1	0.78	73	12.0	10	2	1369.51	2.43
20	40.2	59.4	0.68	45	13.0	10	1	937.24	2.13
21	70.1	85.0	0.83	125	14.3	10	1	2338.71	2.59
22	42.6	62.4	0.68	102	8.8	10	1	1043.36	2.15
23	39.7	65.5	0.61	110	10.9	20	1	1020.64	1.90
24	63.8	76.2	0.84	140	16.6	20	1	1908.16	2.63
25	51.5	74.5	0.69	83	15.7	20	1	1505.92	2.17
26	52.0	61.0	0.85	71	9.6	20	1	1245.01	2.68
27	55.0	69.0	0.80	130	9.9	10	1	1489.54	2.50
28	42.0	53.7	0.78	93	5.9	20	1	885.25	2.46
29	35.0	49.8	0.70	39	9.4	10	4	684.13	2.21
30	45.0	52.0	0.87	116	10.1	20	1	918.45	2.72
31	47.7	48.2	0.99	150	7.5	20	1	902.41	3.11
32	30.5	47.5	0.64	58	11.7	10	1	568.63	2.02
33	41.5	53.0	0.78	112	6.0	10	1	863.30	2.46
34	45.0	60.3	0.75	122	8.3	20	1	1065.05	2.34
35	30.0	46.1	0.65	55	11.6	10	1	542.83	2.04
36	51.5	56.5	0.91	85	11.0	10	4	1142.08	2.86
37	30.0	43.4	0.69	78	6.6	10	1	511.04	2.17
38	52.0	55.0	0.95	48	13.5	10	4	1122.55	2.97
39	46.0	63.0	0.73	33*	16.0	10	4	1137.47	2.29
40	64.5	63.5	1.02	102*	15.1	10	1	1607.58	3.19

KEY: **Abbreviations**: F – Fruit L – Length, Circum.- Circumference
Seed Color Code: Black -10 Brown -20
Endosperm Color Code: Orange – 1 Peach -2 Yellowish Cream -3 Yellow -4
*-With Unfilled Seeds

DISCUSSION

It was observed that fruits of the same size can have a difference of almost 100% in total number of seeds. Akoroda (1990b) reported an average of 62 seeds per fruit from 77 fruits and Ehiagbonare (2008) reported an average of 72 seeds per fruit from 10 fruits. From the present study and from fruits from different sources, an average of 78 seeds per fruit from 25 fruits, 82 seeds per fruit from 40 fruits and 80 seeds per fruit from 49 fruits were recorded. The size of the different fruits was not put into consideration. However, it is beneficial to have an idea of the average number of seeds per fruit that can be found in fruits of various sizes. Since relationship between seed number and fruit size is important in determining number of seeds produced per fruit, this information if provided will increase the precision of seed yield estimates and improve breeding strategies. This study attempted to utilize information on the length and (or) circumference of fruits to determine the number of seeds in the fruit. However, this has not been possible to a large extent from the table created. Some of the fruits did not fall in line with the predictions. The correlation between area, shape and length with Total Seed Number was rather weak. According to Nerson and Paris (2000), the fruit sizes and seed sizes of the two melon cultivars they studied differed significantly, but in the varieties of cucumbers studied, the size of seeds extracted from both large and small fruits was not significantly different. They reported different types of relationships between fruit size and seed yield components of Cucurbits using melon and cucumbers as examples.

Pulp and seed colour in this study varied but, majority of seeds had black colour. The black/dark purple seed-coloured *T. occidentalis* fruits are preferred to the light-brown seed colour fruits in Nigeria (Ajayi, *et al*., 2007b). In this study some black seeds from fruits with orange pulp when planted gave rise to fruits with yellow pulp and brown seeds. *Telfairia* being dioecious, there is high rate of cross pollination which can affect the genetic variability of populations. Among three sets of seeds from known populations (Ife, Famia and Toro) and fruit pulp colour, only seeds from Ife maintained their seed colour in the offspring. In squash (*Cucurbita* spp.), genetic diversity has been highly influenced by size and colour of fruits, number and size of seeds, pulp colour, among other traits (Nerson *et al*., 2000; Ferriol *et al*., 2003; Paksoy and Aydin, 2004; Hernandez *et al*., 2005; Balkaya *et al*., 2009). Balkaya *et al*., (2010) noted high variability of size, colour and shape in seeds of *Cucurbita moschata*. Interpopulational variability of seed and fruit traits has also been reported in other different species (Ali Ghars *et al*., 2006; Goulart *et al*., 2006).

It was observed that fruits from Gbongan were more rounded than fruits from Famia or Toro which were significantly longer and contained almost double the number of seeds in the Gbongan fruits. The lower the value for the shape measurements (length/diameter), the rounder the fruit; the higher the value, the longer the fruit. There was a positive significant correlation (0.43) between shape and area of fruits. Cluster analysis based on fruit shape clustered fruits from Gbongan together in a group while fruits from Ife and Toro all clustered together in another group except for one fruit from Ife which clustered together with the fruit from Famia in a separate group. This may be an indication of genetic diversity among these fruit populations.

With regards to fruit characteristics, length of fruit is a very important factor to consider. The fact that circumference correlates only with area while length correlates with most fruit characteristics measured, shows that the fruit length has higher effect on fruit characteristics than fruit circumference. The longest fruit (in terms of fruit length) did not produce the highest total number of seeds, however, the longest fruits in terms of shape produced the highest total number of seeds per fruit. The correlation of length with total seed number was highly significant. This is contrary to the report of Adeyemo and Odiaka (2005) that number of seeds showed no significant correlation with fruit characteristics. Sakpere *et al*. (2016) also reported that there was no correlation between fresh seed weight and percentage germination. However, the relationships among the fruit and seed characters are complex since many factors influence the outcome of a particular

characteristic. For instance, the total number of seeds in a fruit can be influenced by the size of the seed, how densely packed they are, the amount of pulp (spongy surrounding maternal tissue) present in the fruit and also by the size of the fruit which in turn can be influenced by how long or how wide the fruit is.

Leaf primordia arise from the flanks of the shoot apical meristem (SAM) in a highly ordered spatial and temporal pattern, termed phyllotaxis (Ha *et al*. 2010). Phyllotaxis is a major determinant of plant architecture and in *Telfairia occidentalis*, it was observed that the phyllotaxy of leaves on the first three to four nodes vary in seedlings. Three forms were observed by Ajayi *et al*. (2007a), however, in this study, seven forms were observed and none aligned with any sex. Ajibade *et al*., (2006) recommended analysis of leaf fibre content for sex identification in *Telfairia occidentalis*. Ndukwu *et al.* (2005) reported that even though Okoli and Mgbeogu (1983) noted that dimensions of leaves are necessary in distinguishing males from female plants of *T. occidentalis*, they observed overlaps in the ranges of these features in their study. They therefore concluded that it is not advisable to attempt distinguishing the sexes in this plant based on leaf dimensions only.

According to Li *et al*. (2007), sex-related differences in morphological and physiological characteristics of dioecious plant species have been studied extensively and are extremely variable across environmental gradients, particularly across altitudinal gradients.

Unfilled seeds were found in relatively large fruits. This is contrary to the findings of Akanbi *et al*. (2007) and Chukwudi and Agbo (2014) who reported that high percent of unfilled seeds were present in small sized fruits. The percentages of unfilled seeds in a fruit are a function of fruit development. Fruits that are harvested before maturity will contain a high percentage of unfilled seeds. Odiaka and Akoroda (2009) also reported that high percent of unfilled seeds will be found in fruits harvested before the 6th week after anthesis. Percentage of unfilled seeds in fruits is not a function of fruit size but of fruit development.

In conclusion, based on these observations, the average number of seeds per fruit that can be found in fruits of various sizes has been defined. More seedling phyllotaxy has been identified and seedling phyllotaxy or morpho-physiological characteristics cannot be used in identifying plant sex for this species. The fact that there is still a high percentage of polyembryonic seeds in *Telfairia* fruits has also been established and the relationship between seed size and polyembryony elucidated.

Large fruits are clearly not associated with total number of seeds. That is, a small fruit can have higher number of seeds than a larger fruit. Length of fruit with regards to shape is an important attribute that relate to size of *T. occidentalis* fruit.

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