TITHONIA (ASTERACEAE) IN NIGERIA

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ABSTRACT

The distribution of *Tithonia rotundifolia* and *T. disversifolia* in Nigeria is circumscribed. While the former is an annual widespread from the forest borders to the southern limits of Sahel Savana, the latter is perennial occurring only as small populations except around Jos metropolis where it tends to be invasive. *T. rotundifolia* is propagated by seeds while *T. diversifolia* reproduces exclusively vegetatively. The two taxa are morphologically distinct as they differ with respect to longevity, the size of their capitula and ray florets, the structures of their peduncles, and the shape of their phyllaries; the outermost series of phyllaries are also hairy in *T. rotundifolia* but glabrous in *T. diversifolia.*

Tithonia rotundifolia is much more variable regarding branching patterns, ligule size and even ray floret colour; a red ray population is encountered around Jos almost as an endemic. This study confirms the chromosome number of n=17 in *Tithonia* but raises questions as to whether exclusion of polyploidy in the speciation of *Tithonia* is fully justified. There is no cytological evidence from microsporogenesis to implicate meiotic irregularities in the seed-sterility of *T. Diversifolia.*

Keywords: Tithonia, Annual, Perennial, Speciation

INTRODUCTION

In the best known revision of the genus Tithonia Desf. Ex Gmelin, La Duke (1982) recognized eleven species and thirteen taxa in which he recognized two sections: section Tithonia and section Mirasolia (Sch.-Bip in Seemann) La Duke. Section Tithonia comprises three series: Series Tithonia with four species, series Fruticosae La Duke with two species and series Grandiflorae La Duke with two species.

The only two species found in Nigeria today and studies on which are reported in this contribution, *Tithonia diversifolia* (Helmsl.) A. Gray and *T. rotundifolia* (Miller) S.F. Blake were assigned in La Duke (1982) to series Grandiflorae and series Tithonia respectively. The genus Tithonia has its center of origin in Mexico and Central America. *Tithonia rotundifolia* is the type species of the genus but *T. diversifolia* is the most widespread having been cultivated in Asia, Africa, Australia and North America where it has escaped (La Duke, 1982).

In Nigeria, *Tithonia rotundifolia* is the widespread species having colonized roadsides, waste places, fallow land and disturbed open spaces like abandoned construction sites etc. and displacing traditional weedy species like *Chromolaena odorata and Panicum maximum* (Adebowale and Olorode, 2005).

Tithonia diversifolia, however, is encountered largely as populations of mostly restricted sizes on roadsides and open locations from the forest-savanna borders to Jos Plateau where it shows, curiously, invasive characteristics and occurs as extensive populations in abandoned spaces in Jos metropolis and its outskirts (Adebowale and Olorode, 2005; Figure 1)

Isawumi (1996) addressed the taxonomic problems relating to wrong identification of *Tithonia diverisifolia* and *T. rotundifolia* leading to circumscription of the two species as one i.e. *T. diversifolia*. Using what he called floral microcharacters and certain capitula characters such as number of ray florets and disk florets, he delimited the two species unambiguously. More recently, Moughalu and Chuba (2005) reported their studies (in Zambia) on seed germination and reproductive strategies in *T. diversifolia* and *T. rotundifolia* with data on reproductive attributes (number of capitula per plant, number of seeds per capitula and number of seeds per plant) and allocation of dry matter to different structures (reproductive tissue, stem and total above-ground tissue). In respect of Muoghalu and Chuba's reports cited earlier, the significant point was made that *T. diversifolia* produces viable seeds in Zambia and that, indeed, it has a high reproductive and greater invasive potential than *T.*

rotundifolia. Arising from the observations in Adebowale and Olorode's (2005) studies, more extensive collections and studies of *T. diversifolia* and *T. rotundifolia* became imperative. The results of these studies are reported in this paper.

MATERIALS AND METHODS

Three forms of *Tithonia rotundifolia* (standard yellow, woody yellow and red ray) were analysed in this study. Standard yellow (RS) seedlings were transplanted into our experimental plot near the Screen House of the Department of Botany at Obafemi Awolowo University, Ile-Ife (OAU).

The form referred to as woody yellow *T. rotundifolia* (RW) was a *lone* plant recovered from the large population of RW; it was unique because it survived one full dry season without any human intervention. The red ray (RR) *T. rotundifolia* was from seeds collected from waste places in Jos metropolis, sown in seed boxes and then transplanted into the experimental plot (as above). *Tithonia diversifolia* (YD) were clones from waste places around Jos and around Obafemi Awolowo University; the cuttings were planted in the experimental plot (as above).

Measurements (thirty measurements for each character) of various ray and achene characters were made (in cm) while awn lengths were measured (in mm) in the various collections; the means and standard deviations of the measurements were recorded. A general check of stainability of pollen grains was carried out on each collection by applying cotton-blue-in-lactophenol stains to samples of pollen dust deposited on glass slides and covering the specimens with cover slips. The specimens were then examined under light microscope at X400.

Mitotic and meiotic studies were carried out on some of the specimens using standard squash techniques for root tips and disk florets at appropriate stages (Olorode, 1974; Olorode and Morakinyo, 1978). Photomicrographs were taken under phase contrast from appropriate mitotic and meiotic cells.

Line drawings were made to illustrate gross habit, disposition of capitula, leaf and characteristics of main veins, capitula characteristics and characteristics of ray flowers, disk flowers, paleas and achenes. Photographs of capitula were also taken with a digital camera to illustrate variations in size and colour of ray flowers.

Voucher specimens were prepared and they will be deposited in the herbaria at the University of Abuja, Abuja and Obafemi Awolowo University, Ile-Ife.

RESULTS AND OBSERVATIONS

Distribution of the Two Species in Nigeria

The distribution of *Tithonia rotundifolia* and *T. diversifolia* is already addressed under "Introduction" above and illustrated in Figure 1. It is left to emphasise that in Nigeria, *T. rotundifolia* is the definitive invasive species while *T. diversifolia* is encountered mostly as small populations except around Jos (Plateau State) metropolis and its suburb where it shows definitive invasive characteristic. The red-ray form of *Tithonia rotundifolia* is encountered nowadays only around Jos metropolis (as an escape) although one of us (Olorode) remembers that the form used to be a common annual ornamental (along with species of *Zinnia*) in school gardens in South Western Nigeria in the 1950s and 1960s.

Annuality and Perenniality, Branching Patterns, Leaf Forms and Pigmentation of Main-Veins

Tithonia rotundifolia (yellow and red ray flowers) is preponderantly annual. However, a single plant was found among the yellow-ray population which is distinctly, woody and which survived the dry season into the following raining season. This woody-yellow form was accidentally lost before seeds could be harvested from it. However, *T. diversifolia* is perennial. While *T. rotundifolia* reproduces from seeds copiously produced, *T. diversifolia* is seed sterile thus spreading only through segments of stems arising from slashing. Pollen grain studies showed that both species are consistently pollen-fertile.

Branching may be monopodial leading to determinate capitulum production on the main axis or determinate capitulum production in lateral branches as in Figure 2A:a. This general pattern in *T. rotundifolia* seemed to be affected by the degree of "crowding" in populations of *T. rotundifolia*. Sympodial branching leading to indeterminate capitula production is typical in *T. diversifolia* but it is also encountered in both the yellow- and red-ray *T. rotundifolia* as especially in the perennial woody yellow *T. rotundifolia* (Figure 2A:b).

Leaves are generally stiffer and less hairy in *T. diversifolia* than in *T. rotundifolia*. The general patterns of dissection and lobbing are more or

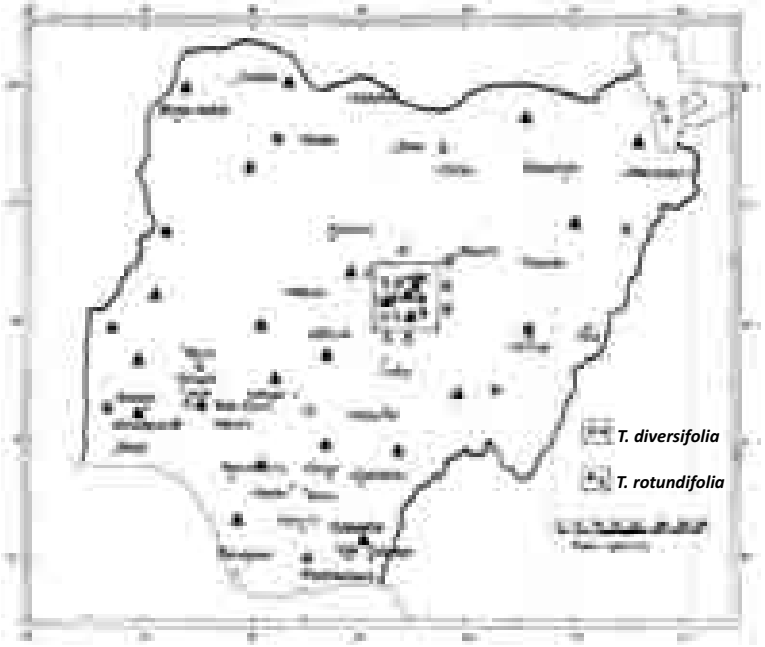


FIG. 1: Distribution Pattern of *Tithonia* Species in Nigeria

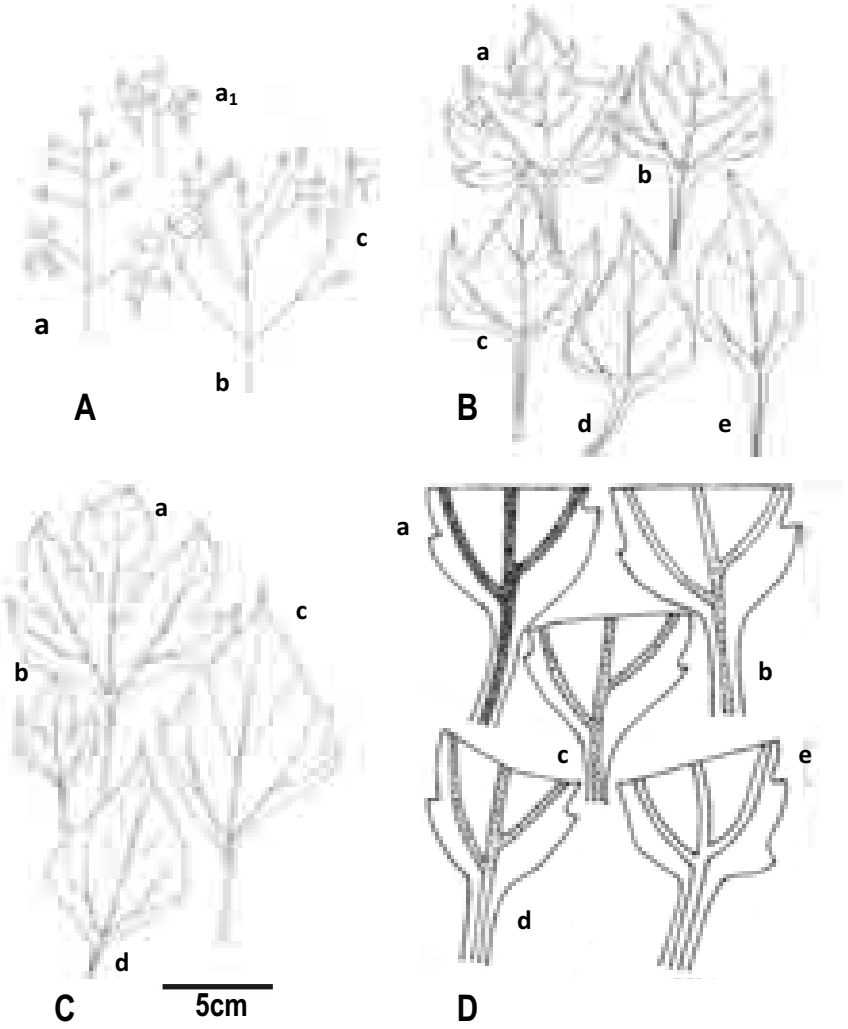


Figure 2: Branching Patterns and Leaf Characteristics in *Tithonia rotundifolia* and *Tithonia diversifolia*. A. Monopodial (a;a_1) and sympodial (b) branching and patterns of capitula production in *Tithonia* collections B. Shape dissection, margins and extension of blade on the petiole in *Tithonia rotundifolia;* a,b,c: degrees of dissection in mature leaves; a is more prevalent in young plants; blade extends more than two-thirds down the petiole. C. Shape dissection margins, and extension of blade on the petiole in *Tithonia diversifolia,* a: Fully-developed leaves at flowering, b: developing leaves before flowering; c,d: Minimally dissected or undissected leaves on the lower parts of branches. D. Pigmentation on midrib and lower main veins in *Tithonia spp*: full pigmentation (a) is prevalent in *T. diversifolia;*

less similar in the two species (Figure 2B, C). The two species also differ regarding the degree to which the leaf blade extends towards the base of the petiole (Figure 2B, C). The intensity of the invariably purple pigmentation on the midrib and main veins is also characteristic in each species. The pigmentation shows deep and generalized consistency in *T. diversifolia* (Figure 2D:a). On the other hand, *T. rotundifolia* populations exhibit considerable inter-plant (i.e. intra-population) variability but consistent intra-plant (i.e. among leaves on the same plant) patterns of mid-rib/mainveins pigmentation (Figure 2D:b,c,d,e).

Table 1: Mean Measurements (Standard Deviations in Parentheses) of Floret and Achene characteristics

Plant	Achene length (cm)	Achene breadth (cm)	Awn (l) length (mm)	Awn (s)* length (mm)	Ray length (cm)	Ray breadth (cm)
T. rotundifolia						
Standard yellow	6.50 (0.4281)	2.40 (0.2682)	1.80 (0.7788)	No Data	2.60 (0.4258)	1.10 (0.1720)
Woody yellow	6.50 (0.3976)	2.50 (0.1738)	2.30 (0.5793	1.30 (0.7715)	2.4 (0.531)	1.10 (0.3215)
Red Ray	8.00 (0.8142)	2.90 (0.3132)	4.90 (1.1375)	3.50 (1.5000)	1.80 (0.4576)	1.00 (0.7135)
T. diversifolia	No Data	No Data	No Data	No Data	4.04 (0.6019)	1.50 (0.1800)

*Awn (l) and Awn (s) are long awn and short awn respectively.

The key aspects of the capitula in the forms (in Nigerian collections) of *T. rotundifolia* and *T. diversifolia* are illustrated fully for the first time in Figures 3, 4, 5 and 6. Phyllaries are characteristic in shape for *T. diversifolia* and *T. rotundifolia* with the outer series being definitively hairy in the latter and glabrous in the former. The peduncles are also typically inflated in *T. diversifolia* (Figure 6). Variations in disk florets and palea are shown in Figures 3-6. In particular, the aristate apices of the paleae in Figures 3 and 4 are of interest.

The shape and size of the ligules in the ray flowers show noticeable variation in *T. rotundifolia* (Figure 3); there is, of course, the two ligule colours (yellow and red). The ligule of ray flowers is longer and more deeply dissected in *T. diversifolia* than in *T. rotundifolia* (Plate 1). A scatter diagram of the length/breadth dimensions of the ligules in the collections of *Tithonia* in Nigeria shows considerable overlaps but definitive clusters for different collections (Figure 7).

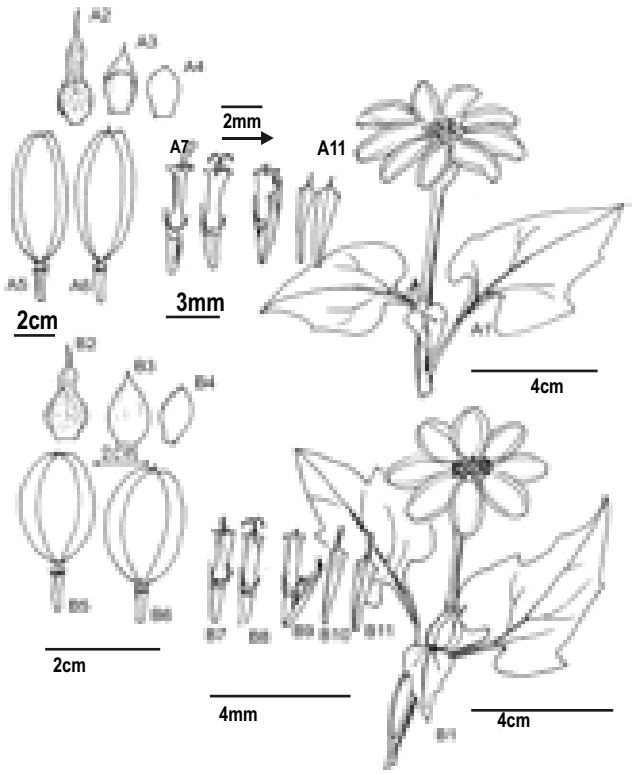


Figure 3. Capitula and Floret Characteristics in Two Forms of Annual Yellow *Tithonia rotundifolia;* Standard Yellow (A) and short ray (sr) yellow. A_1 Fully opened capitulum; A_2, A_3, A_4: outer, middle and inner series of phyllaries respectively; A_5, A_6,: ray florets; A_7, A_8: young and old disk florets respectively; A9; disk floret with palea in side view; A_{10}, A_{11} paleas in back view. B_1; fully opened capitulum B_2, B_3, B4: outer, middle and inner series of phyllaries respectively; B_5, B_6: ray florets: B_7, B_8: young and old disk florets; B_9 disk floret with palea; B_{10}, B_{11}: paleas in back view.

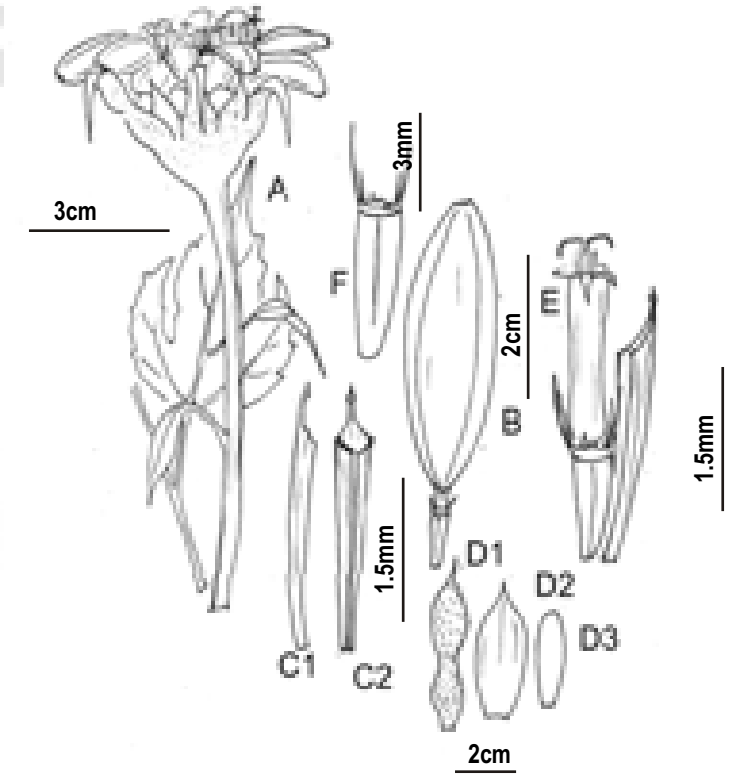
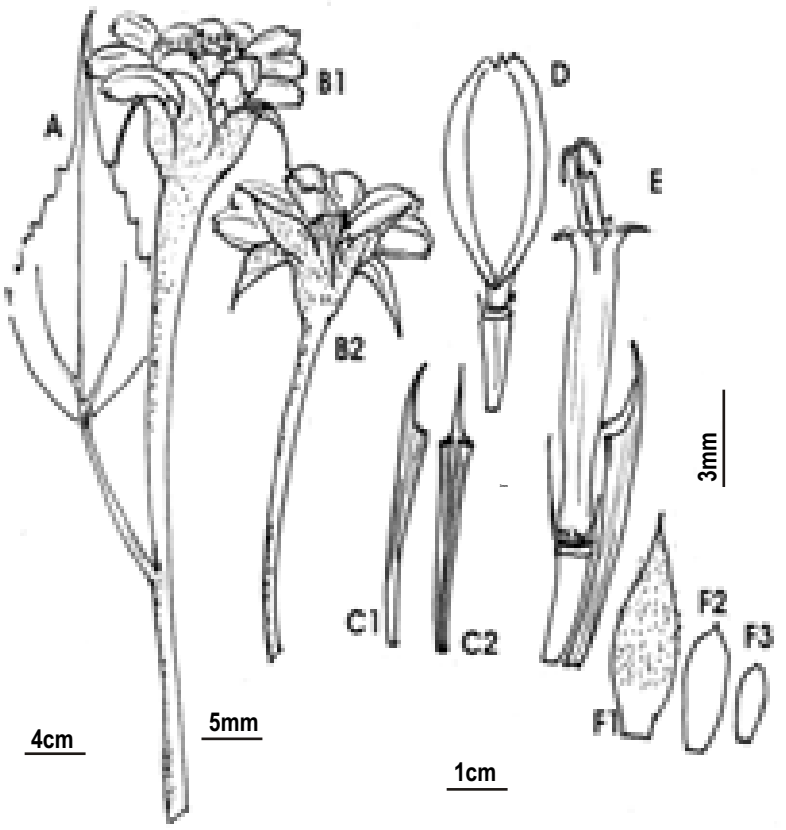


Figure 4. Capitula and Floret Characteristics in (woody) Yellow *Tithonia rotundifolia* A: Capitulum, peduncle and leaf at peduncular base; B: ray floret; C_1, C_2: side and front view, respectively, of palea; D_1, D_2, D_3: outer, middle and inner series, respectively, of phyllaries; E: disk floret and palea; F: achene.

Figure 5.

Tithonia rotundifolia (Red): Capitulum and Floret characteristics. A,B: two views of the capitulum and the peduncle. C: ray floret; D: disk floret with palea; E_1, E_2: palea in side and front views respectively, F_1, F_2, F_3 outer, middle and inner series of phyllaries respectively.



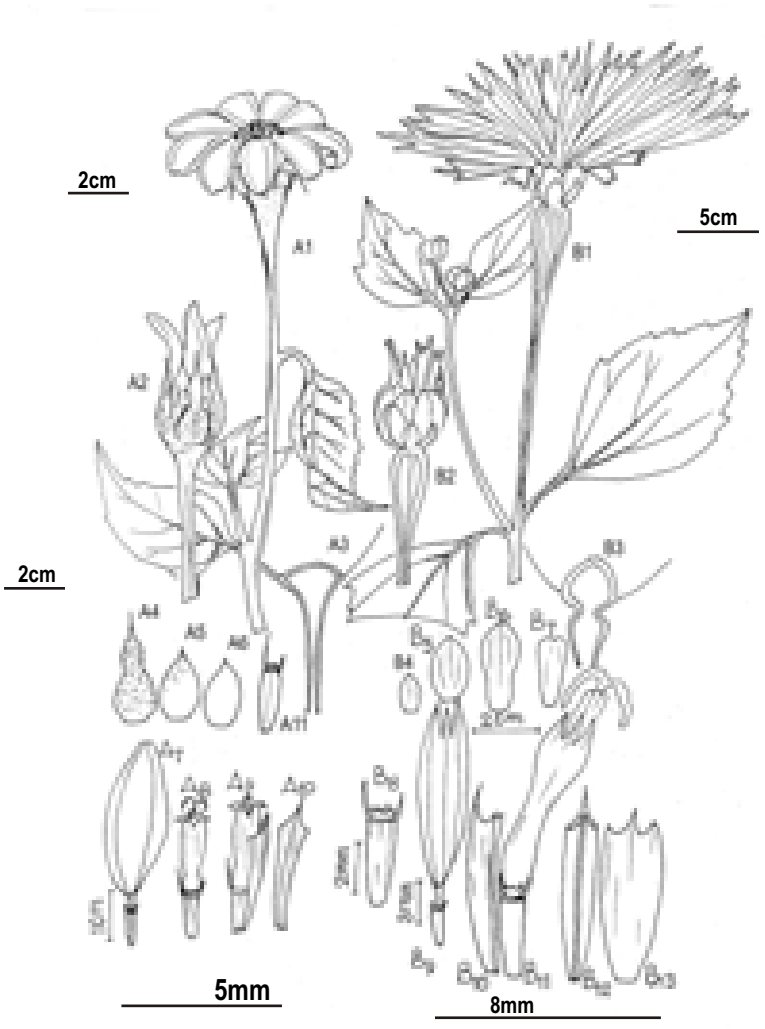


Figure 6.

Capitula and Floret Characteristics in *Tithonia rotundifolia* (A) and *T. diversifolia* (B). A_1, A_2, A_3: Fully opened capitulum, capitulum just opening and vertical section through upper end of penduncle respectively; A_4, A_5, A_6; outer, middle and innermost phyllarierespectively; A_7, A_8, A_9, A_{10}; ray floret, disk floret, disk floret with palea and palea in back view respectively; A_{11}: seed. B_1, B_2, B_3; fully opened capitulum, capitulum just opening and vertical section through upper end of penduncle respectively; B_4, B_5, B_6, B_7: succession of phillary types in the order of their occurrence from outermost (B_4) to the innermost (B_7) series; B_8: achene with spathaceous achene; B_9: ray floret; B_{11}: disk floret; B_{10}, B_{12}, B_{13}: Palea in side view, in front view and spread-out in front view respectively.

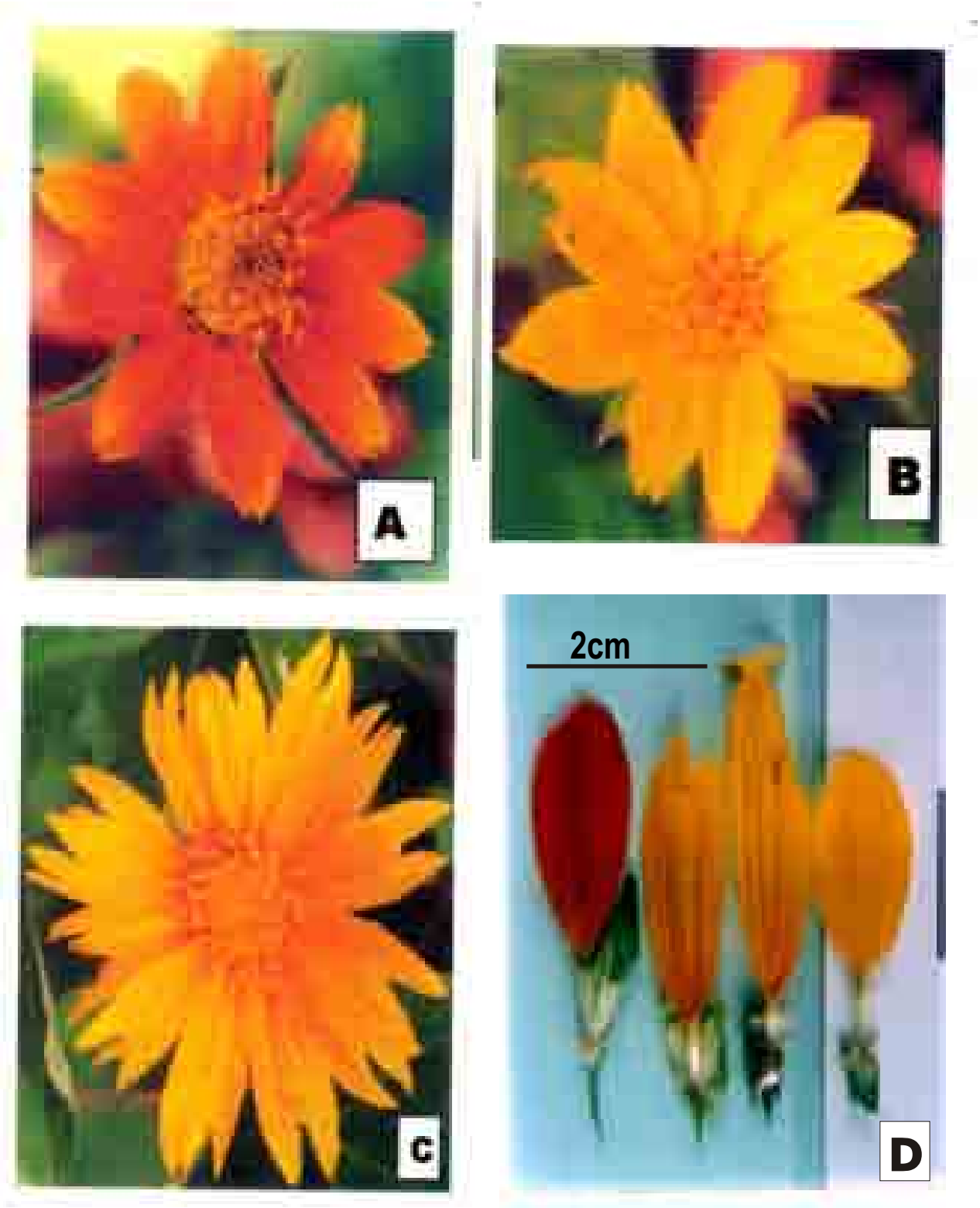


Plate 1: Capitula and Ray Florets in Nigerian Collections of *Tithonia*. A and B: *Tithonia rotundifolia* collections with red and yellow flowers respectively; C: *Tithonia diversifolia*: D: Ray florets (from left to right) in *Tithonia rotundifolia*, *T. rotundifolia T. diversifolia*, *T. rotundifolia*.

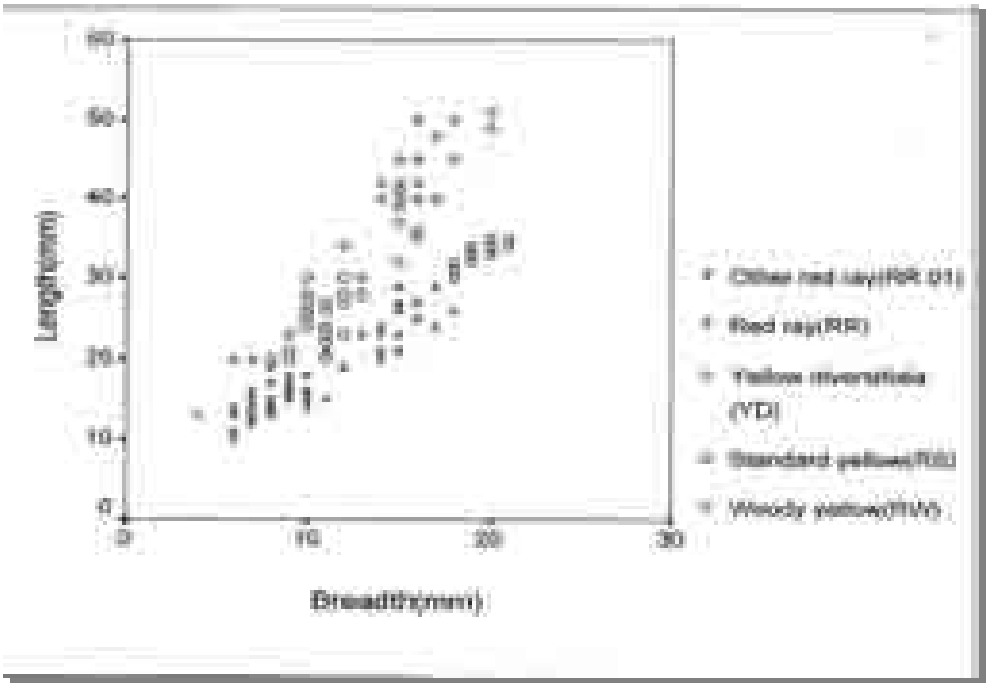


Figure 7: Scatter Diagram of the Measurements (length and breadth) of Ligules of the Ray florets in Nigerian collections of *Tithonia diversifolia* and *Tithonia rotundiflora*. YD: *Tithonia diversifolia;* RR01, RR, RS, RW: *Tithonia rotundifolia.*

Mitosis, Meiosis and Seed Production

Plate 2A and B are root tip mitotic cells showing 2n = 34 diploid numbers in *T. diversifolia* and *T. rotundifolia* respectively. Plate 2C shows diakinesis cells with five (5) quadrivalents and seven (7) bivalents in *T. diversifolia* and *T. rotundifolia* respectively. Plate 2E and F are telophase I cell and metaphase II cells respectively in *T. diversifolia;* Plate 2G is telophase II in *T. diversifolia*. Plate 2E, F

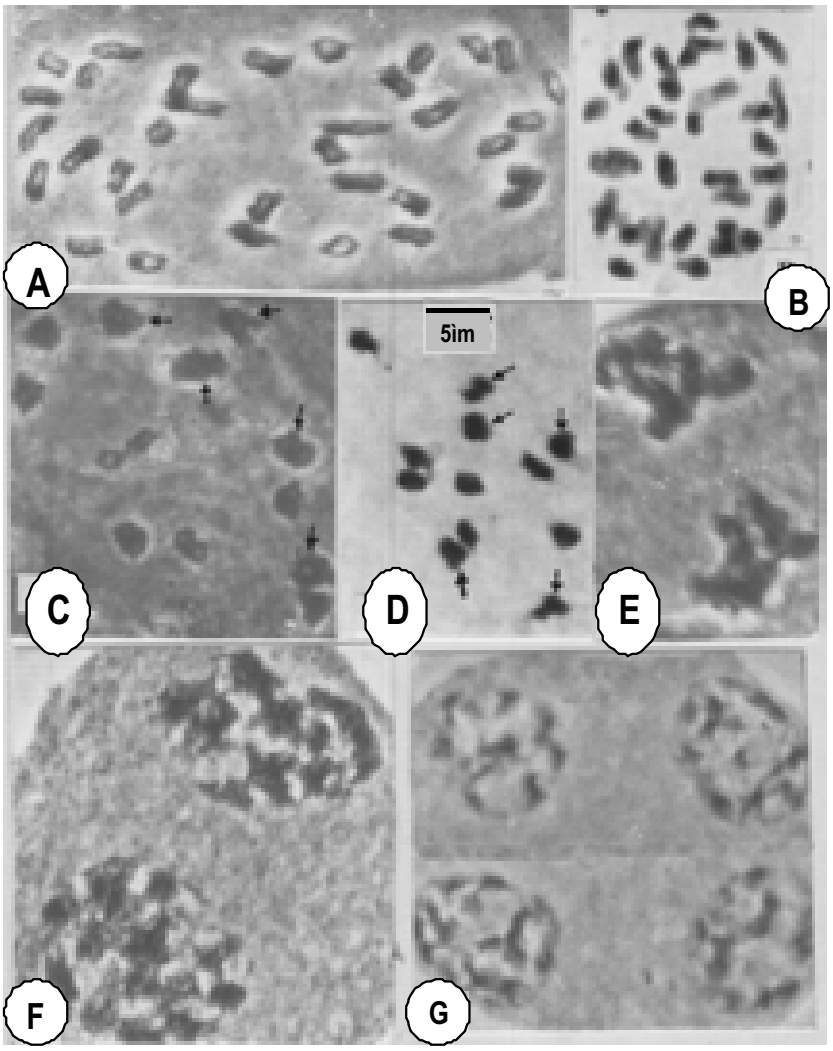


Plate 2: Mitosis and Meiosis in Nigerian Collections of *Tithonia*. A & B: Root tip mitosis in *T. diversifolia* and *T. rotundifolia* respectively (2n=34); C & D: Diakinesis showing 5 IV (arrows) and 7II in *T. diversifolia* and *T. rotundifolia* respectively; E & F: Telophase I and Metaphase II respectively in *T. diversifolia*; G: Telophase II in *T. Diversifolia*.

and G indicate regular meiotic processes in *T. diversifolia* which are consistent with the very high pollen grain stainability observed in the taxon. Seed production was copious in the collections of *T. rotundifolia* while all the mature heads examined in *T. diversifolia* produced no viable seeds whatsoever as the achenes were completely empty!

DISCUSSIONS AND CONCLUSIONS

From the evidence available in this study, there can be no controversy about the species boundaries in Nigerian collections of *Tithonia*. Apart from definitive perenniality of *T. diversifolia* and annuality of *T. rotundifolia* the peduncle and phyllary characteristics and ray floret dimensions, number per head and dissection are diagnostic (Figure 3, 4, 5, 6 and 7; Table 1). The red-ray *Tithonia rotundifolia* are also distinct from the yellow-ray form. Although the two forms may be conspecific, there is no evidence whatsoever that they exchange genes around Jos where they are sympatric. The achenes in the red-ray forms of *T. rotundifolia* are brown and larger than in the yellow-ray forms. The pattern of distribution of *T. diversifolia* and *T. rotundifolia* is also diagnostic as we observed earlier on. It will be interesting to investigate whether branching patterns in *T. rotundifolia* are genetically determined or whether they are plastic responses to population density. Clearly monopodial branching patterns are likely to limit the number of capitula per plant and to be a response to high density of the plants. Sympodial branching, on the contrary, would be possible where density is low and production of high number of capitula is enhanced (Baker, 1965).

Seed production is copious in all collections of *T. rotundifolia* but *T. diversifolia* is seed-sterile. Moughalu and Chuba (2005) were categorical that *T. diversifolia* is invasive with fertile seeds and massive seed production in Zambia. Muoghalu and Chuba (2005) also estimated the number of seeds per capitulum as 179.75 ± 2.32 and 133.33 ± 5.72 for *T. diversifolia* and *T. rotundifolia* respectively. Isawumi's (1995) estimates of number of flowers per capitulum and Adebowale and Olorode's (2005) estimates for Nigerian collections of the two species were much lower. The Nigerian estimates of reproductive potential per capitulum will be still lower if we assume (and we ought to) that not all disk florets will result in seeds. The conspecificity of Zambian and Nigerian collections of *T. diversifolia* becomes problematic!

The evidence from mitotic and meiotic studies in this contribution corroborate previous n = 17 determinations (La Duke, 1982) of chromosome number in the genus *Tithonia*. However, the occurrence of quadrivalents in the diakinesis of both *T. rotundifolia* and *T. diversifolia* without any problems in subsequent stages of meiosis raises a significant query about previous claims (La Duke, 1982) concerning absence of polyploidy in the speciation strategy of *Tithonia* (i.e. that speciation occurred entirely at the diploid level). It is interesting that La Duke (1982) made that suggestion in spite of the observation in the same paper that a base number of x = 8 is known in a related genus *Vigueria* BK.

From the regularity of meiotic processes, it is also evident that seed sterility in *T. diversifolia* is not likely to have arisen from meiotic aberrations. However, at least one other source of seed sterility has been reported (Pandey, 1990) in collections of *T. diversifolia* at Bihar (India). In the report, endorsperms are said to collapse immediately after the globular embryo stage resulting in collapse of the embryo. Giving the successful development of vegetative strategy of propagation in *T. diversifolia* in our study area, it is not surprising that seed sterility had developed contemporaneously.

REFERENCES

Adebowale, A. and Olorode O. 2005. An overview of the invasive potential of *Tithonia* species (Asteraceae) in Nigeria. *Science Focus* 10(3), 65-69.

Baker, H.G. 1965. Characteristics and Modes of Origin of Weeds. *In* H.G. Baker and G.L. Stebbins (Eds.) The *Genetics of Colonising Species*. Academic Press. New York.

Isawumi, M.A. 1995. Floral microcharacters and taxonomy of the genus *Tithonia* (Heliantheae: Asteraceae) in Nigeria. *Comp. NewI.* 29, 31-39.

La Duke, J.C. 1982. Revision of Tithonia. *Rhodora* 84(840), 453-521.

Muoghalu, J.I. and Chuba D.K. 2005. Seed germination and reproductive strategies of *Tithonia diversifolia* Helmsl.) and *Tithonia rotundifolia* (P.M.) Blake. *Appl. Ecol. Envir. Res.* 3, 39-46.

Olorode, O. 1974. Chromosome numbers in Nigerian Compositae. *Bot. Jour. Linn. Soc.* 68(4), 329-335.

Olorode, O. and Morakinyo J.A. 1980. Hybridisation Studies in the *Hyparrhenia involucrata H. subplumosa* complex in Nigeria. *Cytologia* 45, 189-196.

Pandey, A.K. 1990. Development of seed and fruit in *Tithonia diversifolia* (Hemsley) A. Gray (Asteraceae). *Jour. Jap. Bot.* 65(3), 10-16.