GENETIC DIVERSITY, DOMESTICATION AND CONSERVATION IMPLICATIONS OF FRUIT MORPHOMETRIC DATA ANALYSES FOR *DACRYODES EDULIS* IN SOUTHERN NIGERIA

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Abstract : *Dacryodes edulis* – African Pear is of socio-economic importance in the Southern region of Nigeria where it is a major auxiliary revenue source for farmers. Cluster and Principal Component analyses of the fruit data showed three distinct groupings; small-sized fruit, large-sized fruit and an intermediary group of mixed fruit types. These reflect the cadre of genetic diversity inherent in the taxon, and constitute a possible veritable tool for its improvement. Notwithstanding the diversity, the prevailing spread pattern of the taxon across the region threatens to erode a section of the species genetic richness; the small-sized fruit types - var. *parvicarpa*, as well as undermine the genetic integrity of large-sized fruit var. *edulis* population. The trend is driven by a vendor/farmer preference for the large-sized fruit type across the region, and except there is deliberate *In situ* and *Ex-situ* conservation efforts, these intraspecific diversities of the species may be lost altogether.

Keywords : African pear, Farmer/vendor, Genetic erosion, Intra-specific diversity, Spread pattern.

INTRODUCTION

Dacryodes edulis (G. Don) H.J. Lam., constitutes a veritable plant resource for timber and non-timber products in West Africa; with the potential to contribute immensely to the dietary, pharmaceutical, industrial raw materials requirement as well as offer environmental conservation potentials in such countries (Gbile and Adesina 1986).

The species evidently originated and is wide spread and cultivated in the humid, inter-tropical forest of southern Nigeria, Congo and Cameroun (Ngatchou and Kengu 1989). The species is plastic and grows at varied altitudes under a wide range of day length, temperature and edaphic factors. In Nigeria, the species is distributed along the "African pear belt" running from the South–West to the South-East of the country, between the very wet rain forest of the south and the drier savanna of the north. (Aubreville 1962; Kennedy 1936; Keay 1989).

Okafor (1983) identified two varieties of *Dacryodes edulis* var. *edulis* and var. *parvicarpa* on the basis of their fruit shape and size. The var. *edulis* is elongated and ellipsoid, more than 5 cm long and 2.5 cm across; var. *parvicarpa* is rounded to more or less conical, less than 5 cm long and 2.5 cm across. Youmbi *et al.,* (1989), Leakey and Ladipo (1996) and Silou *et al.,* (1999) have reported variation in fruit size and other fruit characteristics in Cameroun. Equally, there is also the report of tree-to-tree variation in fruits (Anegbeh, 2005). With all these variation within a more or less "Wild" population, the genetic resources offers an opportunity for plus-tree selection, such as is already recorded for *Irvingia gabonensis* (Atangana *et al.*, 2001).

Genetic Resources Utilization and Erosion

The characterization of the genetic resources (diversity) of *Dacryodes* is still in its early stage. Certain ecotypes are presumably cultivated in particular localities; however there are evidences of interbreeding coupled with a variety of selection pressures. Whether natural or artificial, selection pressures often focus on the desirable parts(s) of plants, which eventually results in a vast genetic pool as demonstrated for most domesticated plants. This genetic diversity form the basis for plant breeding and improvement efforts and where the integrity of the diversity is compromised, whether by failure to sustain the species, through selective cultivation, or by indiscriminate replacement with introduced forms; genetic erosion sets in (Mok and Schmiediche 1999), which can be exacerbated by deforestation and related activities.

D. edulis faces a stringent regime because the taxon exists only as stands in homestead and traditional agroforestry systems (Aiyelaagbe *et al.,* 1998; Akachuku 2006). The species have only begun to receive some attention and this poor attention coupled with habitat fragmentation, deforestation as well as unsustainable arable land use resulting from economic distresses, urbanization industrialization pressures (Obute and Osuji 2002; Ayodele 2005); prompted the present attempt to ascertain, through fruit morphometric data analysis; the genetic diversity status of the species, the prevailing domestication culture and spread pattern across southern Nigeria and its effects on the genetic integrity as well as conservation needs for *Dacryodes edulis*.

MATERIAL AND METHOD

Study Area

The study area falls within the humid Southern

Nigeria tropical rainforest (Fig. 1). Extending from the South-west (7°15' N; 5^0 55'E), to the South-east (6^0 8'N; 6^0 55'E).

Sampling Frame

The study area consisted of four primary sampling areas: South-west (SNW), South-south South-east (SNE), South-south (SNS) and South-north (SNN), within each sampling area, production areas were ascertained, from where sampling sites were determined. A total of 60 sampling sites were visited. Sampling points co-ordinates were recorded with a hand-help Garmin Colorado 400i GPS. Several collection trips were made to sampling sites, which comprised of homesteads, farmlands, rural (marginal) markets and urban (central) markets. Collection continued throughout the fruiting season from July to December of the 2008 - 2010.

Accession Identification and Sorting

Preliminary morphological identification of fruit accessions commenced at the collection point by direct field observation, with the assistance of farmers, vendors, and household members. Mature, ripe, dark coloured fruits were selected for examination and measurement. Information on local names, descriptions and uses supplied by farmers and vendors were employed for the initial selection, 96 fruit lots were generated from the field collections.

Fruit collections were harmonized and character descriptors to be measured were examined to ascertain their regularity amongst the various fruit lots from the different sampling areas. Duplicates collections as well as fruits with characters that were not consistent across the sampling areas were excluded. A total of 17 fruit samples were sorted for examination and measurement (Table 1).

Fruit Descriptors and Measurements

A total of thirteen (13) character descriptors (Table 3) were generated and examined for the study. Descriptors were generated according to IBPGR (1980); IPGRI (1996, 1997). Ten (10) mature fruits were measured per lot. Quantitative measurements were recorded to the nearest 0.01cm using a Vernier calliper. Single-multi state coding method was employed for descriptors coding. All measurements were completed within 12hours after each collection to avoid fruit pulp deterioration and discolouration and stored at under 4^0C in a non-frost Super-520 Laboratory Refrigerator afterward. Varietal identification of accessions lots was as outlined by Okafor (1983). Adopted colour chart is as charted by Royal Horticultural Society (RHS 1986).

Analysis of Data

Accessions diversity was examined by hierarchical cluster analysis (CA) from a Euclidean distance matrix and principle component analysis (PCA) ordination in space using SPSS 15.0 for Windows.

RESULT

Fruit Character Descriptors

Thirteen fruit character descriptors (Table 3.) generated for the study are: fruit size (fs), fruit shape (fsh), mature skin colour (msc), seed length (sl), seed shape (ssh), fruit/seed size ratio (f/s), fruit epicarp texture (ft), fruit apex (fa), fruit base (fb), fruit interior (fin), fruit pulp diameter (pd), seed position (sd) and endocarp detachment (edt).

Hierarchical Cluster Analysis

The dendogram (Fig. 1) from the cluster analysis separated into three clusters with a mix of the accession from the various zones.

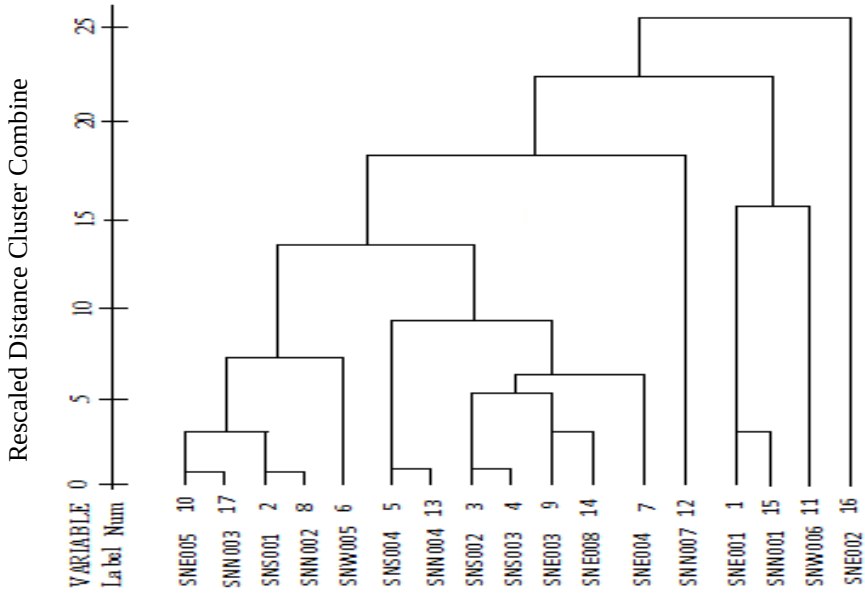

Figure 1. Cluster analysis of the 17 accessions: members of the first cluster are var. *parvicarpa*, (SNE005, SNN003, SNS001, SNN002, SNW005, the last cluster consist predominantly of var. *edulis* (SNE001, SNN001, SNE002, except SNW006); the middle cluster consists of var. *parvicarpa* and var. *edulis* accessions

Principle Component Analysis

The PCA clumping (Fig. 2) resulted in three groups (a-c) with accessions members similar to those of the clusters (Fig. 1).

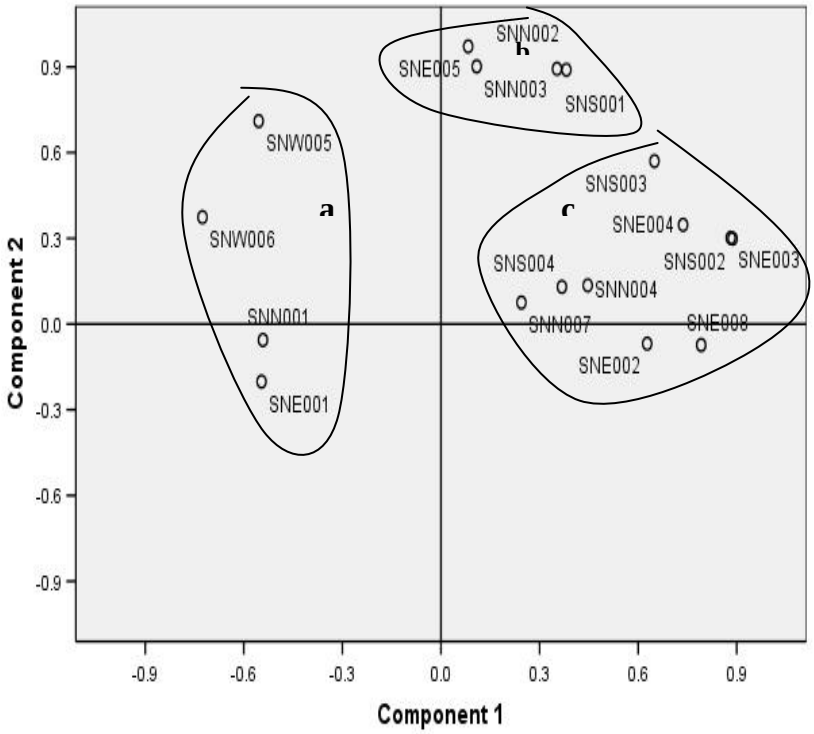

Figure 2. Principle component analysis - PCA ordination in space for the 17 accessions, showing the three groups. Clockwise: Group a, with 4 accessions, Group b with 4 accessions and Group c with 9 accessions.

Analysis Comparison

The squared Euclidean between group cluster analysis of the 17 accessions recorded 3 clusters of varied size. Two smaller clusters (Cluster 1 and 3) accounting for about 41% flank a middle larger cluster (Cluster 2). Similarly, the PCA clumping resulted in three groups (a-c) with similar members as the three clusters; except for the displacement of accession SNE002 by SNW005 in the first group (group a) the addition of two extra accessions to the with middle group b, with 53% accession membership and one accession less in group c.

There is a considerable degree of congruence between the CA and PCA results, with 82% similarity in the grouping pattern; resulting in three distinct groupings similar in size, and identical in membership. The similarity in membership in either analysis is one of the highlights of the present study and the uniformity of the results observed for both analyses is hinged on the consistency of the character descriptors as well as the number characters (13) employed for the analyses.

The dispersion observed for the clusters/groups are linked to a number of characters; fruit apex and base outline, fruit size, fruit shape and seed length that together exerted greater delimiting strength on the resultant grouping than other characters and account for 62.56% of the cumulative component strength under the PCA analysis (Table 4). The resultant groupings separate along the fruit characters line exerting the most delimiting strength as:

Group a (Cluster 1)

● 3.30-4.60cm by 2.50–2.80cm in size .....var. *parvicarpa*

○ Widely Ellipsoid - obovoid in shape

●Fruit with reniform apex, and ringed fruit base,

●Seed, 2.30 – 3.75cm in length

Group c (Cluster 2)

●4.00-7.00cm by 2.00 – 3.30cm in size. ..... var. *edulis; parvicarpa*

○ Narrowly Ellipsoid - ovoid in shape

●Fruit with reniform or oblique apex; ringed or ringless fruit bases,

●Seed, 3.20 – 4.50cm in length

Group b (Cluster 3)

●5.20-8.20cm by 2.40 – 3.30cm in size ..... var. *edulis*

○Narrowly Ellipsoid - Ellipsoid in shape

●Fruit with oblique, with ringless fruit bases,

●Seed, 4.00 – 4.35cm in length

DISCUSSION

One major indicator of the lack of research on *Dacryodes edulis* and other tropical indigenous tree crops is the dearth of information such as standard

character descriptors, which are of great importance in the selection, management and utilization of the genetic resources of the species; as well as for taxonomic, genetic diversity studies and improvement programmes. The thirteen character descriptors generated from the present study (Table 3) will be of immense application in studies involving *Dacryodes edulis*.

Genetic Diversity

The statistical grouping observed is important in interpreting the distribution and diversity of the taxon within the study area. The three groups recorded for both analysis, reflects the consistency of the characters in the construction of the dendogram and scatter plot (Figs. 1 and 2). The first grouping (cluster 1/group a) consists mainly of accessions classed as var. *parvicarpa*, the latter grouping (cluster 3/group b) almost exclusively clumped var. *edulis* accessions, and the mid grouping (cluster 2/group c) housed a mix of either varieties. This may suggest a convergence of the landraces/accessions toward the centre, with resultant mixing of erstwhile distinct accessions; a common situation with increased cultivation.

The characters employed for this delimitation are rather overlapping, hence the corresponding overlap nature of the groups. Earlier delimitation by Okafor (1983) employed only two characters (fruit size and fruit shape) when compared with the 13 engaged for the present attempt. Though overlapping, the resultant groupings present a more robust consideration and a finer (less ambiguous) delimitation for *D. edulis* at the sub species level as well as a better expression of the degree of intra-specific diversity inherent in the taxon, with three separation groupings. The presence of two distinct "*edulis"* "*parvicarpa"* groups agrees with Okafor (1983) earlier delimitation. However, the emergence of a third large group of mixed population differs with that submission, but rather points to an aspect of the population that may have been ignored altogether by the earlier demarcation. Evidently, the taxon posses a population of accessions unaccounted for by the earlier delimitation, distinct enough to substantiate the rich intra-specific variability and the possible degree of genetic diversity housed within the taxon.

Domestication Culture

The strongest intent and concern of all human cultures has been to satisfy hunger, and this constitute the fulcrum of evolution of human food and the main drive behind the various processes of domestication of wild plant for food (John 1990). Consequently, the demand for the edible part(s) of the plant have often determines it cultivation and possible spread.

Observed during the survey, is the growing cultivation of certain accessions of the species. This spread pattern has resulted in a westward cultivation of these accessions from the eastern end. The pattern is a reflection of the steady domestication going on in the western end of the study area, where hitherto, the species was not cultivated. Interestingly, the accessions implicated in the spread are the large-sized fruit type. This not surprising as the spread is directly linked with the seasonal production and sales of *Dacryodes edulis* fruit, which follows a unidirectional movement from the eastern production area to the western end with insignificant production. Certainly, higher income from sales in non producing areas have driven the resultant spread of the species toward such areas and expectedly, only those fruit types that attracts high prices will be sold into such areas and thus will be domesticated by people in these areas. This trade route constitutes the path of increased cultivation observed in the west; and while the drier north cannot support the plant growth; the wetter west can, and have encouraged a steady proliferation (Fig. 3).

Species/accessions with a narrow geographic distribution, specific habitat or small population sizes, are more likely to become victims of elimination where they particularly enjoy very little patronage by farmers/collectors and vendors alike (Rabinowitz 1981). This is the present situation with the small-sized fruits (var. *parvicarpa*) which have not enjoyed the same level of patronage as the large-sized fruit across the region, but have been restricted to marginal cultivation areas (Fig. 3), as well as markets in villages and often do not attract sizeable sales at all, except only in the latter end of the fruiting season when the large-sized fruits are out of season.

Fruit Dispersal and Spread

Most taxa of the Burseraceae family except for *Beiselia*, *Boswellia*, and *Triomma*, possess fruits adapted for endozoochoric dispersal, an attribute that has been integral to in the establishment of isolated oceanic island floras (Carlquist 1974); as well as the spread of most fruit through animal and *Homo sapenic* consumption and dispersal. This is the prime stimulus that drives the domestication of these fruit and one that have made *Dacryodes edulis* an esteemed fruit in Central and West Africa (Leakey *et al.*, 2003).

This spread and increase cultivation pattern observed for the large-sized var. *edulis* fruit however drives a trend that encourages only a slim genetic pool as it is entirely market/vendors rather than farmer driven. This is because the movement westward is entirely based on the price tag on the fruits; hence fruit that have not enjoyed vendors' patronage will certainly loss out of this spread, which leaves only a very lean selection from the diversity inherent in the south, east endemic area of the taxon. Similarly, farmers in the production area will increasingly loss interest in those accession/ecotypes that attract less attention

from vendors and may ultimately be abandoned or replaced altogether, a situation that is common with most indigenous fruits.

Figure 3. Southern Nigeria (Study area) with the direction of spread of the large fruit size Westward and the restricted movement of the small sized fruit

Neglect and Erosion and Conservation

The domestication and sales of species/ecotypes/accessions is often a critical issue and where the accessions enjoy less economic incentives to cultivate and conserve them; the resultant environmental and genetic implications are far reaching for the species and the genetic assortment it may hold for the future. (Leaman et al., 1997). In such situation, common cultural domestication practices cannot be relied on to conserve the species or the accession in question, as such common cultivation habits hinged only on economic incentives will often support only a narrow group of highly favoured accessions.

This present scenario is conservation-wise a worrisome one, in that the spread of the large-sized fruit types westward is driven entirely by the economic incentives it offers. This will certainly eliminate accessions that are not so prized and even amongst the large-sized accessions those without desirable and marketable traits will suffer similar fate. Equally, the small-sized accessions stands no chance at all at been selected for domestication outside the production area and even within the production areas, the small-sized fruits are increasingly under-cultivated and only marginally sold in rural markets, because they attract the least price and hence are of least interest to vendors and consequently farmers.

The overall choice of plant and plant parts consumed by local inhabitants are need-based driven by local cultures and specific attributes (Jain 2000). If the foregoing assertion holds, then the concern is that these small-sized fruits may be facing a race against genetic erosion and their genetic diversity integrity may inadvertently being undermined, by the prevailing domestication culture regarding the taxon within the study area. Interestingly, the study area constitute the zone where the taxon is cultivated in Nigeria, hence the selective cultivation of the large-sized fruits types over the less-fancied small-sized fruits driven by a vendor/farmer preference hinges on the high market profile of the large-sized fruits is worrisome for the species.

Genetic erosion of these accessions may eventually set in and the continuation of the presently observed cultivation preference will certainly exacerbate the condition. While the fruits of *Dacryodes edulis* are mainly eaten fried, roasted, or boiled; a few accessions are sourced for their contribution to medicinal preparations (Gill 1992); and majority of these medicinal fruit types are of the small-sized accessions. Hence the poor contribution of the small-sized fruits to farmers' purse may have fuelled

the observed trend. The medicinal potentials they hold are only localized and may not constitute enough incentives to change the trend and hence the accessions are increasingly isolated in the production areas (Fig. 3).

Considering these domestication trends, in comparison to the diversity present in *D. edulis* expressed by the analysis of its fruit morphometric data; conscious efforts whether *Ex-situ* and/or *In situ* conservation efforts must be engaged to conserve both set of accessions as only a very narrow genetic pool will be cultivated and ultimately a sizeable section of the genetic assortment of the species may be lost.

CONCLUSION

Dacryodes edulis an underexploited tropical fruit tree possess a rich genetic diversity as revealed by the fruit morphometric data analysis and some aspect of this diversity enjoys a gradual spread across the southern region of Nigeria. However, this genetic diversity is being threatened by a selective domestication culture that favours large-sized fruit, neglecting other less-fancied accessions. The small-sized tree accessions are continually under cultivated and only marginally sourced and utilized. This trend is not unconnected with farmer/vendors' preferences for the large-sized fruits types and except conscious efforts toward conservation of these small-sized, fruit trees and some aspects of the large-sized fruit, these veritable genetic resource may soon become a relic of the taxon rich diversity.

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