AAB BIOFLUX

**Advances in Agriculture & Botanics-
International Journal of the Bioflux Society**

Exo-morphology of vegetative parts support the combination of *Solenostemon rotundifolius* (Poir) J. K. Morton with *Plectranthus esculentus* N. E. Br. Natal (Lamiaceae) with insight into infra-specific variability

Otuwose E. Agyeno[1], Adeniyi A. Jayeola[2], Bashir A. Ajala[1], Blessing J. Mamman[1]

[1] Department of Plant Science and Technology, University of Jos, Nigeria; [2] Department of Botany, University of Ibadan, Nigeria. Corresponding author: O. E. Agyeno, lushexteriors@yahoo.com

Abstract. Exo-morphological characters of two controversial taxa, *Plectranthus esculentus* N. E. Br. Natal and *Solenostemon rotundifolius* (Poir) J. K. Morton were studied using both preserved herbarium specimens and living collections from *in situ* and *ex situ* sources. The study aimed at gaining a better understanding of specific relationships between the two species in order to improve their identification and classification. Morphological characters derived from leaf, stem, root and tubers were analyzed numerically, using cluster method. The quantitative characters were mostly continuous rather but not discrete while the qualitative characters revealed multistate nature. The preponderance of intermediate characters coupled with similarity in shared characters are indicative of a weak specific boundary in the circumscription of *P. esculentus* land races and *S. rotundifolius.* Cluster analysis revealed a strong overall similarity relationship among the varieties and land races in a range of 56 % (minimum) and 74 % (maximum) with an intermediate of 68 %.The findings in this study are consistent with the current treatment of *S. rotundifloius* in synonymy with *P. esculentus*. We propose infraspecific recognition of three varieties in the *P. esculentus* as follows: variety I (*P. esculentus* var. “Bebot” and *P. esculenstus* var. “Longat”), var. II (*S. rotundifolius* var. *alba* and *S. rotundifolius* var. *nigra*), var. III *(P. esculentus* var. “Riyom”).
Key Words: *Plectranthus*, combination, exo-morphology, variety, delimitation, tuber.

Introduction. Among the lesser known African tuber crops are two members of the Lamiaceae, *Plectranthus esculentus* (= *Coleus dazo*, *C. esculentus*, *C. floribundus* var. *longipes*, *Plectranthrus floribundus*, *Englerastrum floribundus*) and *Solenostemon rotundifolius* (= *Coleus dysentericus*, *C. rotundifolius*, *Plectranthus coppini*, *P. ternatus*) and *Solenostemon rotundifolius* (*Coleus dysentericus*, *C. rotundifolius*, *Plectranthus coppini*, *P. ternatus*). Following the separation of herbaria in the colonial period a dichotomy in the taxonomy of cultivated species arose by which in French sources, these plants are normally all regarded as Coleus spp. while in English sources the terms *Coleus*, *Plectranthus* and *Solenostemon* coexist but Coleus *sensu stricto* is not found in West Africa (Blench & Dendo 2004). The plethora of taxonomic names underpins the systematic challenges of the correct circumscriptions of *Solenostemon* and *Plectranthus*. Plectranthus L'Her., a large genus of about 300 species, has had numerous taxonomic and nomenclatural changes due to the poor delimitation both of the genus and the species (Lukhoba & Paton 2003). But *Solenostemon* has been merged into *Plectranthus* (Pollard & Paton 2001; Harley et al 2004). Raymond et al (2004) divided the family Lamiaceae into several subfamilies, placing *Solenostemon* and *Plectranthus* in the subfamily Neteptoideae, although several other families were unplaced. Ryding (1999) reviewed the variation of the *Plectranthus barbatus* Andrews complex. Ryding's concept of P. barbatus is followed in this paper and we agree that the Asian material of

Plectranthus comosus Sims seems to differ from the African material. Ryding also discussed a form of P. barbatus that is a large, soft shrub, growing up to 4 m tall with broad and ovate leaves and large flowers of up to 26 mm long. *Plectranthus* L'H6r. (Labiatae) as currently circumscribed (*e.g*., Agnew & Agnew 1994) is a large genus of about 300 species, found in tropical Africa, Asia and Australia (Ryding 1999).

Taxonomic work has yet to clarify the relationship between these species and other cultivated Labiatae in Africa (Blench & Dendo 2004). *P. esculentus,* commonly called rizga (Hausa), finger potato and Livingstone potato is seen to be indigenous to Africa. They appear to have two centers of dispersal, one in South Africa (Malawi or Zambia) and in the Central Africa Republic with central Africa area being considered as primary centre. *S. rotundifolius* is believed to have originated from central or East Africa but spread throughout tropical Africa and into South-east Asia, including India, Sri lanka, Malaysia and Indonesia where it is cultivated on a small scale (Busson 1965; Dhiwayo 2002). It is commonly called Hausa potato, coleus potato and Tumuku. In Sri Lanka, the tubers of *Solenostemon* are consumed as a curry, baked or fried, while cooked tubers are granular to touch. Since it grows over a wide range of climatic and edaphic conditions, morphological characters also vary among populations. On account of the variability, three land races of *P. esculentus* are known, namely *P. esculentus* 'B'bot, *P. esculentus* "Riyom", *P. esculentus* "Long at' while *S. rotundufolius* consists of *S. rotudufolius* var *nigra, S. rotundifolius* var *alba.* In Sri Lanka, there are two varieties of *Solenostemon*, 'Dik Inala' and 'Bola Inala' both showing low genetic variability (Prematilake, 2005). *S. rotundufolius* is richer in iron and lower in starch content than most other tropical tubers (Prematilake 2005).

Unlike their cultivated counterparts, *P. esculentus* and *S. rotundifolius* in spite of their potential usefulness in several cultures, they have remained little studied and therefore poorly known taxonomically. It is important to understand if the so-called differences are merely variation and to determine by careful evaluation if the characters are either continuous or discontinuous in nature. The objective of this research therefore, is to study and compare the defining exo-morphological characteristics of the cultivars and land races of *P. esculentus* and *S. rotundifolius* in their range of occurrence in Nigeria with a view to classifying them correctly.

Material and Method

Land races of *P. esculentus* and varieties *of S. rotundifolius* used in the study were collected from the germplasm stocks of The National Root Crop Research Institute of Nigeria, Umudike, Kuru station, Plateau State. A total of five taxa consisting of three land races of *P. esculentus* (*P. esculentus* 'B'bot, *P. esculentus* "Riyom", *P. esculentus* "Long'at) and two varieties of *S. rotundifolius* (*S. rotudufolius* var *nigra, S. rotundifolius* var *alba*) were earmarked and studied. All plant specimens used were deposited in the Herbarium of the Department of Plant Science and Technology, University of Jos.

Morphological studies. Exo-morphological characters of the five taxa were carefully studied in five accessions each. Morphometric analysis featured eleven characters. Plant height, length of branches, internodal distance, length of tubers and tuber girth and leaf area were measured using the meter rule graduated in centimeters. In the cases of number of sprouted stems, number of leaves, number of branches, as well as number of tubers physical counting was done. For tuber weight a metric weighing balance was used. For each character, ten plants were studied from which mean values were derived. A binary character matrix was generated by scoring for either presence (1) or absence (0) for every character. Data arising from the selected characters were subjected to parametric tests as platforms for unbiased inferences on variance.

Results and Discussion. A summary of the qualitative exo-morphological characters is presented in Table 1 and quantitative characters are summarized in Table 2.

Table 1

Qualitative exo-morphological characters of the studied taxa, *Solenostemon rotundifolius* and *Plectranthus esculentus*

Organs/characters		*S. rotudufolius var nigra*	*S. rotundifolius var alba*	*P. esculentus ‘B’bot*	*P. esculentus “Riyom”*	*P. esculentus “Long’at*
Stem	Habit	Annual herb Decumbent	Annual herb Decumbent	Biannual herb Erect	Biannual herb Erect	Biannual herb Erect
	Stem outline	Very rectangular	Very rectangular	Rectangular	Rectangular	Rectangular
	Hairiness	Glabrous	Glabrous	Moderate pubescent	Very pubescent	Very pubescent
	Pigmentation	Lemon green	Lemon green	Green	Dark green	Green
	Branching position	Basal	Basal	Basal	Upper stem	Basal-mid stem
Leaf	Pigmentation	Lemon green + purple	Yellow + purple	Dark green	Green	Green
	Shape	Cordate	Cordate	Elliptical	Oblong	Oval
	Pubescence	Pubescent	Pubescent	Moderately pubescent	Very pubescent	Moderately Pubescent
	Margin	Serrated	Serrated	Dentrate	Crenate	Dentrate
	Apex	Acute	Acute	Mucronate	Obtuse	Obtuse
	Base	Cuneate	Cuneate	Cuneate	Cuneate	Cuneate
	Venation	Unicostate reticulate	Unicostate reticulate	Unicostate reticulate	Unicostate parallel	Unicostate parallel
Tuber	Formation	Disperse	Disperse	Clusters	Clusters	Clusters
	Pigmentation	Dark brown	Pale yellow	Yellow	Light brown	Light brown
	Epidermis	Brown	white	White	White	White
	Shape	Ovoid	Rotund	Finger shape	Finger shape	Oblong
	Flesh	Glabrous	Glabrous	Moderate pubescent	Very pubescent	Moderate pubescent

Table 2

Quantitative exo-morphological characters of *Plecranthus esculentus* land races and *Solenostemon rotundifolius* cultivars

Plant species	*Number of spouted stems*	*Plant height (cm)*	*Number of branches*	*Length of branches (cm)*	*Number of leaves*	*Size of leaves (cm^2)*	*Internodal distance (cm)*	*Number of tubers/ stand*	*Tuber weight (g)*	*Tuber length (cm)*	*Tuber diameter (cm)*
P. esculentus var "Long'at"	4a±0.00	54.18a±12.76	15.67a ±1.47	42.67a ±0.64	16.67ac ±15.53	42.00a ±0.00	3.50a ±0.26	66.00a ±22.54	600.00ab ±100.00	11.40a ±3.14	7.27a ±1.10
P. esculentus var. 'Riyom'	1b±0.00	39.20b±7.27	10.00b ±1.00	28.24b ±2.89	10.67bc ±2.89	56.25b ±0.0	2.80bc ±0.11	21.6b ±7.6	466.67a ±57.7	10.13a ±0.12	7.60a ±0.53
P. esculentus var 'Bebot"	3c±0.00	56.67ad±7.27	3.67c ±0.58	39.58c ±1.48	19.00a ±3.00	24.75c ±0.00	3.00c ±0.05	4.33b ±0.58	366.67a ±57.7	12.50a ±3.50	11.90b ±17.71
S. rotundifolius var *alba*	2d±0.00	19.52c±0.21	10.17b ±2.08	28.87b ±1.35	13.00c ±2.65	35.00d ±000	2.90bc ±0.03	87.67a ±11.24	533.33ab ±11.49	6.83b ±0.62	11.80b ±1.04
S. rotundifolius var *nigra*	2d±0.00	66.48d±5.54	23.67d ±0.29	30.91b ±1.73	8.33bc ±0.58	38.69e ±0.00	3.04c ±0.03	88.33a ±29.93	866.67b ±404.15	8.23ab ±175	7.97a ±2.19
F-ratio	**	**	**	**	**	**	**	**	**	*	*
DMRT	0.489	11.143	2.283	2.583	4.702	0.563	0.231	34.246	391.189	4.506	2.917

Means following by the same alphabet in same column are not significantly different at (p<0.05) using the Dunkan multiple range test (DMRT).

The observable characteristics of the tubers are shown in Figure 1, while the shoot system of the species is shown in Figure 2. The dendrogram of similarity relationships among the *P. esculentus* land races and *S. rotundifolius* varieties based on their exo-morphological characters are shown in Figure 3.

In all figures, the following legends are used: A = *P. esculentus* var. “Bebot”, B = *P. esculentus* var. “Riyom”, C = *P. esculenstus* var. “Longat” D. = *S. rotundifolius* var. *alba* and E = *S. rotundifolius* var. *nigra*.

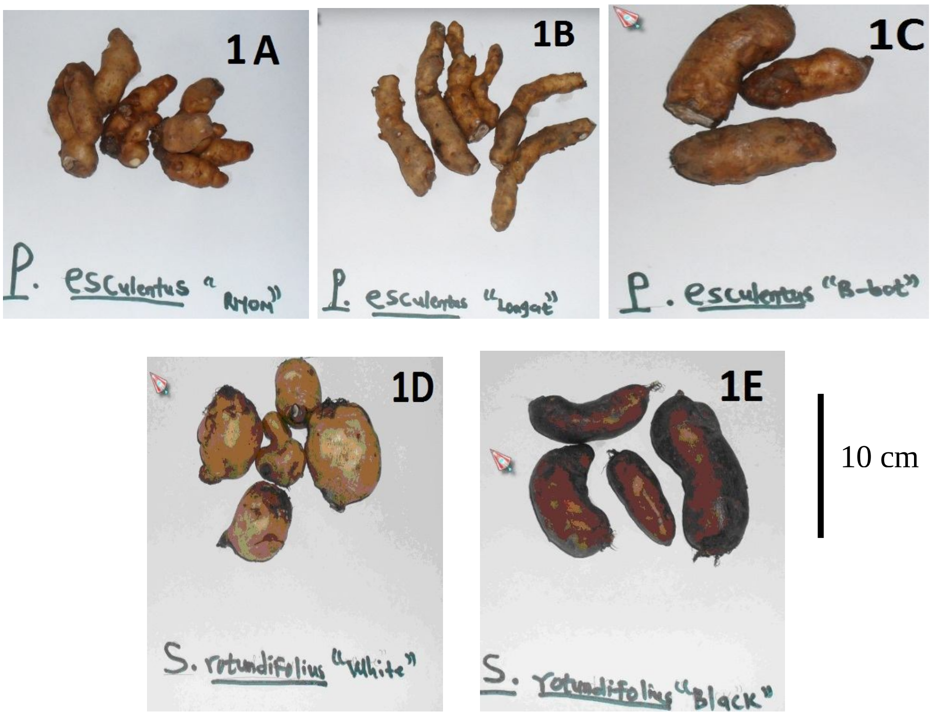

Figure 1. Variation in tuber morphology of land races of *Plectranthus esculentus* and varieties *of Solenostemon rotundifolius.* Bar indicates 10 cm.

Colors of the tubers vary from light brown (Figure 1 B and D) to deep brown (Figure 1 A, C and E). Tuber shapes vary from short, irregular ones (Figure 1A), bottle-shaped (Figure 1D), more or less linear (Figure 1B) and relatively bulky, curved to straight ones (Figure 1 C and E). Tuber length varies between 6.88 cm in *S. rotundifolius* and var *alba* and 12.50 cm in *P. esculentus* var. ‘Riyom’. Average weight of tuber ranges between 366.67 g in *P. esculentus* var. ‘Bebot” and 866.67 g in *S. rotundifolius* var. *nigra.*

Data on quantitative characters shows that plant height or length ranges between 19.52 cm in *S. rotundifolius* var. *alba* (Figure 2D) and 66.48 cm in *S. rotundifolius* var *nigra* (Figure 2E) while the values for land races of *Plectranthus* range from 39.20 cm (*P. esculentus* var. ‘Riyom’) to 56.67 cm (*P. esculentus* var “Bebot”) and 54.1 cm (*P. esculenstus* var “Long’ at”) embedded within that range.

Habit also varies from decumbent in *S. rotundifolius* var *alba* and *S. rotundifolius* var *alba* to errect in *P. esculentus* var “bebot”, *P. esculentus* var “Riyom” and *P. esculenstus* var “longat”.

Leaf margin are serrate in both S*. rotundifolius* var. *alba* and *S. rotundifolius* var *nigra* but debate in *P. esculentus* var “Riyom” and *P. esculentus* var “bebot” and crenate in *P. esculenstus* var “longat”.

Hairs are present in all *P. esculentus* var “Riyom”, *P. esculenstus* var “long’ at” and *P. esculentus* var “bebot” in varying degrees whereas *S. rotundifolius* var. *alba* and *S. rotundifolius* var. *nigra* are glabrous.

Figure 2. A = *P. esculentus* var "Bebot", B = *P. esculentus* var "Riyom", C = *P. esculenstus* var. "Longat" D. = *S. rotundifolius* var *alba* and E = *S. rotundifolius* var *nigra*.

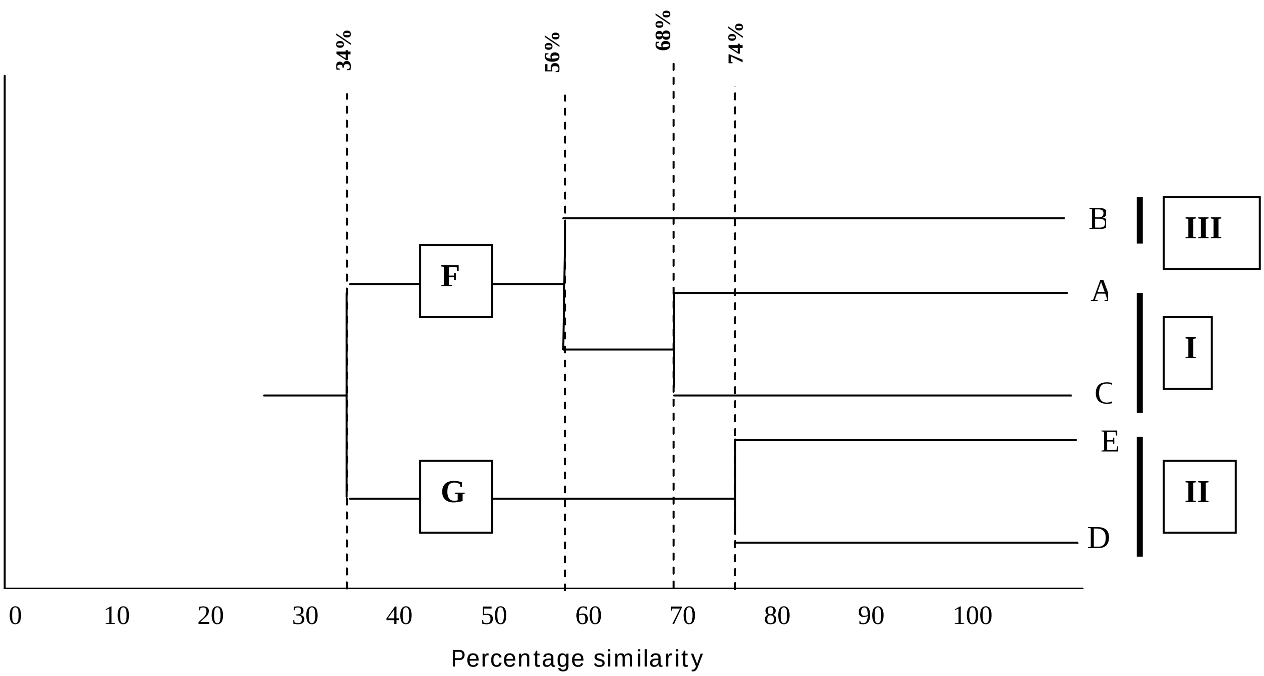

Figure 3. Dendogram showing similarity relationships among *Plectranthus esculentus* and *Solenostemon rotundifolius* land races and cultivars.

The dendrogram of similarity relationships (Figure 3) splits the taxa into clade F consisting of *P. esculentus* var. “Bebot”, *P. esculentus* var “Riyom” and *P. esculentus* var. “Bebot” and clade G comprising *S. rotundifolius* var. *alba* and E *S. rotundifolius* var. *nigra* at a similarity level of about 34 % as indicated by the phenon line. Phenon level describes a particular level in a dendrogram at which the clusters are pairwise disjoint and the clusters do not meet and every element of the dendrogram belongs to some cluster. Four phenon levels are shown in this study, indicated by the main level at 34 % similarity and the sub-clades I, II and III are embedded at 56 %, 68 % and 74 % levels, respectively. *S. rotundifolius* and *P. esculentus* cannot be separated until after 34 % similarity level while the land races and varieties separated between 56 % and 74 % phenon levels. The phenon level 68 % (subclade I) is intermediate to phenon level 56 % (subclade III) and phenon level 74 % (subclade II).

The results of exo-morphological study have shed light on both inter-specific and infra-specific relationships in *S. rotundifolius* and *P. esculentus* through a careful evaluation of there external characteristics. There is extensive overlap in the quantitative characters while the qualitative characters also exhibit different states of the same characters. Characters involving habit, leaf pigmentation, leaf margin and tuber formation, color clearly showed multiple states within the same species. Except for number of tubers per stand and tuber length which are clear-cut, quantitative characters showed overlapping range of values for both between *S.n rotundifolius* and *P. esculentus*.

The range of morphological variation is vividly demonstrated in this study in the leaves, stem and tuber characteristics. It could be that, seasonal conditions change and these change the environment of the leaf-producing tissue, causing developmental changes which result in marked variation particularly in quantitative leaf characters referred to as heteroblasty. The resulting plastic response of the species could well have led to variation in character differentiation as seen for example in leaf mergins of both *S. rotundifolius* and *P. esculentus*. The selective action of some environmental factors could foster the formation of genetic races or variety or ecotypes which then maintains a narrow phenotypic range. Variation may be obvious in a plant species but taxonomically it may be difficult to interpret evolutionarily if it forms a cline, which is continuous from one extreme to the other as amply shown in the number of leaves, height of plant, area of leaf and weight of tubers. Within species, varieties of *S. rotundifolius* differ only in the color of epidermis and shape of tubers such that *S. rotundifolius* var. *nigra* have been commonly referred to as black variety while *S. rotundifolius* var. *alba* have been called the white variety (Kyesmu 1994; Olojede et al 2005). Variation in defensive chemistry can occur at many scales: within a leaf on a single plant (Gibberd et al 1988), among tissues on the same plant (Nitao & Zangerl 1987; Van Dam et al 1996; Pavia et al 2002), and among populations (Mithen et al 1995). There may be a strong environmental, rather than genetic component to this variation, especially in leaf morphology which would explain some of the regional variation encountered through the existence of locally adapted populations. Morphological characters of plants have been used extensively both for producing classification and for diagnostic purposes and they are still indispensable to the taxonomists today.

The vegetative characters are as important in the identification of majority of flowering plants as do the floral characters. Observed and recorded character states of vegetative organs have been utilized by Sneath & Sokal (1962) and Jayeola (2001) in the numerical evaluation of similarities among taxa. Cluster analysis illustrated by the dendrogram suggests that at the infra-specific level, land races, *P. esculentus* var. “Bebot”, and *P. esculenstus* var. “Longat” are similar but both differ from *P. esculentus* var. “Riyom”. In comparison with *P. esculentus* var. “Bebot” and *P. esculenstus* var. “Longat”, *P. esculentus* var. “Riyom” can be distinguished by dark green stem color, stem branching midway its length, leaf densely pubescent, leaf margin crenate. *P. esculentus* var. “Bebot”, and *P. esculenstus* var. “Longat” are so close that they are not separable on the basis of branching pattern, color of leaf, degree of pubescence, leaf margin and leaf base, thus explaining a resemblance between them recorded at 68 % on the phenon scale. There is an indication that *P. esculentus* var “Riyom” is noticeably distinct from the other two land races, *P. esculentus* var “Bebot” and *P. esculenstus* var. “Longat”.

Infraspecific relationship in *S. rotundifolius* is clearer. Both *S. rotundifolius* var. *alba* and *S. rotundifolius* var. *nigra* show greater resemblance between them, at a level higher than those levels seen in *P. esculentus* land races. Indeed, only one qualitative and discontinuous character, white tuber color, separates *S. rotundifolius* var. *alba* and *S. rotundifolius* var. *nigra* which has a dark-brown tuber skin. According to some previous works on these species, the two varieties of *S. rotundifolius* differ only in the color of epidermis and shape of tubers such that var. *nigra* has been commonly referred to as black variety while var. *alba* has been called the white variety (Kyesmu 1994; Olojede et al 2005). This is to say that there resemblances in these characters across the two species (Ozeigbem et al 2011). Storage of energy-rich materials in vegetative organs is a characteristic of plants evolved to survive unfavorable periods, usually in subterranean organs which are presumably better protected from herbivores and from physical damage by being surrounded by soil (Smith & Klingeer 1985).

The dendrogram of relationships has provided a graphical summary of the levels and degree of closeness between the genera. The preponderance of intermediate characters coupled with similarity in shared characters is indicative of the weak specific boundary in the circumscription of *Solenostemon* and *Plectranthus* and a pointer to conspecificity. This similarity is amply shown by the dendrogram of relationships among the taxa studied. Morton (1962) separated *Solenostemon* from *Plectranthus* primarily on the morphology of the lateral and anterior calyx lobes, based on examination of West African species. Keng (1978) and Hedge et al (1998) did not recognize *Solenostemon*, placing it in synonymy under Plectranthus. Recent work on the generic limits of Tribe Ocimeae (Lamiaceae) suggests that species formerly recognized as *Solenostemon* Thonn. should be placed in *Plectranthu*s L'Her. (Pollard & Paton 2001; Harley et al 2004). The findings in this study are consistent with the current treatment of *S. rotundifloius* in synonymy with *P. esculentus* (*S. rotundifolius* (Poir.) J. K.Morton). Several West African species require combinations in *Plectranthus* (Pollard et al 2006).

There is sufficient basis however to recognize the land races of *P. esculentus* as formal varieties, corresponding to subclades I (*P. esculentus* var "Bebot" and *P. esculenstus* var. "Longat"), II (*S. rotundifolius* var. *alba* and *S. rotundifolius* var. *nigra*) and III (*P. esculentus* var. "Riyom"). In the classification of another tuber-producing angiosperm (Dioscoreaceae), Burkill (1985) proposed a tentative system of varietal classification based on leaflet size and lamina thickness, pubescence density and distribution, and fruit length, and Milne-Redhead (1975) formalized part of Burkill's infraspecific classification, dividing the East African populations of *D. quartinana* into four varieties.An indented dichotomous key based on these exo-morphological characters:

1a. Biannual herb, stem rectangular, suffrutescent, erect, pubescent; leaves pubescent, pigmented, cordate, elliptic, oval, cuneate; tuber formed in clusters and pubescent ………………………………. ……….2
    2a Stem, leaf, tuber, branching basal, tuber oblong. Yellow or green, leaf elliptical oval, dentrate, mucronate apex …………………….. *P. esculenthus* variety I.
    2b Stem, leaf, tuber, branching upper stem, leaf apex obtuse, tubers finger-like Stem dark green, leaves oblong, crenate ……… *P. esculenthus* variety III.
1b. Annual herb, stem succulent, decumbent, glabrous, leaves cordate, pubescent, acute, serrated, tuber dispersed, glabrous, with white flesh. Leaves lemon green or purple, yellow+purple tubers oval, tubers rotund tuber epidermis brown, white epidermis ………………………………………………………….. *P. esculenthus* variety II.

Conclusions. The preponderance of intermediate characters coupled with similarity in shared characters is indicative of the weak specific boundary in the circumscription of *Solenostemon* and *Plectranthus* and a pointer to possible conspecificity. Data collected in this study indicates a diversity of traits in exo-morphology of the land races of *P. esculenthus*. These traits are consistently different to warrant the recognition of three land races as formal varieties. A detailed study of the genomics of the Lamiales will resolve the lingering conflict of opinion on the status of *Solenostemon* and *Plectranthus*.

References

Agnew A. D. Q., Agnew S., 1994 Upland Kenya wild flowers. 2nd ed, East African Natural History Society, Nairobi, pp. 283-297.

Blench R., Dendo M., 2004 Lesser-known African tuber crops and their roles in preshistory. http://homepage.ntlworld.com/roger_blench/RBOP.htm

Burkill H. M., 1985 The useful plants of West Tropical Africa. Vol 5, Botanic Gardens, Kew.

Busson F., 1965 Labiates *Solenosetmon rotundifolius* (Poir) J. K. Morton plantes Alimentaries de I' Quest African: Etude Biologique et Chimique, pp. 402-406, Marseilles, France: L' Imprimerie Leconte 568 pp.

Dhiwayo P. D., 2002 Under exploited tuber crop in Zimbabew: a study on the living stone potato (*Plectranthas esculentus*) Plant Generic Resource newsletter F.A.O-PGAI 130:77–88.

Gibberd R., Edwards P. J., Wratten S. D., 1988 Wound-induced changes in the acceptability of tree foliage to lepidoptera within-leaf effects. Oikos 51:43-47.

Harley R. M., Atkins S., Budantsev A., Cantino P. D., Conn B. J., Grayer R., Harley M. M., De Kok R., Krestovskaja T., Morales R., Paton A. J., Ryding O., Upson T., 2004 Labiatae. In: The families and genera of vascular plants, vii: Lamiales (except Acanthaceae, including Avicenniaceae), Kadereit J. W. (ed), Springer-Verlag, Berlin.

Hedge I. C., Clement R. A., Paton A. J., Phillipson P. B., 1998 Labiatae. In: Flore de Madagascar et des Comores. Museum National d'Histoire Naturelle, Paris.

Jayeola A. A., 2001 Effects of numerical methods, quantity and composition of numerical characters on the classification of the angraecoid orchids of Nigeria and Cameroun. Nigerian Journal of Ecology 3:39-40.

Keng H., 1978 Labiatae. In: Flora Malesiana. Van Steenis C. (ed), 8(3):301-394, Sijthoff & Noordhoff, Aalphen aan den Rijn, The Netherlands.

Kyesmu P. M., 1994 Plectranthus esculentus N.E.Br.- a minor tuber crop in dire need of rescue from extinction. Lamiales Newsletter 3:3-5.

Lukhoba C. W., Paton A. J., 2003 A new species and new variety in *Plectranthus* L'Her. (Labiatae) from Eastern Africa. Kew Bull 58:909–917.

Milne-Redhead E., 1975 Dioscoreaceae. In: Flora of tropical east Africa. Polhill R. M. (ed), pp. 1-25, Crown Agents, London.

Mithen R., Raybould A. F., Giamoustaris A., 1995 Divergent selection for secondary metabolites between wild populations of *Brassica oleracea* and its implications for plant-herbivore interactions. Heredity 775:472-484.

Morton J. K., 1962 Cytogenetic studies on the West African Labiatae. Bot J Linn Soc 58:231–283.

Nitao J. K., Zangerl A. R., 1987 Floral development and chemical defense allocation in wild parsnip (*Pastinaca sativa*). Ecology 68:521–529.

Olojede A. O., Illuebbey P., Dixon A. G. O., 2005 IITA/NRCRI collaborative Germplasm and data collection on root crops in Nigeria. In: NRCRI Annual, pp. 82-85.

Ozeigbem M., Faluyi J. O., Azeez S. O., 2011 Comparative vegetative and fruit characteristics of seven *Ludwigia* (Linn) species in Nigeria. Nigerian Journal of Botany 24(2):19-230.

Pavia H., Toth G. B., Aberg P., 2002 Optimal defense theory: elasticity analysis as a tool to predict intraplant variation in defenses. Ecology 83:891-897.

Prematilake D. P., 2005 Inducing genetic variation of innala (*Solenostemon rotundifolius*) via. *in vitro* callus culture. J Natl Sci Found 33(2):123-131.

Pollard B. J., Paton A. J., 2001 A new rheophytic species of Plectranthus L'He'r. (Labiatae) from the Gulf of Guinea. Kew Bull 56:975-982.

Pollard B. J., Parmentier I., Paton A., 2006 *Plectranthus inselbergi* (Lamiaceae) a new species from Equatorial Guinea (RioM uni) and Gabon, with notes on other Central and West African species of Plectranthus. Kew Bull 61:225-230.

Raymond M. H., Sandy A., Andrey L. B., Philip D. C., Barry J. C., Renee J. G., Madeline M. H., Rogier P. J., Tatyana V. K., Ramon M., Alan J. P., Olof R., 2004 Labiatea.

In: The families and genera of vascular plants. Klaus K. (ed), vol. VII. Springer-Verlag, Berlin, Germany.
Ryding O., 1999 Notes on Plectranthus (Lamiaceae) in Somalia. Kew Bull 54(1):117-127.
Smith J. M. B., Klinger L. F., 1985 Aboveground:belowground phytomass ratios in venezuelan paramo vegetation and its significance. Arctic and Alpine Research 17(2):189-198.
Sneath P. H. A., Sokal R. R., 1962 Numerical taxonomy. Nature 193(4818):855–860.
Van Dam N. M., De Jong T. J., Iwasa Y., Kubo T., 1996 Optimal distribution of defenses: are plants smart investors? Funct Ecol 10:128-136.

Received: 10 July 2013. Accepted: 30 July 2013. Published online: 13 March 2014.
Authors:
Otuwose Emmanuel Agyeno, University of Jos, Department of Plant Science and Technology, Nigeria, Plateau State, P.M.B 2084 Jos, e-mail: lushexteriors@yahoo.com
Adeniyi Akanni Jayeola, University of Ibadan, Department of Botany, Nigeria, Ibadan, e-mail: Adeniyi.jayeola@gmail.com
Bashir Akani Ajala, University of Jos, Department of Plant Science and Technology, Nigeria, Plateau State, P.M.B 2084 Jos, e-mail: baajala@gmail
Blessing James Mamman, University of Jos, Department of Plant Science and Technology, Nigeria, Plateau State, P.M.B 2084 Jos, e-mail: bjmamman@yanoo.com

How to cite this article:
Agyeno O. E., Jayeola A. A., Ajala B. A., Mamman B. J., 2014 Exo-morphology of vegetative parts support the combination of *Solenostemon rotundifolius* (Poir) J. K. Morton with *Plectranthus esculentus* N. E. Br. Natal (Lamiaceae) with insight into infra-specific variability. AAB Bioflux 6(1):16-25.