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NUMERICAL TAXONOMIC STUDY OF SOME *IPOMOEA* SPECIES (CONVOLVULACEAE) IN ANAMBRA, SOUTHEASTERN NIGERIA.

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ABSTRACT: Numerical study was conducted on eight species of genus *Ipomoea* in Anambra State, Southeastern Nigeria based on morphological characters. This was done in order to better understand their interrelationship and aid its identification. The species are *Ipomoea aquatica, I. asarifolia, I. quamoclit, I. involucrata, I. triloba, I. acanthocarpa, I. hederifolia* and *I. nil.* The samples were all gotten from the wild and authenticated in the herbarium where voucher specimens were deposited. Discrete characters were noted in the field while qualitative and quantitative characters were observed and measured in the laboratory. A total of48 attributes comprising 31 qualitative and 17 quantitative characters were studied and coded for analysis. UPGMA (Unweighted Pair Group Method with Arithmetic Mean) and Jaccard similarity coefficient were carried out on the detains order to elucidate the relationship among the tax of the genus, while dendrogram and their taxonomic keys were constructed. UPGMA tree derived from cluster analysis reveals three major clusters, cluster 1to cluster 3 containing 3, 3 and 2 species respectively. Species within the same cluster had greater similarity than those in the other clusters. The results of this study therefore, confirmed and established previous works on this genus and provided an excellent statement on the relationship among these species. Thus showing the significance of numerical analysis for taxonomic relationship in the genus *Ipomoea.*

KEYWORDS: Numerical taxonomy, *Ipomoea*, cluster analysis, Morphology, Similarity.

INTRODUCTION

*Ipomoea*L., is the largest genus of the family Convolvulaceae (Mabberley, 2017) with about 650 species or up to 1000 species in recent phylogenetic conceptions of the group (Wilkin, 1999; Manos *et al*., 2001; Miller *et al*., 2002). It is distributed in the tropical and subtropical regions of the world. The plant species of the genus *Ipomoea* distributed across the world's tropical and subtropical regions are some of the most beautiful ornamentals of the plant world. Most *Ipomoea* species in Nigeria grow in the wild and are always attractive because of their showy flowers while *Ipomoea* batatas is grown for food. It is known that 38 species have been reportedly found in West Africa of which 30 have been recognized to be present in Nigeria. These species are commonly found in the Southern region, a few are found in the Northern location in the Savanna zones (Hutchinson and Dalziel, 1963). *Ipomoea* are good flagship species and possible good environmental indicators (Gill, 1988).

The genus *Ipomoea* is characterized by herbaceous nature and climbing habit in majority of the species. Apart from *I. batatas* and *I. quamoclit* that are eaten others are cultivated for their showy flowers (Sharma and Data, 1958).The corolla are very varied in colour and form but usually conspicuous and often open for a short time (morning or night only), commonly pink, less commonly blue, red, cream or white, commonly funnel-shaped and gradually widened with a broad spreading unlobed (sometimes weakly lobed) limb, less commonly campanulate, orcrateriform with a cylindrical tube. The trumpet- or funnel-shaped flowers are commonly borne in the axils of the leaves and are variable in size and colour. The fruit is a capsule and usually contains 4–6 seeds. Morphological characters are features of external forms or appearance. They currently provide the characters used for hypothesizing phylogenetic relationships. These features have been used for a longer time than the anatomical evidence in the beginnings of plant systematic. Morphological characters are easily observed and find practical use in keys and description. They include the external features of the plant parts used, including the particulars of their size, shape and colour. (Uka *et al*, 2014). Numerical taxonomy is a classification system which deals with the grouping of taxonomic units by numerical technique based on their character states (Sneath and Sokal, 1973). Cluster analysis is a technique commonly used in numerical taxonomy to produce a hierarchical classification of entities based on the similarity matrix. It represents a logical means of expressing the relationships existing

between taxonomic units. Numerical taxonomy received considerable attention for species relationships in different genera (Bello *et al*., 2013; Bolourian andPakravan, 2011)

Quite a number of work has been done on *Ipomoea*, both in Nigeria and the world as a whole. Austin (1975, 1979, and 1997) and Austin and Huáman (1996) divided *Ipomoea* into 3 subgenera, i.e. subgenus *Eriospermum* (Hallier f.) Verdcourt ex Austin, *Ipomoea*, and *Quamoclit* (Moench) Clarke. Morphologically genus *Ipomoea*is highly diverse it shows large degree of variation at intra and inter specific level. Mondal *et al.,* (2006) reported morphological variations in ten *Ipomoea*species from Bangladesh. Folorunso (2013) studied taxonomic importance of foliar micro morphological characters of 15 *Ipomoea*species from South- Western Nigeria. AbdelKhalik and Osman, (2007) used the seed micro morphological characters for the infrageneric classification of *Ipomoea*. But not much has been done in Southeastern Nigeria.

Ipomoea species are highly variable in nature, most especially in Nigeria where they have received little attention when compared with the species from other countries and this has led to the description of intraspecific species.

The high variability in *Ipomoea* species has created identification problems, a better system of classification and delimitation of the species using morphological characters is needed. The current study is therefore aimed at using the advantage of numerical analysis to better describe the species of this species which will help in better identification and to also show their relatedness.

MATERIALS AND METHODS

Collection of Samples

Eight species of the genus *Ipomoea* were collected from the wild, from Awka, Onitsha, Isuofia and Igbo-ukwu towns in Anambra State (Table 1 and Fig 1). They were taxonomically identified and authenticated by comparing the collection with the available specimens deposited in the herbarium of Botany Department of Nnamdi Azikiwe University, Awka and voucher specimens were deposited at the same herbarium.

Morphological Study

Discrete characters like the colour of floral parts were recorded in the field. Qualitative characters such as presence of hairs on the stem, leaves and petioles were observed in the

laboratory with the aid of hand lens. Characters like leaf shape, apex, base, margin, fruit texture and size and those of the seed and number of seed(s) per fruit were also recorded. Continuous characters were taken from both vegetative and reproductive parts. The length and breadth of the leaves stem and fruit diameter, length of petiole and floral parts were measured using a metric ruler and photographs taken. These characters and character states were coded for numerical analysis as shown in Table 2. In total 61 characters were taken into consideration, comprising 13 quantitative and 48 qualitative characters

Data Analysis

Each species was treated as Operational Taxonomic Units (OTU's). Jaccard Similarity coefficient was carried out on the data using Palentological Statistics, Ver. 2.17c (PAST). Sokal and Sneath (1963) was used to show the level of similarity in the species studied.

Table 1: Collection sites, coordinates and voucher numbers of *Ipomoea* studied

Species	Collection site	Coordinates	Voucher No.
I. aquatica	In front of Unizik Beautiful Gate	6° 14' 25.4076" N 7° 7' 24.6576" E	180[A]
I. asarifolia	Besides Anambra State Govt house, Awka	6° 13' 46.6356" N 7° 5' 30.12" E	181[A]
I. quamoclit	Besides the Palace Of the Igwe of Igboukwu, Igboukwu	6° 1' 25.9104" N 7° 0' 46.1448" E	178[A]
I. involucrata	Km 4 Ontsha-Owerri Expressway, Onitsha	6° 47' 44.3076" E7° 0' 45.054" E	167[B]
I. triloba	Besides Ekwusigo Park, Isuofia	6° 1' 39.54" N 7° 3' 48.6936" E	163[B]
I. acanthocarpa	At Science Village Unizik, Awka	6° 15' 3.8412" N 7° 6' 52.5348" E	182[A]
I. hederifolia	Besides the Palace Of the Igwe of Igboukwu, Igboukwu	6° 1' 31.0764" N 7° 0' 45.054" E	179[A]
I. nil	Inside Real Estate, Awka.	6° 13' 50.9412" N, 7° 5' 27.2472" E	169[A]

RESULTS.

The summary of the habit and morphological characteristics of *Ipomoea species* were presented in Table 2. All the eight *Ipomoea* species are herbaceous. Four of them are annual while *I. asarifolia* is perennial. They showed much variability in their leaf shape and margin and all of them are glabrous, except *I. nil* and *I. involucrata*that are both hairy while *I. triloba* are either pubescent or glabrous. *I. aquatica* and *I. asarifolia* have hollow stem while the rest do not. Their flower colour are variable, ranging from pink-purple to red. They have two flower shapes which are funnel form and salver form, with *I. quamoclit* and *I. hederifolia* having the later. All of them have milky sap.

Table 3. showed the quantitative and qualitative characters of the plants. Their different character states and coding were also shown.

The result obtained by using Jaccard similarity coefficient was shown in Figure 1. The dendogram was gotten from the quantitative and qualitative morphological characters of the *Ipomoea* species. The tree showed three clusters*, I. quamoclit* was more similar to *I. hederifolia* than others with 0.72 similarity, closely related by *I. acanthocarpa* at 0. 56 while *I. involucrata* and *I. triloba* weremore related with about 0.71 similarity,with *I. nil*being a sister to the pair at 0.64 similarity. And *I. aquatica* and *I. asarifolia* at 0.57 similarity were more related to each other than to any other group.

Table 2: Summary of the Morphological Characteristics of the I*pomoea S*pecies.

Characteristics	***I. aquatica***	***I. asarifolia***	***I. quamoclit***	***I. involucrata***	***I. triloba***	***I. acanthocarpa***	***I. hederifolia***	***I. nil***
Habit	Herbaceous	Herbaceous	Herbaceous	Herbaceous	Herbaceous	Herbaceous	Herbaceous	Herbaceous
Life cycle	Annual or Perennial	Perennial	Annual	Annual or perennial	Annual	Annual or perennial	Annual	Annual
Leaf shape and margin	Ovate-lanceolate, Entire	Suborbicular or reniform, entire	Ovate-elliptic, ovate or oblong, Pinnate	Ovate-cordate, entire	Ovate to orbicular, entire or lobed	Ovate-deltoid Entire	Ovate or suborbicular, Entire or lobed	Ovate, entire or lobed
Leaf surface	Glabrous	Glabrous	Glabrous	Pubescent	Glabrous or slightly pubescent	Glabrous	Glabrous	Hairy
Stem colour, Hollow and surface	Green or brown. Hollow and glabrous	Green, hollow and glabrous	Green/Brown, not hollow and glabrous	Green/brown, Not hollow and Pubescent pubescent	Green, Not hollow and glabrous or slightly pubescent	Green/Brown, not hollow and glabrous	Green/Brown, not hollow and Glabrous	Green/Brown, not hollow and Glabrous
Flower colour and shape	Pink-purple, funnelform	Pink-Purple, funnelform	Red and salverform	Pink-purple, funnelform	Pink to pale purple, funnelform	White, funnelform	Red and salverform	Blue and salverform
Seed surface, colour	Pubescent, brown	Glabrous, dark brown	Glabrous, black	Glabrous, Dark brown	Glabrous, Dark brown	Brown	Rough, dark brown or black	Pubescent, dark
Milky sap	Present	Present	Present	Present	Present	Present	Present	Present

Table 3: A List of Qualitative and Quantitative Characters and Character States Used for the Numerical Analysis

S/N	Character	Character State		Code
1	life cycle	Annual	0	3
		Annual or Perennial	1	
		Perennial	2	
2	Stem surface	Glabrous	0	3
		Hairy	1	
		Glabrous or Pubescent	2	
3	Stem Outline	Oval	0	4
		Circular	1	
		Oval with hills	2	
		Circular with hills	3	
4	Trichomes (Stem)	Present	0	2
		Absent	1	
5	Stem type	Slender	0	2
		Thick	1	
6	Stem colour	Green	0	2
		Green/Brown	1	
7	Stem hollow	Present	0	2
		Absent	1	
8	Plant nature	Twiner	0	3
		Twiner or Prostrate	1	
		Trailer	2	
9	Leaf nature	Simple	0	2
		Compound	1	
10	Leaf margin	Entire	0	3
		Entire or lobed	1	
		Pinnate	2	
11	Leaf apex	Acute, Obtuse, and Mucrunote	0	4
		Rounded	1	
		Acute	2	
		Acute or acuminate	3	
12	Leaf base	Cordate	0	2
		Cordate, Sagittate or Hastate	1	

13	Leaf Shape	Ovate-lanceolate	0	7
		Suborbicular or reniform	1	
		Ovate-elliptic, ovate or oblong	2	
		Ovate-cordate	3	
		Ovate to Orbicular ovate to circular	4	
		Ovate-deltoid	5	
		Ovate or suborbicular	6	
14	Leaf adaxial surface	Glabrous	0	3
		Hairy	0	
		Glabrous or hairy	1	
15	Leaf abaxial surface	Glabrous	0	3
		Hairy	1	
		Glabrous or hairy	2	
16	Petiole Surface	Glabrous	0	3
		Hairy	1	
		Glabrous or hairy	2	
17	Pedicillate	Present	0	
		Absent	1	
18	Flower Size	Big	0	2
		Small	1	
19	Corolla colour	Pink to purple or	0	4
		Pink to Purple	1	
		Red	2	
		White	3	
20	Inflorescence orientation	Axillary	0	2
		Terminal or Axillary	1	
21	Colour of corolla throat	Purple	0	4
		Pink to purple	1	
		White	2	
		Orange	3	
22	Shape of flower	Funnelform	0	2
		Salverform	1	
23	Inflorescence in boat shaped involucre	Present	0	2
		Absent	1	
24	Sepal shape	Ovate to Oblong	0	4
		Elliptic-oblong	1	
		Lanceolate	2	
		Ovate	3	
25	Sepal apex	Acute to obtuse	0	6

		Obtuse	1	
		Acute	2	
		Acute to obtuse	3	
		Acute to mucronate	4	
		Obtuse-Truncate	5	
26	Sepal surface	Glabrous	0	2
		Pubescent	1	
27	Seed shape	Ovoid	0	3
		Elongate to pear shape	1	
		Pyriform	2	
28	Seed colour	Brown	0	3
		Dark brown	1	
		Black	2	
29	Seed surface	Glabrous	0	2
		Hairy		
30	Shape of fruit	Ovoid	0	3
		Globose	1	
		Subglobose	2	
31	Stamen External	Exserted	0	2
		Included	1	
32	Stem Diameter	0.0-0.4	0	
		0.41-0.7	1	
33	Internode length (cm)	5-10	0	2
		10.1-15	1	
34	Leaf Length (cm)	5-10	0	2
		10.1-15	1	
35	Leaf width (cm)	5-10	0	2
		10.1-15	1	
36	Petiole (cm)	1-5	0	3
		5.1-10	1	
		10.1-15	2	
37	Pedicel (cm)	None	0	3
		0-1	1	
		1.1-5	2	
38	Peduncle (cm)	1-5	0	2
		5.1-10	1	
39	Corolla Length (cm)	1-5	0	2
		5.1-10	1	
40	Corolla width (cm)	1-5	1	2
		5.1-10	2	

41	Calyx length (cm)	0-1 1.1-5	0 1	2
42	Length of style (cm)	0.0-1 1.1-5	0 1	2
43	Seed length (cm)	0.0-0.5 0.51-1	0 1	2
44	Seed width (cm)	0.0-0.5 0.51-1	0 1	2
45	Fruit length (cm)	0.0-0.5 0.51-1	0 1	2
46	Fruit width (cm)	0.5-0.6. 0.61-0.8	0 1	2
47	Number of locules	2 3 4	0 1 2	3
48	Filament length (cm)	0.0-1 1.1-5	0 1	2

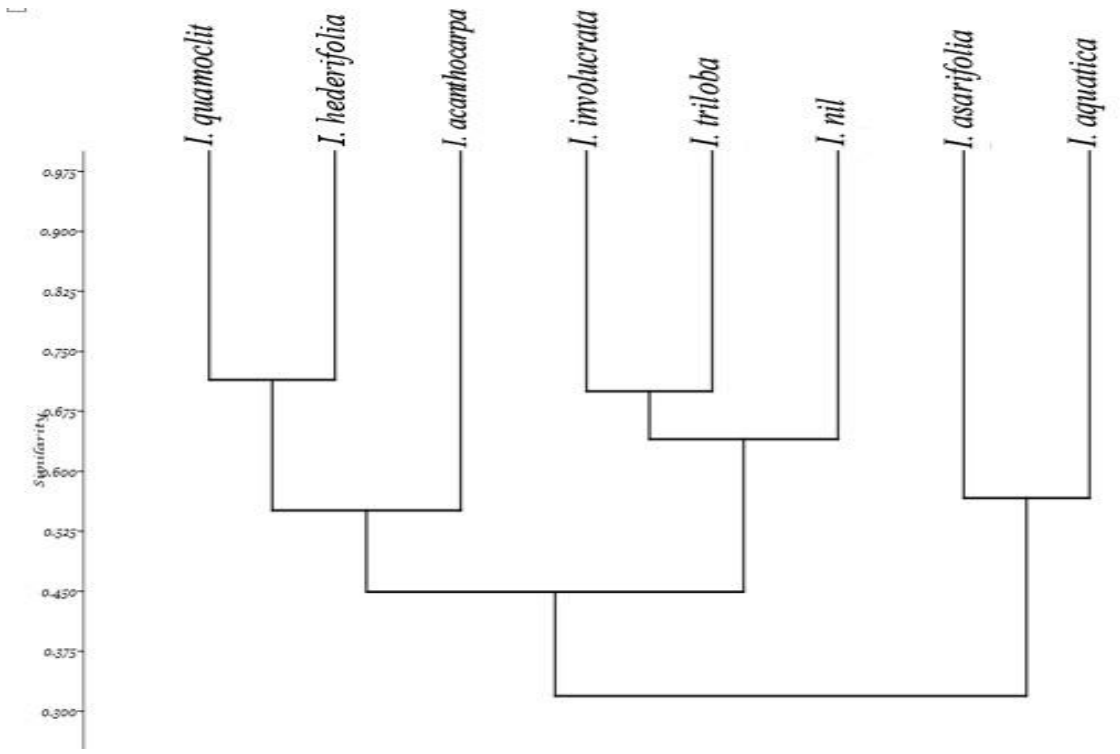

Fig. 1.UPGMA dendogram of Cluster Analysis of the eight investigated taxa of *Ipomoea*

TAXONOMIC KEYS OF THE*IPOMOEA* SPECIES

1. Stem hollow, flower big, petal pink-purple, leaf margin entire, leaf simple……2
   Stem not hollow, flower small, slender, green or brown, leaf margin entire, lobed or pinnate, leaves glabrous, hairy or glabrous…….3
2. Leaf shape reniform or suborbicular, life cycle perennial, fruit shape globose…***I. asarifolia***
   Leaf shape ovate-lanceolate, life cycle annual or perennial, fruit shape ovoid….***I. aquatica.***
3. Flowers in involucrate heads……..***I. involucrata***
   Flowers not in involucrate heads…….4
4. Life cycle annual, stem surface glabrous, plant nature twiner, flower salverform, corolla red, style exserted……5
   Life cycle annual or perennial, plant nature twiner or prostrate, flower funnelform, corolla pink-purple, blue or white, style included…….6
5. Inflorescence orientation terminal or axillary, corolla throat white, leaf compound pinnate ……***I. quamoclit***
   Inflorescence orientation terminal, corolla throat orange……***I. hederifolia***
6. Leaf apex acute or acuminate, stem and leaf surfaces hairy or glabrous, corolla pink-purple, seed glabrous…….***I. triloba***
   Leaf apex acute or acuminate, stem glabrous or hairy, seed hairy or wooly, corolla white or blue….7
7. Stem and leaves glabrous, corolla white with purple throat, seed surface wooly...***I. acanthocarpa***

Stem and leaves hairy, corolla blue with white throat, seed with short hairs…..***I. nil***

DISCUSSION

Ipomoea species in Southeastern Nigeria possessed variable and valuable characters in the leaf, stem and root. The colour of flower, plant height, nature of inflorescence, stem colour and form, number of sepals and leaf size are all systematically significant.

The morphological study of the *Ipomoea* species showed a lot of similarities among the species, they all have milky latex and was also herbaceous. *I. aquatica* and *I. asarifolia* had hollow stem unlike the others, this could be a good diagnostic character. Their flower shape divides them into two major groups, *I. quamoclit* and *I. hederifolia* had a salverform shape while the rest had funnel form shape. The findings of this study are in agreement with the work of Mondal *et al* (2006). Despite their similarities, they showed quite a lot of variability and multi-state in most of their characters which is in line with the work of Tayade and Patil (2011) who reported that *Ipomoea* have some phenotypic uniformity and there is a great deal of variability and diversity in their internal structures. This variability could be due to environmental factors and the stages of

development which consequently lead to wrong identification. Hence using only morphological characters to identify and delimit this genus may not be the best, there is need to involve data from other fields of study. The hollow pith found in some of the species and the two types of flower shape are two major characters that could help in separating this tax or show their relatedness.

Morphologically, the vegetative features and habits of the genus are useful tool in their taxonomic similarity which has been emphasized by Vijay and Ramaya (1987) and Vijay (1988).

The result of the numerical analysis carried out on the morphological characters of the *Ipomoea* (fig 1) showed the level of similarity and dissimilarity among the seven *Ipomoea* species and the interspecific relationships within the genus studied. The first cluster consists of *I. quamoclit, I. hederifolia* and *I. acanthocarpa,* with the first two species making up the sub-cluster in this group. It showed that *I. quamoclit* and *I. hederifolia* were more similar and related having been made morphologically distinct by having red salverform flower, exserted stamen, glabrous and twining stem.*I. acanthocarpa*was more closely related to the pair than other species. The second cluster consists of *I. involucrata* and *I. triloba*, closely related by *I. nil*. The third cluster is made up of *I. aquatica* and *I. asarifolia.*Their close affinity is supported by their having hollow stem,big and pinkish purple flower which are funnel form and an included stamen. This therefore, separates them from the rest. This is not a surprise as Austin (1975, 1979, and 1997) and Austin and Huáman (1996) put *I. quamoclit* and *I. hederifolia* in subgenus *Quamoclit*, Sect. *Mina* and *I. aquatica* and *I. asarifolia* in subgenus *Eriospermum*, Sect. *Erpipomoea*. At 0.71*I. triloba* and *I. involucrata* were similar, although Austin (1975, 1979, and 1997) and Austin and Huáman (1996) put the former in Subgenus *Eriospermum,* Sect. *Eriospermum* and the later in Subgenus *Ipomoea* Sect. *Ipomoea* (Biju, 1997). *I. nil* is sister to the pair. This shows their close relationship.

Although the species of this genus are quite variable, they also have characters that are overlapping which have led to difficult or wrong identification.

CONCLUSION.

This study has helped to show the affinity among these *Ipomoea* species thereby giving a better and a more complete understanding of the *Ipomoea* species relationships. But there still remains some questions which morphological study may not be able to resolve adequately

hence the need to incorporate other sources such as cytology, anatomy, phytochemistry and molecular/ genetic data in order to clear the arguments and controversies in this genus.

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