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SEEDLING MORPHOLOGY OF SOME TREE SPECIES OF THE ANGIOSPERMIC ORDER RUTALES IN THE FOREST PATCHES OF DAKSHINDINAJPUR DISTRICT, WEST BENGAL AND THEIR SIGNIFICANCE IN REVEALING CORRELATION.

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ABSTRACT ■ Seedling morphology of four species each of the families Rutaceae and Meliaceae of the order Rutales (*sensu* Takhtajan, 1997) were studied and objectively correlated. The seeds and seedlings were collected from the forest patches of Dakshinsinajpur district of West Bengal. Seeds were sown in seed beds and seedlings raised there from were characterized for identification, comparison with natural ones, and work out correlation in them by using UPGMA method to reveal relevance to Takhtajan's (1997) system of classification.

Key words: *seeds, seedlings, correlation, Takhtajan*

INTRODUCTION

Non–volatile morphological characters are very important to notice development of seedlings in plant life cycle [Paria *et al*, 2006]. On the basis of these juvenile characters, diversity of seedling morphology within different taxa as well as their correlation can be can be understood. There are many publications on seedling morphology and their importance in taxonomy (Naidu and Shah,1978; Sampathkumar,1982; Balasubhramanyam and Swarupanandan, 1986; Deb and Paria, 1986; Kamilya and Paria, 1993a, 1993b, 1997; Paria and Kamilya,1999; Paria *et al.*, 1990, 2006; Kmilya, 2011; Duke,1965,1969; De Vogel,1980; Bokdam,1977; Ng,1975; Popma and Bongers, 1988; Guillermo *et al.*,2001 and Zanne *et al.*, 2005). However studies on correlation in taxa using seedling characters are rather inadequate or even lacking. Although correlation of characters may yield undesirable ambiguous results, but there are always some determinative relationships among the taxa [Sneath and Sokal, 1973].

Of the ten families of Rutales (*sensu* Takhtajan, 1997), we have considered two families *viz.*, Rutaceae and Meliaceae selecting four tree species from each of them from the forest patches of Dakshindinajpur in conformity with the work of Mitra and Mukherjee (2013) to understand relationship in the concerned species at their juvenile stage. Numerical evaluation of similarities or dissimilarities in the context of their morphological features was carried out to assess quantitatively

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relationship in them. The objective of the work was to find out whether the correlation thus revealed is in conformity with Tskhtajan's system of classification received in 1997.

MATERIALS AND METHODS

The study was conducted in the different natural and seminatural forest patches spread all over Dakshindinajpur district of West Bengal from August, 2013 to July, 2014. The forest area covered is 2.95 sq.km (Mitra and Mukherjee, 2013) receiving an annual rainfall of 1847.8mm with the mean annual temperature varying from 23-29ºc. The vegetation is mostly of semi–deciduous type. Seeds and seedlings were collected from different regions of the district at different times keeping parity with the UGC Major Research Project [F. No. 41-484/2012(SR) dt. 16.07.2012]. After cleaning, air–drying, characterizing and weighing, the seeds were sown and seedlings raised in the experimental garden of the department of Botany, Balurghat College. The seedlings were then technically described and compared with the natural ones for identification and processed for herbarium preservation. An artificial key to the taxa was prepared to facilitate identification at their seedling stage in natural habitats.

For statistical analysis, the characters of each species were coded in numerical form (Table–I) and the DendroUPGMA software was used to obtain a dendrogram of form-relationships in the concerned taxa. DendroUPGMA calculates a similarity and dissimilarity matrix from a set of variables and accomplishes

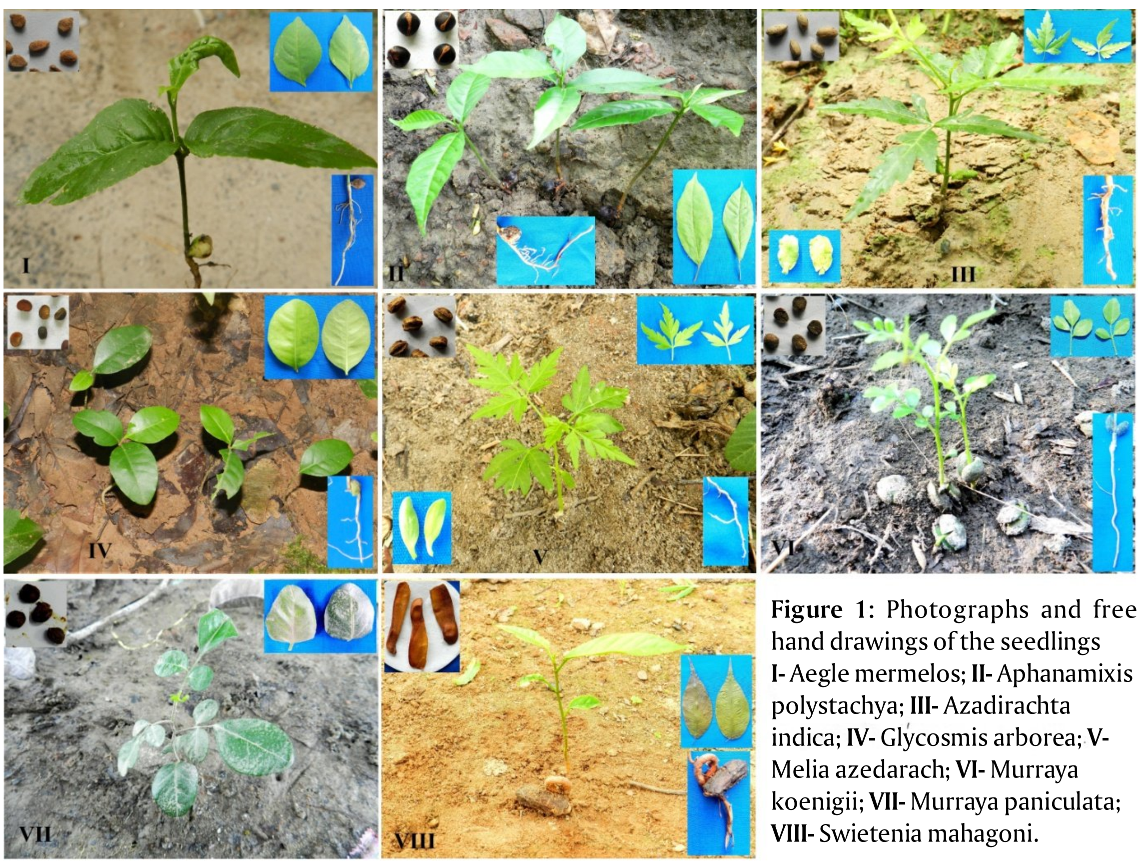

Figure 1: Photographs and free hand drawings of the seedlings **I-** Aegle mermelos; **II-** Aphanamixis polystachya; **III-** Azadirachta indica; **IV-** Glycosmis arborea; **V-** Melia azedarach; **VI-** Murraya koenigii; **VII-** Murraya paniculata; **VIII-** Swietenia mahagoni.

clustering using Unweighted Pair Group method with Arithmetic Mean (UPGMA) algorithm (Garcia-Vallve, 1999). The numerical values of characters were put in fasta–like format and the system run in Pearson coefficient to measure linear correlation between OTUs. The outcome was in phylip format from which the dendrogram was finally obtained.

Characterization of seedlings

The seedling characters are displayed in the form of field photographs [Fig. 1] and in the form of numerical value [Table I] with the relevant legend subtended. The species are arranged alphabetically with author's name in the table along with corresponding figure numbers.

Table Ia: Characters of seeds and seedlings of taxa in numerical form

Name of the species	Seed		Seedling nature	Hypocotyl		Cataphylls	Paracotyledons					
	shape	surface		shape	Surface		petiole	shape	base	apex	margin	venation
Aegle mermelos (L.) Corr; Fig. I	3	1	1	0	0	0	0	0	0	0	0	0
Aphanamixis polystachya (Wall.)Park.; Fig. II	1	2	1	0	0	1	0	0	0	0	0	0
Azadirachta indica A.Juss. Fig. III	2	1	3	1	1	0	1	1	1	1	1	1
Glycosmis arborea (Retz.) DC. Fig. IV	1	2	1	0	0	0	0	0	0	0	0	0
Melia azadarach L. Fig. V	2	1	3	1	1	0	1	1	2	1	1	1
Murraya koenigii (L.) Spreng. Fig. VI	1	1	2	0	0	0	0	0	0	0	0	0
Murraya paniculata (L.) Jack Fig. VII	1	1	2	0	0	0	0	0	0	0	0	0
Swietenia mahagoni (L.) Jacq. Fig. VIII	4	2	2	0	0	1	0	0	0	0	0	0

Table I continued

Name of the species	First two leaves								Subsequent leaves		Internodes	
	Phyllotaxy	nature	stipule	Shape	Base	apex	margin	venation	phyllotaxy	nature	shape	surface
Aegle mermelos	3	1	0	2	4	1	2	1	1	1	1	3
Aphanamixis polystachya	1	1	0	5	1	1	3	1	1	1	2	1
Azadirachta indica	2	2	0	1	2	2	2	1	2	1	2	2
Glycosmis arborea	3	1	0	3	3	4	1	1	1	2	1	2
Melia azadarach	2	2	0	1	2	2	2	1	2	1	2	1
Murraya koenigii	1	2	0	4	3	3	1	1	1	1	1	1
Murraya paniculate	1	1	0	2	5	3	1	1	1	1	1	1
Swietenia mahagoni	1	1	0	3	1	2	1	1	1	1	2	2

Seed: Shape: round1, oval 2, ovate 3, winged 4. Surface: rough 1, smooth 2. **Seedling: Nature**: cryptocotylar/ hypogeal 1, cryptocotylar/ geal 2, phanerocotylar/ epigeal 3. **Hypocotyl**: shape- round 1, absent 0; surface- glabrous 1, absent 0. Cataphylls: present 1, absent 0. **Paracotyledons**: petiole absent 0, present 1; shape- oblong 1, absent 0; base- rounded 1, auriculate 2, absent 0; apex- rounded 1, absent 0; margin- entire 1, absent 0; venation- hyphodromous 1, absent 0. **First two leaves**: Phyllotaxy- alternate 1, opposite 2, subopposite 3; nature- simple 1, compound 2; stipule- absent 0; shape- lanceolate-elliptic 1, ovate 2, elliptic 3, obovate 4, oblong 5; base- subrounded 1, attenuate 2, cuneate 3, rounded 4, trunvate 5; apex- acute 1, acuminate 2, retuse 3, obtuse 4; margin: entire 1, serrate 2, undulate3; venation- camptodromous 1. **Subsequent leaves**: Phyllotaxy- alternate 1, opposite 2; nature- compound 1, simple 2; **First internode**: shape- round 1, angular 1; surface- pubescent 1, glabrous 2, minutely pubescent 3.

Key to the identification of concerned taxa:

1. Seeds round, ovate or winged; seedlings cryptocotylar, first two leaves subopposite or alternate, simple or compound, ovate, elliptic, obovate or oblong, base subrounded, cuneate or truncate……..2

1a. Seeds elliptic; seedlings phanerocotylar, first two leaves opposite, compound, lanceolate–elliptic, base attenuate……..7

2. Cataphylls absent; first two leaves subopposite or alternate, simple or compound, base rounded, cuneate or truncate; shape of first internode round……..3

2a. Cataphylls present; first two leaves alternate, simple, base subrounded; shape of first internode angular………..6

3. Seeds ovate; seedlings hypogeal, base of first two leaves rounded, apex acute, margin serrate; surface of first internode minutely pubescent…….. *Aegle mermelos*

3a. Seeds round; seedlings geal or hypogeal, base of first two leaves cuneate or truncate, apex obtuse or retuse, margin entire; surface of first internode pubescent or glabrous …….4

4. Seed surface smooth; seedling hypogeal, first two leaves subopposite, elliptic, apex obtuse; subsequent leaves simple; surface of first internode glabrous…….. *Glycosmis arborea*

4a. Seed surface rough; seedling geal, first two leaves alternate, obovate or ovate, apex retuse; subsequent leaves compound; surface of first internode pubescent……..5

5. First two leaves compound, trifolilate, shape obovate, base cuneate…….. *Murraya koenigii*

5a. First two leaves simple, shape ovate, base truncate…….. *Murraya paniculata*

6. Seeds round; first two leaves oblong, apex acute, margin undulate; surface of first

internode pubescent........... *Aphanamixis polystachya*

6a. Seeds winged; first two leaves elliptic, apex acuminate, margin entire, surface of first internode glabrous........... *Swietenia mahagoni*

7. Base of paracotyledons auriculate, thicker in texture........ *Azadirachta indica*

7a. Base of paracotyledons rounded, not much thicker in texture........ *Melia azedarach*

Table II: Distance matrix of the concerned taxa

	Aegle mermelos	*Aphanamixis polystachya*	*Azadirachta indica*	*Glycosmis arborea*	*Melia azedarach*	*Murraya koenigii*	*Murraya paniculata*	*Swietenia mahagoni*
Aegle mermelos	0	52.91	40.61	28.38	55.94	38.36	28.74	36.40
Aphanamixis polystachya		0	76.93	44.13	82.21	30.00	58.86	34.09
Azadirachta indica			0	53.36	8.60	48.90	44.12	51.28
Glycosmis arborea				0	63.44	16.67	20.27	40.68
Melia azedarach					0	54.35	49.32	62.58
Murraya koenigii						0	14.64	35.43
Murraya paniculate							0	51.93
Swietenia mahagoni								0

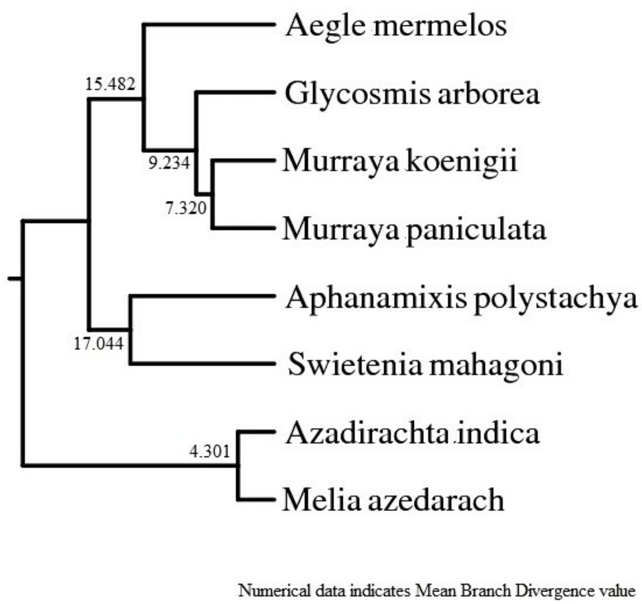

Figure 2: Dendrogram of interrelationship in the species studied

DISCUSSION

The correlation in taxa as revealed in the dendrogram(Fig.2) can be interpreted at par with the artificial key. In the dendrogram, primarily two principal clusters are displayed –one with the two phanerocotylar genera *viz., Azadirachta indica* and *Melia azedarach*, and the other with the remaining six cryptocotylar taxa.

The two phanerocotylar taxa *i.e, A. indica* and *M. azedarach* are little apart from each other with the mean branch divergence value or mbdv 4.301 as they show difference only in the base of paracotyledons and surface of internodes as depicted in the keys.

The cryptocotylar taxa can be divided into two secondary clusters, the first of which consists of four taxa *viz., Aegle mermelos, Glycosmis arborea, Murraya koenigii* and *Murraya paniculata* of which *A. mermelos* is separated from the rest forming an isolated solitary cluster (mbdv 15.481). The two species of *Murraya paniculata* show closer proximity to *Glycosmis arborea* showing mbdv 9.234 and are in a single cluster [mbdv 7.320] being distinguishable from *G. arborea* by its seed surface, seedling type, characters of first two leaves and surface of first internodes as shown in the key. Of the two species of *Murraya, M. koenigii* has the first two leaves compound with obovate leaflets having cuneate base and *M. paniculata* shows first two leaves simple with ovate lamina having truncate base. This small magnitude of differences is also reflected by the low mbdv (7.320).

The other major cluster links *Aphanamixis polystachya* and *Swietenia mahagoni* showing mbdv 17.044. These species are distinguishable on the basis of seed shape, nature of seedling, shape, apex and margin of first two leaves keeping parity with the artificial key.

CONCLUSION

From taxonomic point of view, the correlation of taxa based on seedling morphology as revealed in the present study brings into light some significant observations. The seedlings are first clustered on the basis of their phanerocotylar or cryptocotylar mode of germination, which is the most important parameter to understand the nature of germination of seedling. In the cryptocotylar group, the genera are differentiated in a way that supports Takhtajan's system of classification which is a synthetic one. Among the taxa from Rutaceae, two species of genus *Murraya*, find placement in the same cluster. Similarly the two phanerocotylar taxa *Azadirachta indica* and *Melia azedarach* are similar in many of their juvenile characters. Again within the scope of the present work based on seedling characters of six species, two families could be distinguished and their relationship quantitatively revealed in the dendrogram, thus proving its worth in taxonomic resolutions. However, to arrive at a concrete decision for revealing inter–relationships more number of taxonomic units and variables deserve consideration.

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