Phenetic Analysis of Morphological and Molecular Traits in some taxa of Araliaceae in Egypt

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**Abstract**

This study investigated the morphological features (namely,whole plant, leaf and stem anatomy, leaf architecture, and epidermal characteristics) and molecular characteristics of Araliaceae taxa to explain the diversity and diagnostic significance of these attributes. The sum of both characteristic states of morphological and molecular criteria (182 traits and 78 bands, respectively) from the total (260 traits) of the examined taxa was subjected to a numerical analysis using the NTSYS-PC program (version 2.02). The generated dendrogram explained the similarities and differences between the examined taxa and the specific relationships are discussed and compared with current classification systems. The generated dendrogram from morphological attributes confirmed the separation of Aralieae and Schefflerieae as two tribes of Araliaceae and supported the separation of simple leaved taxa from compound-leaved ones.

**Keywords**: Morphology, Anatomical structure, Lamina architecture, Stomatography, ISSR, Araliaceae

**1. Introduction**

According to **Wen *et al*. (2001)**, Araliaceae comprises 47 genera and **>**1.350 species. Five of the six largest genera with ≥50 species are best represented inthe tropical or subtropical zone (*Schefflera*, *Oreopanax*, *Dendropanax*, *Polyscias*, and *Osmoxylon*, except *Aralia*), although several smaller genera (e.g. *Brassaiopsis*, *Panax*, *Macropanax*, *Hedera*, *Oplopanax*,and *Gamblea*) are found in the north temperate zone. Araliaceae are also well-developed in the Old World in Southeast Asia, The Pacific, and Indian Ocean basins. New World araliads include only a few genera. Most of them are also largely the Old World such as *Aralia*, *Oplopanax*, *Panax*, *Pseudopanax*,and *Dendropanax*. With the inclusion of *Sciadodendron* in *Aralia* **(Wen, 2002),** *Oreopanax* is now the only genus in the New World. Araliaceae are trees or shrubs, sometimes woody vines. Their leaves are simple, palmately lobed, palmately compound or 1- to 3 pinnately compound. Their fruits are drupe or berry.

A significant step was taken in resolving the placement of Araliaceae among the main genealogy of the order Apiales (**Plunkett** and **Lowry, 2001; Plunkett *et al.*, 2003**) and knowing the relationships within and between related genera of Araliaceae **(Wen** and **Zimmer, 1996;** **Eibl *et al.*, 2001;** **Plunkett *et al.,* 2001)**. **Harms (1894–1897)** accurately classified the family into three tribes: tribe Aralieae with imbricate aestivation andMackinlayeae and Schefflereae with valvate aestivation and separated from one another by petal insertion based on petal aestivation and base insertion. **Bentham (1867)** provided nearly similar tribes Mackinlayeae and Aralieae, but the genera classified in Schefflereae by**Harms** were treated as tribes Panaceae and Hedereae (with smooth and ruminate endosperm, respectively**)** in addition to Plerandreae (where the stamen number exceeded the petal number).

Based on the traditionally morphological **(Harms, 1898;** **Judd *et al*., 1994**) and anatomical by **(Metcalfe** and **Chalk, 1950)** evidence, Araliaceae have been classified with Apiaceae and supported by recent molecular studies **(Plunkett *et al*., 1996a, 1997**).

**Jacobs *et al* (2010)** studied the fruit set in *Hedera helix*. **Mourad (2013)** showed the separation of simple leaved *Meryta denhamii* from lobed (*Hedera helix* and *Tetrapanax papyrifer*) and compound leaves *Polyscias* spp., where *Schefflera* ssp. and *Schefflera pueckleri* are the modern names of *Sciadophyllum pulchrum* leaves.

**Amini *et al.*(2019)** studied the micromorphology of *Hedera* species in Iran**.** **Lestari** and **Elya (2019)** made macroscopic studies of *Polyscias guilfoylei* leaves. The essential use of leaf architectural characteristics to aid in the delimitation of genera and species was conducted in paleobotany **(Mouton, 1966;** **Dilcher,** **1974)**. **Zhernova *et al*. (2021)** made comparative wood for the anatomy of *Astropanax* and *Neocussonia*.

**Savulescu** and **Luchian (2009)** studied the diagnostic value of *Hedera* epidermis and the epidermis made up of one cell layer with polygonal cells and a thin lateral wall. **Amini *et al.* (2019)** studied epidermal cell descriptions of *Hedera* species in Iran. **Kotina *et al.* (2010)** surveyed the bark anatomy of Araliaceae and some related taxa. **Ostroumova *et al.* (2010**) surveyed the leaf anatomy of Araliaceae and some related taxa.

**Rout *et al*. (2007)** used randomly amplified polymorphic DNA (RAPD) and inter simple sequence repeat (ISSR**)** markers to study the genetic relationship between *Polyscias* and *Schefflereae*. **Hoi *et al.* (2021)** used ISSR markers to assess the genetic diversity of *Panax bipinnatifidus*.

Araliaceae have a taxonomic problem within and between its related genera. Aralieae and Schefflerieae are not accurately delimited, and their leaf forms are represented within the Araliaceae family that has a tremendous array. This study aimed to find the interspecific relationships of the studied taxa by investigating their morphological, anatomical, and molecular characteristics and performing a numerical evaluation of such traits.

**2. Materials and Methods**

**2.1. Sampling**

Twelve Araliaceae taxa representing six genera were collected from the Botanical Garden of Mansoura University and Orman Botanical Garden, Giza, Egypt (Table 1). Identification was confirmed by comparing the specimens in the herbarium of the Faculty of Science, Ain Shams University (CAIA). Voucher specimens of the investigated species were kept at the Mansoura Herbarium, Botany Department, Faculty of Science, Mansoura University. Nomenclature has been updated according to several websites (<https://www.ipni.org/>).

**2.2.** **Macro-micromorphological** **investigation**

The macromorphological characteristics of the leaves, inflorescence, flowers, and fruits were described from fresh specimens. For anatomical features, the methods were characterized by **Johansen (1940)** and adopted by **Jensen (1962)** **and** **Peacock** and **Bradbury (1973)**.

Leaf vein architecture was conducted according to the usual method of **Jesudass *et al.* (2003)**. Lamina’s architectural terminology followed **Hickey (1973)** and **LAWG (1999)**.

Stomatography was conducted according to **Stace (1965)**. Using a Reichert Microstar IV microscope the photomicrographs were taken at the Plant Taxonomy Research Laboratory, Botany Department, Faculty of Science, Ain Shams University, Cairo, Egypt. For scanning electron microscopy (SEM) of small (7 mm2) pieces of the lamina, the material was installed on SEM stubs with a double-sided tape, coated with gold in an SPI-Module sputter coater, checked, and photographed in JEOL JSM 5200 at various magnifications (×500 and ×1000). The description of epidermal characteristics terminology wasbased on **Metcalfe** and **Chalk (1950)**, **Murley (1951)**, **LAWG (1999)**, and **Prabhakar (2004)**.

**2.3. Molecular assessment [ISSR-** **polymerase chain reaction (PCR) analysis]**

Genomic DNA was extracted from 12 samples according to Gene JET Genomic DNA Purification Kit (K0721/ Thermo Fisher). Total genomic DNA was amplified through the GeneAmp PCR system cycler. PCR for amplified genomic DNA was conducted according to **El-Assal *et al*. (2011).** ISSR-PCRs were conducted using six primers for the genotype (Table 2). A gel documentation system (Geldoc-it, UVP, and England,) was applied for data analysis using Totallab analysis software (**version 1.0.1 www.totallab.com).**

**2.4. Data analysis**

The UPGMA function and SAHN program were used by **Sneath** and **Sokal (1973**). All computations were made with the help of NTSYS-PC version 2.02 **(Rohlf 2005)**.

**3. Results and Discussion**

**3.1. Leaf shape**

Simple in three taxa, namely, *Hedera canariensis*, *M. denhamii*, and *Oreopanax guatemalensis***;** simple lobed palmate in *H. helix* and *T.papyrifer***;** compound palmate in four species of *Schefflera***;** and compound pinnate in three species of genus *Polyscias*, as shown in Figure 1.

**3.2. Stem and lamina anatomy**

**3.2.1. Stem investigation**

Angled in seven taxa and terete infive taxa(*H. helix*, *P. guilfoylei*, *P. scutellaria*, *S. actinophylla* and *S. pueckleri*).All taxa are not glandular; glandular in *H. canariensis*; lenticel is present in six taxa (*H. helix*, *M. denhamii*, *O. guatemalensis*, *S. elegantissima*, *S. pueckleri*, and *T. papyrifer*). Collenchyma is absentin six other taxa, may be angular-lamellar in nine taxa, and is angular in *M.* *denhamii*, *O. guatemalensis*, and *S. arboricola*. As shown in Figure 2, the aspect of vascular bundles is siphonostelic in 11 taxa and distinct in *P. scutellaria*.

**3.2.2. Lamina anatomy**

Raised adaxially in 11 taxa and flattened adaxially in *S. actinophylla*. All taxa are not glandular, peltate eglandular in *H.helix*, and multicellular branched eglandular in *T. papyrifer*. Collenchymais annular in five taxa (*H. canariensis*, *H. helix*, *P. fruticosa*, *S. actinophylla*, and *S. elegantissima***)**, annular-lamellar in five taxa (*M. denhamii*, *O. guatemalensis*, *S. arboricola*, *S. pueckleri*, and *T. papyrifer)*, angular-lamellar in *P. guilfoylei*, and angular in *P. scutellaria*. The vascular system is partially continuous in six taxa **(***H. canariensis*, *H. helix*, *O. guatemalensis*, *P. fruticosa*, *P. guilfoylei*, and *S. actinophylla***)** and distinct in six other taxa. As shown in Figure 2,all taxa have druses-raphides**,** except druses in *P. scutellaria*.

**3.3. Lamina vein architecture**

The primary vein category is pinnate in six taxa **(***M. denhamii*, *O. guatemalensis*, *P. fruticosa*, *S. actinophylla*, *S. elegantissima*, and *S. pueckleri***),** suprabasal in *H. canariensis*, and *H. helix*, acrodromous (basal) in *P. guilfoylei*, suprabasal actinodromous in *P. scutellaria*, suprabasal actrodromous in *S.arboricola*, andpalinactinodromous in *T. papyrifer*. The secondary vein category is brochidodromou in four taxa **(***H. canariensis*, *H. helix*, *P. guilfoylei*, and *P. scutellaria***);** reticulodromous in *M. denhamii*, and *S. arboricola*; festooned brochidodromous in *O. guatemalensis*, *S. actinophylla*, and *S. pueckleri*; weak brochidodromous in *P. fruticosa*; intramarginal vein in *S. elegantissima*; and interior (seven basal veins) in *T. papyrifer.* The tertiary vein is category random reticulate in seven taxa, alternate percurrent in four taxa **(***O. guatemalensis*, *P. fruticosa*, *P. guilfoylei*, and *P. scutellaria***),** and dichotomizing in *S. elegantissima.* The quarternary vein category isregular polygonal reticulate (RPR) in nine taxa, alternate percurrent in *M. denhamii,* dichotomizing in *S. elegantissima,* and absent in *O. guatemalensis.* The quinary vein categoryis RPR in five taxa **(***H. canariensis*, *H. helix*, *M. denhamii*, *S. arboricola*, and *T. papyrifer***)**, dichotomizing in fivetaxa *(P. guilfoylei*, *P. scutellaria*, *S. actinophylla*, *S. elegantissima*, and *S. pueckleri***),** and absentin *O. guatemalensis, P. fruticosa* as shown in Figure 3.

**3.4. Epidermal cell description**

Cell shape wasirregular in four taxa **(***H. canariensis*, *H. helix*, *M. denhamii*, and *T. papyrifer***)**and polygonal in eight taxa, anticlinal wallsinuous in four taxa **(***H. canariensis*, *H. helix*, *M. denhamii*, and *T. papyrifer***),** slightly curved in eight taxa,and stomatal shape elliptical in all taxa.The stomatal type is anomocytic and anisocytic in *H. canariensis* and *H. helix*, anisocytic in seven taxa, and anisocytic and diacytic in *P. fruticosa*, *P. guilfoylei* and *S. elegantissima*. The sculpture is ruminate in four taxa *(H. canariensis*, *O. guatemalensis*, *S. actinophylla*, and *pueckleri***);** pusticulate in *H. helix* and *M. denhamii*; reticulate-aerolate in *P. fruticosa*, *P. guilfoylei, and* *P. scutellaria* reticulated in *S. arboricola*; favulariate in *S. elegantissima* and striate in *T. papyrifer* as shown in Figure 4.

**3.5. Molecular** **assessment**

All primers were produced 78 bands and showed monomorphic and polymorphic bands (Table 3). Primer iPBS primer 2270produced one monomorphic band and nine polymorphic bands (seven common and two unique), C1produced one monomorphic band and 14 polymorphic bands (13 common and one unique), G4 produced one monomorphic band and 13 polymorphic bands (12 common and one unique),andPseCra5produced no monomorphic band and 13 polymorphic bands (13 common). Although no unique bands were produced, PseLes1produced no monomorphic and 13 polymorphic bands (13 common). Although no unique bands were produced, PseCra3Bproduced no monomorphic and 13 polymorphic bands (13 common), and no unique bands were recorded, asshown in Figure 5.

**3.6. Numerical analysis**

Data from the whole plant, stem, and leaf anatomy for the examined taxa were amalgamated with data from lamina architecture and stomatographic analyses. They were subjected to numerical analysis to explain the relationship among the studied taxa based on 182 macro-micromorphological traits used for computation and produced a dendrogram, as shown in Figure 6. Data extracted from ISSR analysis were subjected to numerical analysis to explain the relationship among the examined taxa based on 78 molecular traits. As shown in Figure 7, these traits were used for computation and produced a dendrogram. Finally, data extracted from macro-micromorphological attributes were amalgamated with data from ISSR analysis. They were subjected to numerical analysis to explain the relationship among the studied taxa based on 260 macro-micromorphological and molecular traits used for computation and produced a dendrogram, as shown in Figure 8.

The resulting dendrogram from morphological attributes was compared with current system treatments. The dendrogram shows that the taxa under investigation were split into two main series (I and II), three clusters (A - C), and five groups (Figure 6A). Series I included only one cluster (A) and one group. Cluster A included one group of three studied species. Series II involved two clusters (B and C) and four groups. Cluster B involved two groups: the first group involved two studied species, whereas the second one involved four studied species. Cluster C involved two groups; the first group involved two studied species when the second one involved only one studied species. The interrelationships among these taxa are summarized as follows.

Series I: Group 1 includes *H. canariensis*, *H. helix*, and *T.* *papyrifer*. Theresults agreed with **Harms** **(1894-1897)** classification system that put them in the same tribe. **Hutchinson (1967)**, **Bentham (1867)**,and **Tseng** and **Hoo (1982)** placed them in different tribes. **Calestani (1905)** and **Viguier (1906)** placed *T. papyrifer* in the same tribe but *H. canariensis*, and *H. helix* in different tribes. **Seemann (1868)** placed *T. papyrifer* in the same family but a different tribe and placed *H. canariensis*, and*H. helix* in a different family.

Series II: Group 2 includes *M. denhamii*, and *O. guatemalensis*.The results agreed with the **Harms (1894-1897)** classification system that put them in the same tribe**. Hutchinson (1967), Bentham (1867), Tseng** and **Hoo (1982),** and **Seemann (1868)** placed *M. denhamii* in the same tribe but *O. guatemalensis* in a different tribe. **Calestani (1905)** and **Viguier (1906)** placed *O. guatemalensis* in the same tribe but *M. denhamii* in a different tribe.

Group 3 includes *S. actinophylla*, *S. pueckleri*, *S elegantissima*, and *S. arboricola.* The results agreed with **Harms (1894-1897)**, **Calestani (1905)**, and **Viguier (1906)** classification systems that put them in the same tribe. **Hutchinson (1967)**, **Bentham (1867)**, **Seemann (1868)**, and **Tseng** and **Hoo (1982)** placed them in the same family but different tribes.

Group 4 includes *P. fruticosa* and *P. guilfoylei*. The results agreed with **Bentham (1867)**, **Seemann (1868)**, **Harms (1894-1897)**, **Calestani (1905)**, **Hutchinson (1967)**,and **Tseng** and **Hoo (1982)** classification systems that put them in the same tribe. Vi**guier (1906)** placed them in the same family but different tribes.

Group 5includes *P. scutellaria*. The results agreed with **Bentham (1867)**, **Seemann (1868)**, **Harms (1894-1897)**, **Calestani (1905)**, **Hutchinson (1967)**, and **Tseng** and **Hoo (1982)** classification systems that put them in the same tribe. **Viguier (1906)** placed it in the same family but a different tribe.

**4. Conclusion**

Araliaceae have a taxonomic problem within and between its related genera and a tremendous array of leaf forms. Aralieae and Schefflerieae are not accurately delimited. The numerical analysis interprets the relationships between the studied taxa based on 260 macro-micromorphological and molecular traits. Data on the macro-micromorphological traits confirmed the separation of Aralieae and Schefflerieae as two tribes of Araliaceae and confirmed the separation of simple leaved taxa from compound leafed ones.

**Data availability**

All data generated or analyzed during this study are included in this published article

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**Competing Interests**

The authors have no relevant financial or non-financial interests to disclose.

**Author Contributions**

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Mai M. Wahba, Ashraf S. Haider, Magdy M. Mourad, I.A. Mashaly and Ihsan E. El-Habashy. The first draft of the manuscript was written by Mai M. Wahba and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

**Ethics approval**

This article does not contain any studies with human participants performed by any of the authors.

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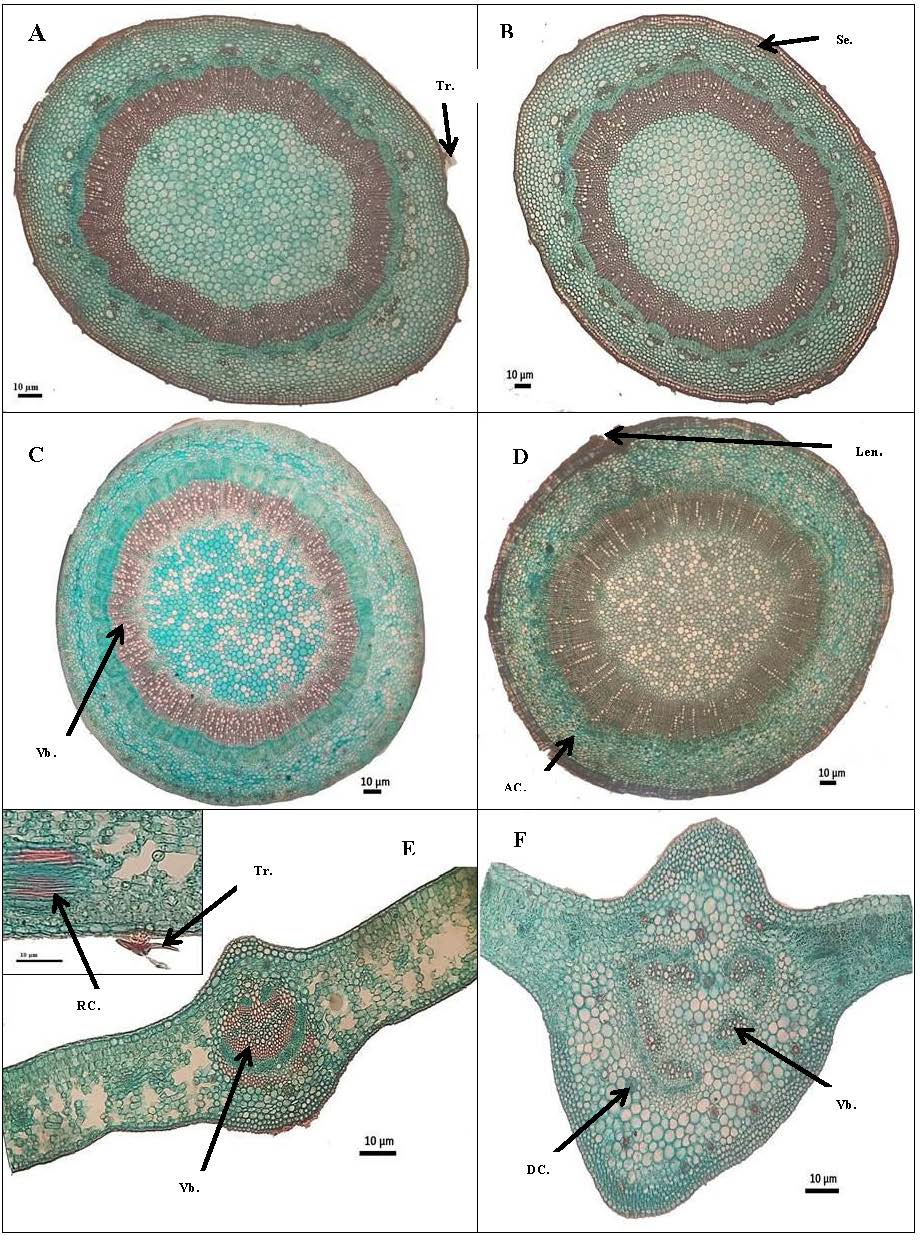
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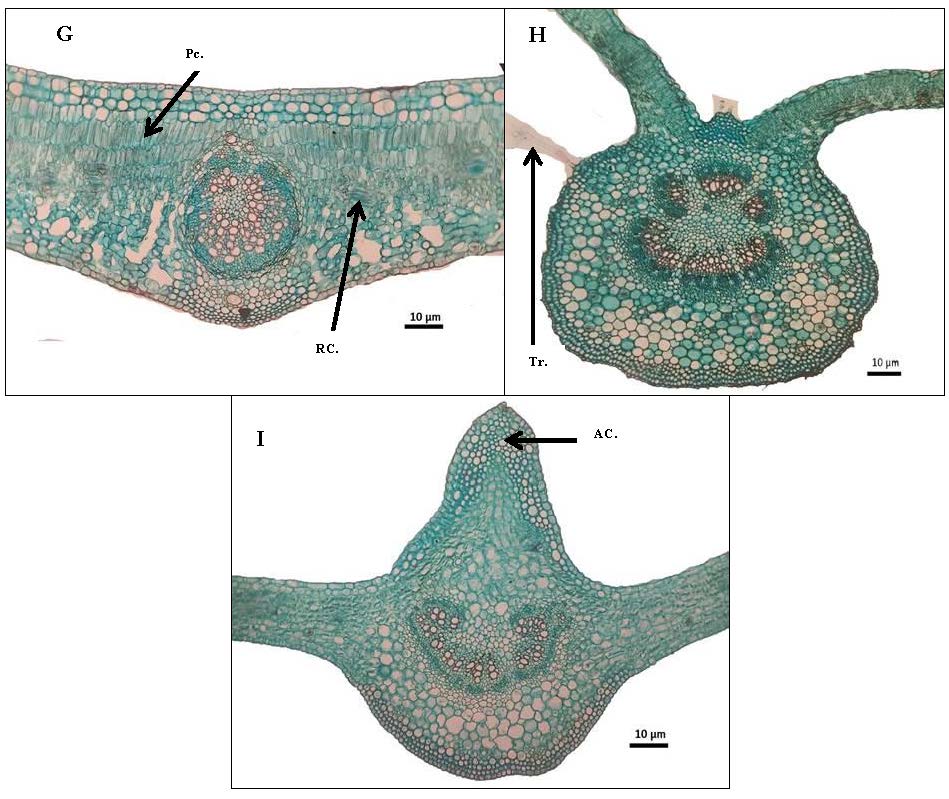
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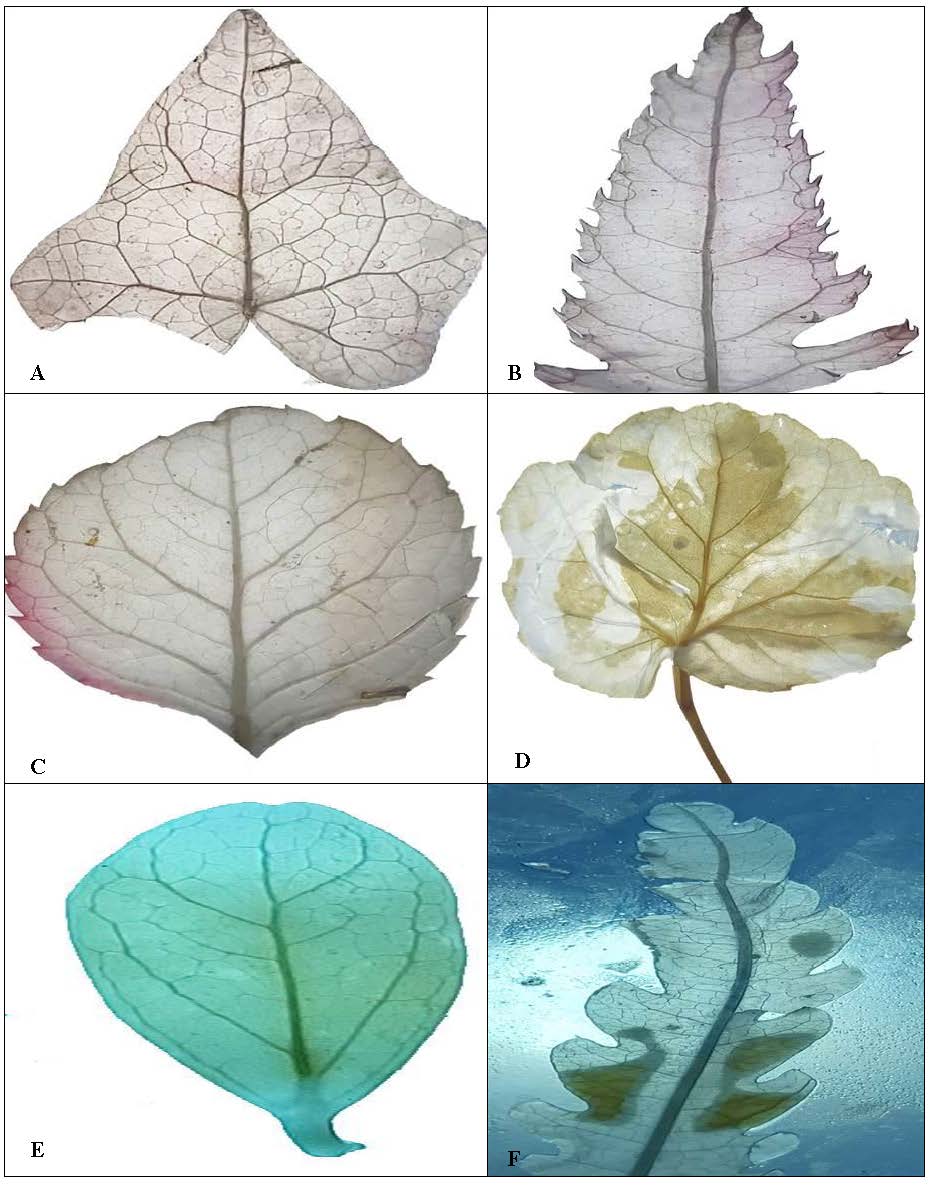
**Figure1. A-D) Leaves photographs of some studied taxa; A) Simple; B) Simple lobed palmate; C) Compound pinnate; D) Compound palmate.**



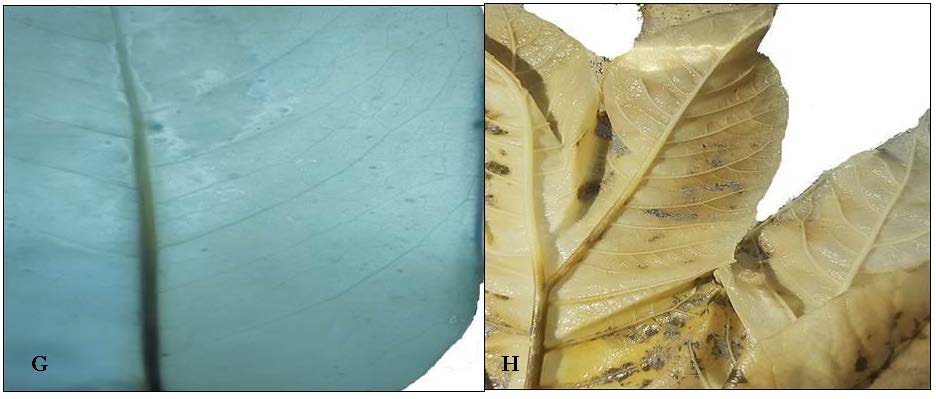
**Figure2. A-D) Photographs of some stem anatomy of studied taxa; A) Angled, egland unicellular unbranched trichome, siphonostelic vascular bundle; B) Terete, lenticel; C) Distinct vacular bundle; D) Angular collenchyma. E-I) Photographs of some lamina anatomy of studied taxa; E) Raised adaxially, peltate eglandular trichome, annular collenchyma, druses & raphides crystal, partially continuous vascular bundle; F) Druses crystal, angular collenchyma, distinct vascular bundle. Abbreviations: Tr. trichome; Se. sub epidermal periderm; Vb. vascular bundle; Len. lenticel; AC. angular collenchyma; RC. raphides crystal; DC. druses crystal.**

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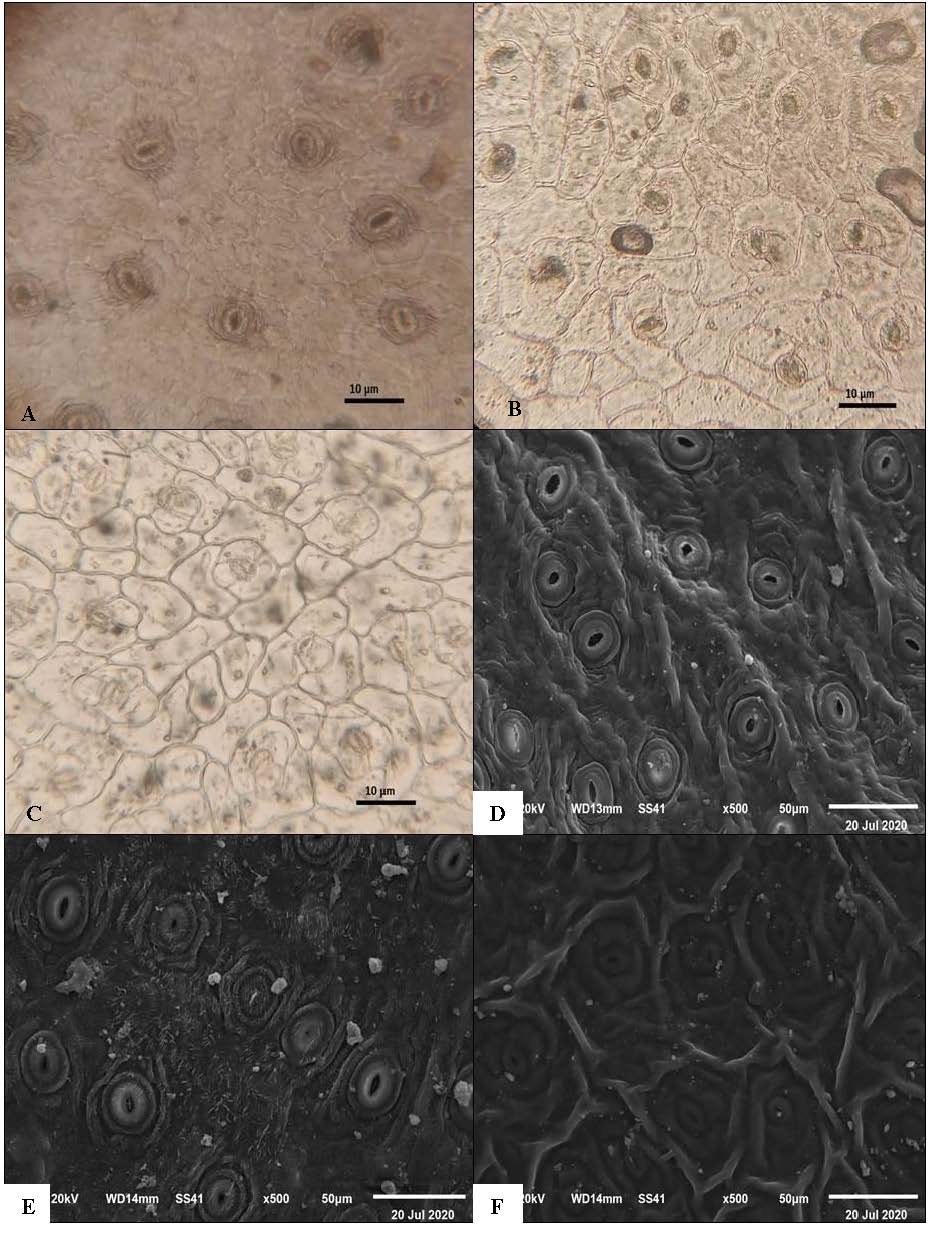
**Continued Figure2. G-I) Photographs of some stem anatomy of studied taxa; G) Flattened adaxially; H) Multicellular branched eglandular trichome; I) Angular & lamellar. Abbreviations: Pc. palisade cells; RC. raphides crystal; Tr. trichome; AC. angular collenchyma.**



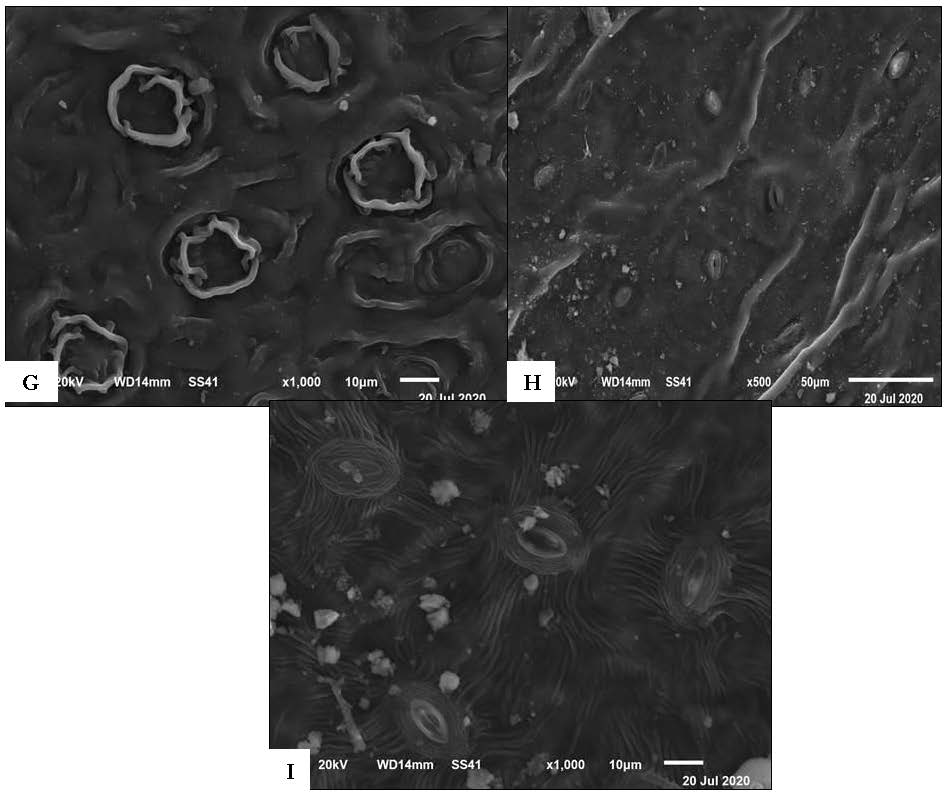
**Figure3. A-H) The main categories of lamina vein architecture with LM; A) Suprabasal 1°V, brochidodromous 2°V, random reticulate 3°V, regular polygonal reticulate 4°V 5°V; B) Pinnate 1°V, weak brochidodromous 2°V, alternate percurrent 3°V; C) Acrodromous 1°V, dichotomizing 5°V; D) Suprabasal actinodromous 1°V; E) Suprabasal acrodromous 1°V, reticulodromous 2°V; F) Dichotomizing 3°V, 4°V, 5°V.**



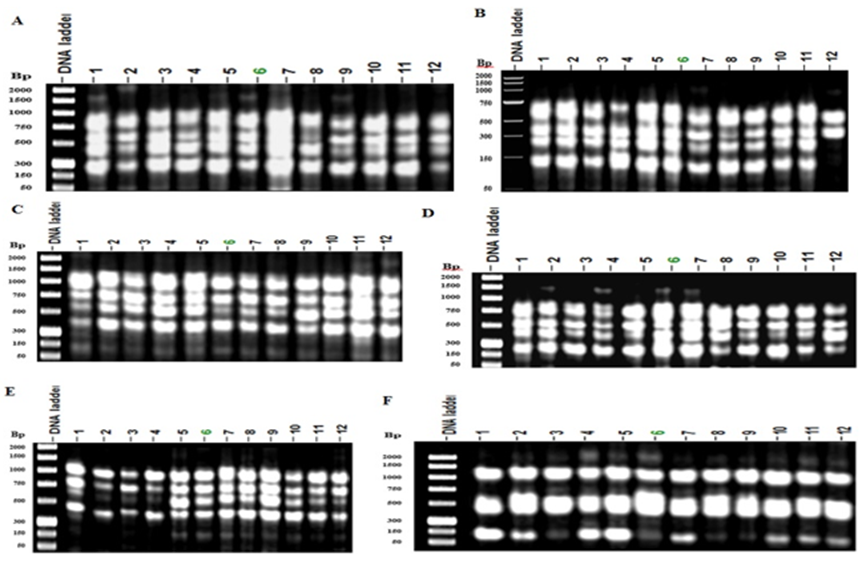
**Continued Figure3 G-H) The main categories of lamina vein architecture with LM; G) Festooned brochidodromous 2°V; H) Palinactinodromous 1°V.**



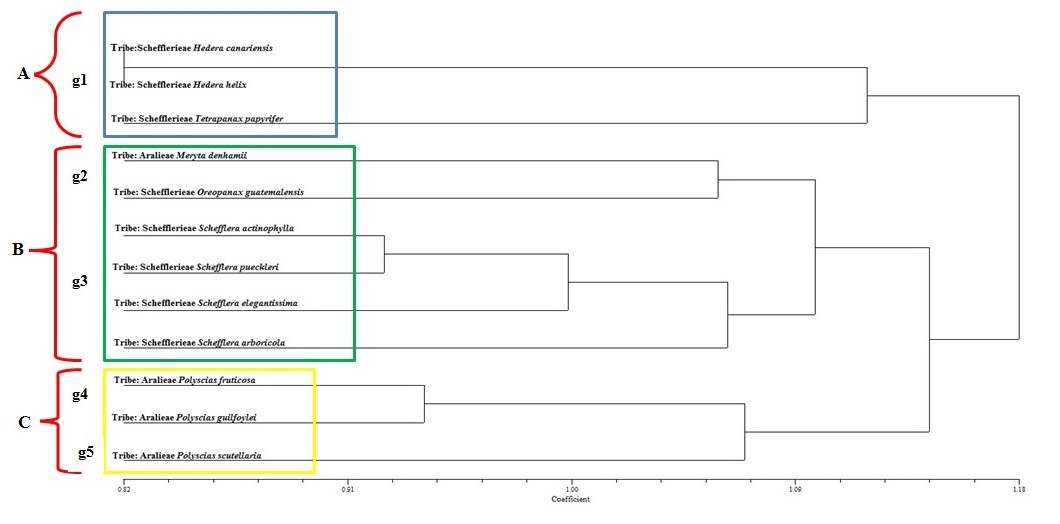
**Figure4. A-C) Major categories of stomatography as revealed with LM; A) Anomocytic & anisocytic stomata, irregular cell shape, sinuous anticlinal wall; B) Anisocytic stomata, polygonal cell shape, slightly curved anticlinal wall; C) Anisocytic & diacytic. D-F) Major types of lamina surface sculpture with SEM; D) Ruminate; E) Pusticulate; F) Reticulate-aerolate.**

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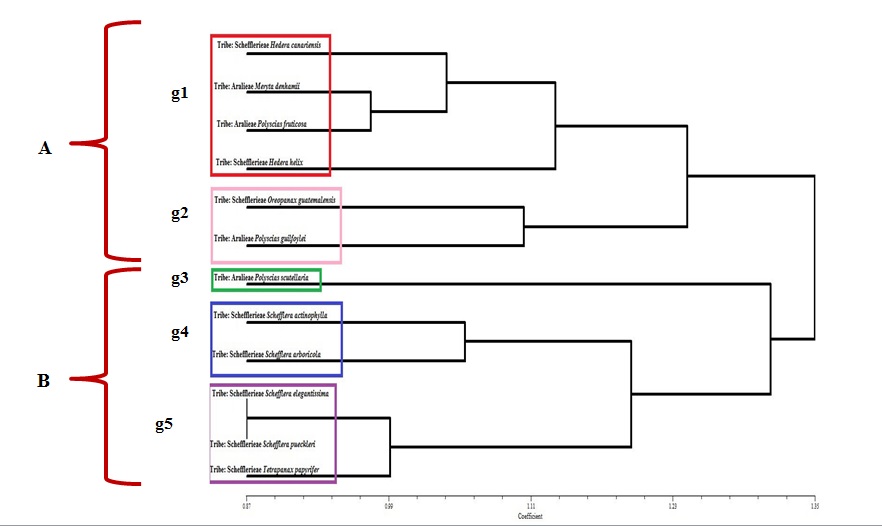
**Continued Figure4 G-I) Major types of lamina surface sculpture with SEM; G) Reticulate; H) Favulariate; I) Striate.**



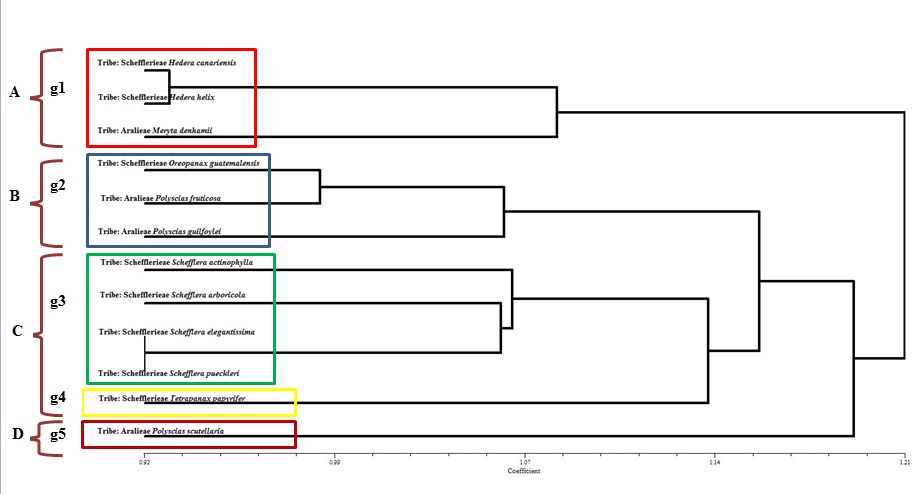
**Figure5. A-F) ISSR profile of the studied taxa of Araliaceae generated by A) iPBS primer 2270; B) primer C1; C) primer G4; D) primer PseCra5; E) primer PseLes1; F) primer PseCra3B.**



**Figure6. Dendrogram of studied taxa of Araliaceae based on morphological characters (182).**



**Figure7. Dendrogram of studied taxa of Araliaceae based on molecular characters (78).**



**C**

**Figure8. Dendrogram of studied taxa of Araliaceae based on morphological and molecular characters (260).**

Table 1. List of the studied Araliaceae taxa and their collection data.

|  |  |  |  |
| --- | --- | --- | --- |
| Location | Date of Collection | Taxa | No. |
| Mansoura University Garden | 5/2020  3/2021 | *Hedera canariensis* Willd., Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Freunde Berlin 2: 171 (1808).  Synonym: *H. grandifolia* Hibberd, The Ivy 96 (1872). | 1 |
| // | 5/2020  3/2021 | *H. helix* L., Sp. Pl. 1: 202 (1753).  Syn: *H. donerailensis* Hort. ex K.Koch, Dendrologie 1: 680 (1869). | 2 |
| Orman Botanical Garden | 5/2020  4/2021 | *Meryta denhamii* Seem., Bonplandia 10: 295 (1862).  *Syn: M. macrocarpa* Baill., Adansonia 12: 155 (1878). | 3 |
| // | 6/2020  2/2021 | *Oreopanax guatemalensis* Decne. & Planch., Rev. Hort. [Paris]. Ser. IV, iii. (1854) 108, nomen.  Syn: *O. obtusifolius* L.O.Williams, Fieldiana, Bot. 31: 20 (1965). | 4 |
| // | 5/2020  3/2021 | *Polyscias fruticosa* Harms, Nat. Pflanzenfam. [Engler & Prantl] iii. (1894) 45.  Syn: *Aralia tripinnata* Blanco, Fl. Filip. [F.M. Blanco] 223 (1837). | 5 |
| Mansoura University Garden | 5/2020  3/2021 | *P. guilfoylei* L.H.Bailey, Rhodora 1916, xviii. 153.  Syn: *Aralia guilfoylei* W.Bull, Cat. New Beautiful Rare Pl. [W. Bull] 83: 4 (1873). | 6 |
| // | 5/2020  3/2021 | *P. scutellaria* (Burm.f.) Fosberg, Occas. Pap. Univ. Hawaii 46: 9 (1948).  Syn: *Aralia cochleata* Lam., Encycl. [J. Lamarck & al.] 1(1): 224 (1783). | 7 |
| // | 5/2020  3/2021 | *Schefflera actinophylla* (Endl.) Harms, Nat. Pflanzenfam. [Engler & Prantl] 3(Abt. 8): 36 (1894).  Syn: *Brassaia singaporensis* Ridl., J. Straits Branch Roy. Asiat. Soc. 75: 38 (1917). | 8 |
| // | 5/2020  3/2021 | *S. arboricola* (Hayata) Hayata ex Merr., Lingnan Sci. J. 5(1-2): 139 (1928).  Syn: *Heptapleurum arboricola* Hayata, Icon. Pl. Formosan. 6: 23 (1916). | 9 |
| Orman Botanical Garden | 6/2020  2/2021 | *S. elegantissima* (Veitch ex Masters) Lowry & Frodin, Baileya 23(1): 9 (1989): (1989).  Syn: *Schefflera fagueti Baill., Adansonia 12: 142 (1878).* | 10 |
| Mansoura University Garden | 5/2020  3/2021 | *S. pueckleri* (K.Koch) Frodin, Baileya 23(1): 10 (1989).  Syn: *Tupidanthus calyptratus* Hook.f. & Thomson, Bot. Mag. 82: t. 4908 (1856). | 11 |
| Orman Botanical Garden | 6/2020  2/2021 | *Tetrapanax papyrifer* (Hook.) K.Koch, Wochenschr. Gärtnerei Pflanzenk. 2: 371 (1859).  Syn: *Aralia mairei* H.Lév., Repert. Spec. Nov. Regni Veg. 13: 342 (1914). | 12 |

Table 2.ISSR primers names and sequence.

|  |  |  |
| --- | --- | --- |
| No | Primers | Sequences |
| 1 | iPBS primer 2270 | 5´-ACCTGGCGTGCCA-3´ |
| 2 | C1 | 5´-AGGGCTGGAGGAGGGC-3´ |
| 3 | G4 | 5´-ACTGACTGACTGACTG-3´ |
| 4 | PseCra5 | F-5´-CCAGCGTCACCTCCATTATT-3´  R-5´-TCACAGCCAGCCACTGTATC-3´ |
| 5 | PseLes1 | F-5´-AAGTTGATGGCTTCGCTCAT-3´  R-5´-ACCACCCCAATACAAAACCA-3´ |
| 6 | PseCra3B | F-5´-ATGTTTGTGAATTGTGAGTGTGG-3´  R-5´-CCCCATCTTTTGTCCCTCA-3´ |

Table 3. Type of bands and percentage of polymorphism of ISSR primers applied on the studied taxa of family Araliaceae.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Primer | Monomorphic bands | Polymorphic | bands | | | Total bands | Polymorphism % |
| **Common** | | **Unique** |  |
| iPBS primer 2270 | 1 | 7 | | 2 | | 10 | 90 |
| C1 | 1 | 13 | | 1 | | 15 | 93.33 |
| G4 | 1 | 12 | | 1 | | 14 | 92.86 |
| PseCra5 | 0 | 13 | | 0 | | 13 | 100 |
| PseLes1 | 0 | 13 | | 0 | | 13 | 100 |
| PseCra3B | 0 | 13 | | 0 | | 13 | 100 |