DOI:10.21608/TAEC.2023.248336.1053 Taeckholmia 43 (2023): 141-176

Taxonomic relationships of some taxa of the family Amaryllidaceae (*s.l.*) as reflected by macro- and micromorphological characters

Gehad M. M. Naga[1], Sherif M. Sharawy[1], Heba H. Abouseadaa[1, 2], Salma S. Abd El-Ghany[1 *]

[1] Botany department, Faculty of Science, Ain Shams University, Cairo, Egypt
[2] Department of Biological Sciences, Faculty of Basic Sciences, Galala University, Suez, Egypt
*Corresponding authors: salmasaid@sci.asu.edu.eg

Abstract

Macro- and micromorphological characters of 31 taxa of Amaryllidaceae (representing 29 species and two varieties) were investigated. The foregoing data estimated based on the differences between them in the macromorphological characters *viz*. whole plant, habit, root, stem, leaf, inflorescence, flowers, and fruit characters in addition to micromorphological traits *viz*. root, stem, scape, a portion of the middle lamina characters and lamina epidermal characteristics. The data were numerically analyzed using NTSYS-pc program (version 2.02) (Rohlf 2005). The main objective of the current investigation is interpreting the similarities and dissimilarities between the studied taxa to facilitate the separation and support the systematic position of these taxa within their specific categories. The conclusion of the study supports the separation of the examined taxa in two separate families; family Agavaceae which include the genera *Agave* and *Furcraea* and family Amaryllidaceae which divided into three subfamilies; Hypoxidoideae, Amaryllidoideae and Allioideae. Moreover, supports the transfer of *Molineria capitulata* from family Hypoxidaceae to subfamily Hypoxidoideae under family Amaryllidaceae and does not support the grouping of *Agave polianthes* in family Agavaceae and also confirms returning the species name to *Polianthes tuberosa*. However, the present study confirmed the inclusion of *Allium* species in tribe Allieae and *Agapanthus africanus* and *Tulbaghia violacea* in tribe Agapantheae belong to subfamily Allioideae in the family Amaryllidaceae.

Key Words: Anatomy; Classification; Monocotyledons; Morphology; UPGMA analysis

Introduction

The Amaryllidaceae (*s.l.*) a cosmopolitan family of petaloid monocots, represents one of the elements of the Linnaean *Hexandria monogynia* (Linnaeus 1753). Fifty-one genera of which have been variously classified since as Liliaceous or Amaryllidaceous. This basic dichotomy represents the generally uncertain phylogenetic placement of many petaloid monocots until the past two clades. Several genera of the fifty-one that Linnaeus placed them in *Hexandria monogynia* have been included within different common taxonomic unit, as section Narcissi (Adanson 1763; Jussieu 1789), suborder Amarylleae (Baker 1888), order Amaryllidales (Lindley 1836; Herbert 1837), subfamily Amaryllidoideae (Traub 1963; Pax 1888), family Amaryllidaceae (Jaume 1805; Brown 1810; Bentham & Hooker 1883 and Hutchinson 1934, 1959).

Brown (1810) was the first to propose that the genera with superior ovaries be excluded from Amaryllidaceae, a restricted followed faithfully until Hutchinson (1934). Hutchinson's (1934, 1959) classification was the first radical circumscription of Amaryllidaceae since Brown (1810). In defining the unifying character of the family to be "an umbellate inflorescence subtended by an involucre of one or more spathaceous bracts" he segregated Agavaceae, Hypoxidaceae and Alstroemeriaceae and added tribes Agapantheae, Allieae and Gilliesieae (Alliaceae). Takhtajan (1969) recognized Amaryllidaceae in the narrowest sense and maintained a distinct Alliaceae. Thorne (1976) and Cronquist (1988) included Amaryllidaceae within broad concepts of Liliaceae.

Received on 13/11/2023 and accepted on 19/12/2023

Recently, Shipunov (2007, 2009, 2010 & 2021) included Amaryllidaceae along with Asparagaceae in the order Liliales. APG II (2003); APG III (2009); APG IV (2016) considered Amaryllidaceae (*s.l.*) along with Alliaceae, Hypoxidaceae and Asparagaceae (*s.l.*) in addition to other 11 families under Asparagales based on phylogenetic studies.

At infra-familial and tribal level, Bentham & Hooker (1883) stated that Amaryllidaceae included the tribes Hypoxideae, Alstroemerieae, Agaveae, Vellozieae and Amaryllideae, based on the presence of inferior ovary. Pax & Hoffmann (1930). reclassified the Amaryllidaceae into four subfamilies: Amaryllidoideae, Agavoideae, Hypoxidoideae and Campanematoideae depending on the habit of the plant and the type of the inflorescence. Furthermore, they used the presence or absence of corona to subdivide Amaryllidoideae into two tribes: Amaryllideae and Narcisseae. Traub (1963) included two additional groups with superior ovary in Amaryllidaceae, the Allioideae and Hemerocalloideae, based on comparative organography and chromosome numbers. Hutchinson (1973) defined the family Amaryllidaceae using inflorescence characters, and included beside the Allieae, two additional groups with superior ovary, Agapantheae, and Gilliesieae.

Dahlgren *et al.* (1985) distinguished 9 tribes in this family and restructured the classification of Amaryllidaceae depending on the morphological, cytological, and chemical characters. Müller-Doblies & Müller-Doblies (1996) recognized 10 tribes and 19 subtribes in the family Amaryllidaceae while Meerow & Snijman (1998) recognize 14 tribes. Currently Amaryllidaceae is divided into three subfamilies: Agapanthoideae, Allioideae and Amaryllidoideae (Chase *et al.* 2009 and Büneker *et al.* 2016).

Amaryllidaceae consists of perennial herbs, either caulescent or acaulescent bulbous, cormous, rhizomatous, or fibrous-rooted. Leaves radical or cauline, alternate, mostly narrow with entire margin. Inflorescence a terminal spike, umbel, raceme or panicle, Flowers are usually bisexual, the perianth of six parts or lobes, at least the three inner parts simulating a corolla. Stamens usually six, inserted in the throat or on base of perianth segments, the anthers introse. Style long and filiform. Stigma usually 3-loobed or fid. Ovary inferior or superior, 3-celled, each cell with many or sometimes only few ovules, placentation typically axile. Fruit a capsule or sometimes baccate, mostly loculicidal.

Unfortunately, little anatomical works have been carried out on the family. Few comprehensive, detailed surveys of vegetative anatomy have been published and delimited such as root anatomy (Kauff *et al*. 2000), leaf anatomy (Arroyo & Cutler 1983) and inferior ovary (Sharawy & Khalifa 2018) or have been restricted to studies of individual cell types, such as tracheids and vessels elements (Cheadle 1969), meriestms (Fisher & French 1978), stomata (Shah & Gopal 1970). Also, to genera e.g., *Cyrtanthus* (Gordon-Gray & Wright 1969), *Pancratium* (Björnstad 1973) and *Amaryllis* (Artyushenko 1970).

In this work, the macro- and micromorphological characters of 31 taxa of Amaryllidaceae (*s.l.*) collected from different localities in Egypt were studied. The data were analyzed by a clustering method and similarity coefficient using NTSYS-pc program. Finally, the data produced from all attributes were combined and used to construct and compare the phenetic relationships and to explore the contribution of macro- and micromorphological characters in classification of Amaryllidaceae in the light of current system of classification.

Materials and Methods

Fresh fully mature flowering specimens representing 29 species, and two varieties belonging to 12 genera of Amaryllidaceae were collected from their natural habitats and different botanical gardens in Egypt (Table 1). The studied taxa were identified according to Taeckholm (1974) and Boulos (2005) for wild taxa and according to Bailey (1949) and Bailey & Bailey (1976) for cultivated taxa. Moreover, some websites were used to update the scientific names *viz*. (http: www.ipni.orglind ex. Html.; http: www. the plant lists. Org. and http: www.tropicos. Org.). Herbarium specimens of the studied taxa were deposited at the Herbarium of Botany Department, Faculty of Science, Ain Shams University.

The macromorphological characters of the whole plant, habit, root, stem, leaf, inflorescence, flowers, and fruit were studied and described directly from the fresh specimens (Plate I). Macrophotographs for the studied taxa were taken by Canon Power Shot A720 digital camera. The Pollen grains of the studied taxa were collected from mature flowers by a needle or laboratory wire loop. The collected pollen grains of each taxon were mounted in two drops of glycerol on a clean slide for microscopic investigation. The pollen characters are cited from Dönmez & Işik (2008), Bhattacharya *et al*. (2011) and Bahadur *et al*. (2018).

Several transverse and vertical sections of root, stem, scape, and a portion of the middle lamina were prepared according to Johanson (1940) for micromorphological investigations (Plate II). Terminology of Eames (1929); Metcalfe & Chalk (1950) was used to describe the anatomical features. For the study of leaf surface characters adaxial and abaxial epidermal peels were soaking in equal volumes of nitric acid and hydrogen peroxide solution in petri dishes, placed in electric oven until appearing air bubbles under the leaf surface of the fragments, washed in distilled water, then transferred into 50% alcohol to harden for about 2 min, stained in safranine for 3-5 min., and mounted in glycerin on a slide with the edges of the cover slip. The stomata and trichomes characters were described according to Solerder (1908); Bahadur *et al.* (2018). The cross sections of root, stem, leaf, and scape were examined and photographed using Olympus CX23LEDRFS1 light microscope with digital Canon power shot A720 camera.

The relationships among the studied taxa were estimated based on the differences between them in the macro- and micromorphological traits separately and in combination. The macro- and micromorphological traits were given codes ranging between 0 and 9 depending on the variation in the average value for the measured traits (Table 2). To construct trees elucidating the relationships among the studied taxa, the coded data were analyzed using UPGMA method based on distance matrix (Sneath & Sokal 1973; Dunn & Everitt 1982). All analyses were performed with NTSYS-pc, version 2.02 program (Rohlf 2005).

Table 1. List of the studied taxa and their localities

No	Studied Taxa	Locality
1	*Agapanthus africanus* (L.) Hoffmanns	Mazhar Botanical Garden in Giza, Agricultural Museum Garden in Cairo
2	*Agave americana* L.	Orman Botanical Garden in Giza, Ain Shams Botanical Garden in Cairo
3	*Agave americana* var. *marginata* Trel	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza, Agricultural Museum Garden in Cairo
4	*Agave angustifolia* var. *marginata* Gentry	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza, Agricultural Museum Garden in Cairo
5	*Agave attenuata* Salm-Dyck.	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza, Agricultural Museum Garden in Cairo
6	*Agave decipiens* Baker	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza
7	*Agave ferox* K. Koch	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza
8	*Agave macroacantha* Zucc.	Orman Botanical Garden in Giza
9	*Agave polianthes* Thiede & Eggli	Flower Shop
10	*Agave pygmaea* Gentry	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza, Agricultural Museum Garden in Cairo
11	*Agave sisalana* Perrine	Ain Shams Botanical Garden in Cairo

12	*Agave victoriae-reginae* T. Moore	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza
13	*Allium cepa* L.	Private Plant Nurseries
14	*Allium sativum* L.	Qaliobya Farmers' Fields
15	*Allium tuberosum* Rottler ex Spreng.	Ain Shams Botanical Garden in Cairo
16	*Amaryllis belladonna* L.	Orman Botanical Garden in Giza
17	*Amaryllis reginae* L.	Agricultural Museum Garden in Cairo
18	*Amaryllis vittata* L'Hér.	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza, Agricultural Museum Garden in Cairo
19	*Clivia miniata* (Lindl.) Verschaff.	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza
20	*Clivia nobilis* Lindl.	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza
21	*Crinum asiaticum* L.	Orman Botanical Garden in Giza, Mazhar Botanical in Garden Giza, Ain Shams Botanical Garden in Cairo
22	*Crinum augustum* Roxb.	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza
23	*Crinum bulbispermum* (Burm.f.) Milne-Redh. & Schweick.	Ain Shams Botanical Garden in Cairo
24	*Crinum jagus* (J. Thomps.) Dandy	Mazhar Botanical Garden in Giza
25	*Furcraea foetida* (L.) Haw.	Orman Botanical Garden in Giza, Mazhar Botanical Garden in Giza, Agricultural Museum Garden in Cairo
26	*Hymenocallis littoralis* (Jacq.) Salisb.	Heliopolis Road Gardens in Cairo, Mazhar Botanical Garden in Giza, Azhar University Garden in Cairo
27	*Molineria capitulata* (Lour.) Herb.	Mazhar Botanical Garden in Giza, Zuhria Botanical Garden in Cairo
28	*Narcissus tazetta* L.	Ain Shams Botanical Garden in Cairo
29	*Pancratium arabicum* Sickenb.	The Western Mediterranean Coastal Region
30	*Pancratium maritimum* L.	The Western Mediterranean Coastal Region
31	*Tulbaghia violacea* Harv.	Mazhar Botanical Garden in Giza

Results

Relationships based on macromorphological attributes

The UPGMA cluster analysis illustrating the relationships based on 59 macromorphological attributes is shown in (Fig. 1). At this level, eleven taxa (*Furcraea foetida*, *Agave attenuata*, *A. victoriae-reginae*, *A. macroacantha*, *A. angustifolia* var. *marginata, A. americana* var. *marginata*, *A. sisalana*, *A. pygmaea*, *A. ferox*, *A. decipiens*, and *A. americana*) are delimited together as a separate cluster from another major cluster that comprises the remaining taxa of family Amaryllidaceae (*Molineria capitulata*, *Clivia miniata*, *C. nobilis*, *Pancratium arabicum*, *P. maritimum*, *Narcissus tazetta*, *Hymenocallis littoralis*, *Crinum augustum*, *C. bulbispermum*, *C. jagus*, *C. asiaticum*, *Amaryllis vittata*, *A. reginae*, *A. belladonna*, *Agave polianthes*, *Allium tuberosum*, *A. sativum*, *A. cepa*, *Agapanthus africanus* and *Tulbaghia violacea*) at UPGMA distance coefficient of about 1.18. In the former major cluster, at a taxonomic distance of about 0.6 the two species *Furcraea foetida* and *Agave attenuata* are split off from the other species of *Agave*. *Agave victoriae-reginae* and *A. macroacantha* are also separated from other species at the taxonomic distance of about 0.48 and 0.38 respectively. The remaining species of *Agave* are divided into two groups at the 0.31 level. The first group includes *Agave angustifolia* var. *marginata* and *A. americana* var. *marginata* while the second group includes *Agave sisalana*, *A. pygmaea*, *A. ferox*, *A. decipiens* and *A. americana*. In the second major cluster *Molineria capitulata* is clearly separated from the remaining taxa at a taxonomic distance of about 0.84. The remaining taxa are divided into two groups, the first group includes

Tulbaghia violacea, *Agapanthus africanus*, *Allium cepa*, *A. sativum,* and *A. tuberosum* and the second group includes *Agave polianthes*, *Amaryllis belladonna*, *A. vittata*, *A. reginae*, *Crinum asiaticum*, *C. jagus*, *C. bulbispermum*, *C. augustum*, *Hymenocallis littoralis*, *Narcissus tazetta*, *Pancratium arabicum*, *P. maritimum*, *Clivia miniata*, and *C. nobilis.* Within the first group, *Tulbaghia violacea* and *Agapanthus africanus* are separated together from the three species of *Allium* (*A. cepa*, *A. sativum*, and *A. tuberosum*) at an average taxonomic distance of about 0.73. In the second cluster, *Agave polianthes* and the two species of *Clivia* (*C. miniata*, and *C. nobilis*) are separated from the remaining taxa at taxonomic distances of about 0.68. The remaining taxa are divided into two groups at a distance of 0.64, the first group includes the three species of *Amaryllis* (*A. belladonna*, *A. vittata*, and *A. reginae*) and the second group is also divided into two subgroups; the first subgroup comprises the four species of *Crinum* (*C. asiaticum*, *C. jagus*, *C. bulbispermum*, and *C. augustum*). The latter species *Crinum augustum* is distinguished from the other three species of *Crinum* at an average taxonomic level of about 0.48. While the second subgroup includes *Hymenocallis littoralis*, and *Narcissus tazetta*, which are separated at distance of about 0.48 and 0.41 respectively from the two species of *Pancratium* (*P. arabicum* and *P. maritimum*).

Relationships based on micromorphological attributes:

The UPGMA phenogram produced from the cluster analysis based on the 72 micromorphological characters is shown in (Fig. 2). The topography of this tree resembles that of the tree based on macromorphological attributes. The studied taxa are delimited in two major clusters, the first cluster consists of (*Furcraea foetida*, *Agave polianthes*, *A. pygmaea*, *A. ferox*, *A. decipiens*, *A. sisalana*, *A. americana* var. *marginata*, *A. attenuata*, *A. victoriae-reginae, A. macroacantha*, *A. angustifolia* var. *marginata,* and *A.* americana) while the second cluster comprises the remaining taxa of family Amaryllidaceae (*Hymenocallis littoralis*, *Clivia miniata*, *C. nobilis*, *Molineria capitulata*, *Pancratium arabicum*, *P. maritimum, Narcissus tazetta, Tulbaghia violacea, Amaryllis vittata, A. reginae, A. belladonna, Crinum jagus*, *C. bulbispermum*, *C. augustum*, *C. asiaticum*, *Allium tuberosum A. sativum*, *A. cepa* and *Agapanthus africanus*). In the first major cluster, *Furcraea foetida*, and *Agave polianthes* are separated at distances of about 0.97 and 0.88 respectively from the remaining species of *Agave*. The remaining species are also separated into two groups at 0.44 Level. The first group contains *Agave pygmaea*, *A. ferox*, *A. decipiens*, *A. sisalana*, and *A. americana* var. *marginata* while the second group contains *Agave attenuata*, *A. victoriae-reginae*, *A. macroacantha*, *A. angustifolia* var. *marginata*, and *A. americana*. In the second major cluster, *Hymenocallis littoralis*, *Clivia miniata* and *C. nobilis* are clearly separated at a distance of about 0.83 from the other taxa. Also, *Agapanthus africanus* and *Molineria capitulata* are separated from the remaining taxa at a taxonomic distance of 0.80 and 0.73 respectively. The remaining taxa are then delimited as two groups at taxonomic distance of about 0.65, the first group contains *Allium cepa*, *Allium sativum*, *Allium tuberosum*, *Crinum asiaticum*, *C. jagus*, *C. bulbispermum*, and *C. augustum*, where at distance of about 0.52 the three species of *Allium* are separated from the four species of *Crinum*. The second group is divided into two subgroups at 0.53 level. The first subgroup comprises *Narcissus tazetta*, *Pancratium arabicum* and *P. maritimum*. The second subgroup comprises *Tulbaghia violacea*, *Amaryllis belladonna*, *A. reginae* and *A. vittata*. At a distance level of about 0.38 *Tulbaghia violacea* is clearly delimited from the three *Amaryllis* species. The latter three species are distinguished from each other, where *Amaryllis vittata* is distinct at an average taxonomic level of about 0.26 from *A. belladonna* and *A. reginae*.

Relationships based on macro- and micromorphological attributes combination:

The overall relationship between the studied taxa based on variation of 131 macro-and micromorphological attributes is illustrated by the UPGMA tree shown in (Fig. 3). In this tree the studied taxa are separated into two clusters; the first cluster comprises (*Furcraea foetida*, *Agave attenuata*, *A. victoriae-reginae*, *A. pygmaea*, *A. sisalana*, *A. ferox, A. decipiens, A. americana* var. *marginata, A. macroacantha, A. angustifolia* var. *marginata,* and *A. americana*) and the second cluster comprises (*Molineria capitulata*, *Agave polianthes*, *Clivia miniata*, *C. nobilis*, *Crinum asiaticum*, *C. jagus*, *C. bulbispermum*, *C. augustum*, *Pancratium arabicum*, *P. maritimum*, *Narcissus tazetta*, *Hymenocallis littoralis*, *Amaryllis belladonna*, *A. vittata*, *A. reginae*, *Tulbaghia violacea*, *Agapanthus africanus*, *Allium cepa*, *A. sativum*, and *A. tuberosum*) at distance coefficient of about 1.25. Within the first cluster, *Furcraea foetida*, *Agave attenuata* and *A. victoriae-reginae* are splitted off from the rest species of *Agave* at a taxonomic distance of about 0.82, 0.62 and 0.56 respectively. The remaining species of *Agave* are divided into two groups at 0.44 level. In the first group, *Agave americana* var. *marginata* is separated from the remaining taxa at a taxonomic distance of about 0.42. The remaining taxa are divided into two subgroups; the first subgroup includes *Agave pygmaea* while the second subgroup includes *Agave sisalana*, *A. ferox* and *A. decipiens*. The second group includes *Agave macroacantha*, *A. americana* and *A. angustifolia* var. *marginata*.

While in the second cluster; *Molineria capitulata* and *Agave polianthes* are clearly separated from the remaining taxa at a taxonomic distance of about 1.1 and 0.94 respectively. The remaining taxa are divided into two groups at a taxonomic distance 0.84. The first group includes *Clivia miniata*, *C. nobilis*, *Crinum asiaticum*, *C. jagus*, *C. bulbispermum*, *C. augustum*, *Pancratium arabicum*, *P. maritimum*, *Narcissus tazetta*, *Hymenocallis littoralis*, *Amaryllis belladonna*, *A. vittata* and *A. reginae* while the second group includes *Tulbaghia violacea*, *Agapanthus africanus*, *Allium cepa*, *A. sativum*, and *A. tuberosum*. The first group at a taxonomic distance 0.80 segregated into 6 subgroups: the first subgroup including (*Clivia miniata* and *C. nobilis*), the second subgroup including (*Crinum asiaticum*, *C. jagus*, *C. bulbispermum* and *C. augustum*), the third subgroup including (*Pancratium arabicum* and *P. maritimum*), the fourth subgroup including *Narcissus tazetta*, the fifth subgroup including *Hymenocallis littoralis* and the sixth subgroup including (*Amaryllis belladonna*, *A. vittata*, and *A. reginae*). The second group in turn divided into two subgroups; the first subgroup containing *Agapanthus africanus* and *Tulbaghia violacea* that are separated from the second subgroup that includes the three species of *Allium* (*A. cepa*, *A. sativum*, and *A. tuberosum*) at an average taxonomic distance of about 0.80.

Discussion

The relationships between the studied species of the family Amaryllidaceae (*s. l.*) are discussed in the present work through the numerical analysis of all attributes *viz*. macro- and micromorphological characters (Fig. 3). The generated dendrogram clarifies the clustering of *Agave attenuata, A. victoriae-reginae, A. pygmaea, A. sisalana, A. ferox, A. decipiens, A. americana* var. *marginata, A. macroacantha, A. angustifolia* var. *marginata,* and *A. americana* along with *Furcraea foetida* in one cluster.

Although, the *Agave* and *Furcraea* species are characterized by presence of inferior ovary which is the most important character of the family Amaryllidaceae (Benaream & Hooker 1883). The macro- and micromophological characters observed in this study are consonant with Gray (1821) and Lindley (1846) who placed them in separate family. Hutchinson (1959) removed several taxa of family Agavaceae from Amaryllidaceae based on the morphological characters of stem and inflorescences type, also Meerow & Snijman (1998) based on phylogenetic analysis of rbcL sequence and nrDNA (ITS) sequence data separated the family Agavaceae from the family Amaryllidaceae. The macro-and micromorphological characters recorded in this study have also confirmed the separation of these genera (*Agave* and *Furcraea*) in the family Agavaceae. Macromorphologically; spiral sessile leaves with spiny apex and margin, the presence of terminal raceme or panicle inflorescence and spheroidal, reticulate and disulcate pollen grains (Plate I, 32 & 33).

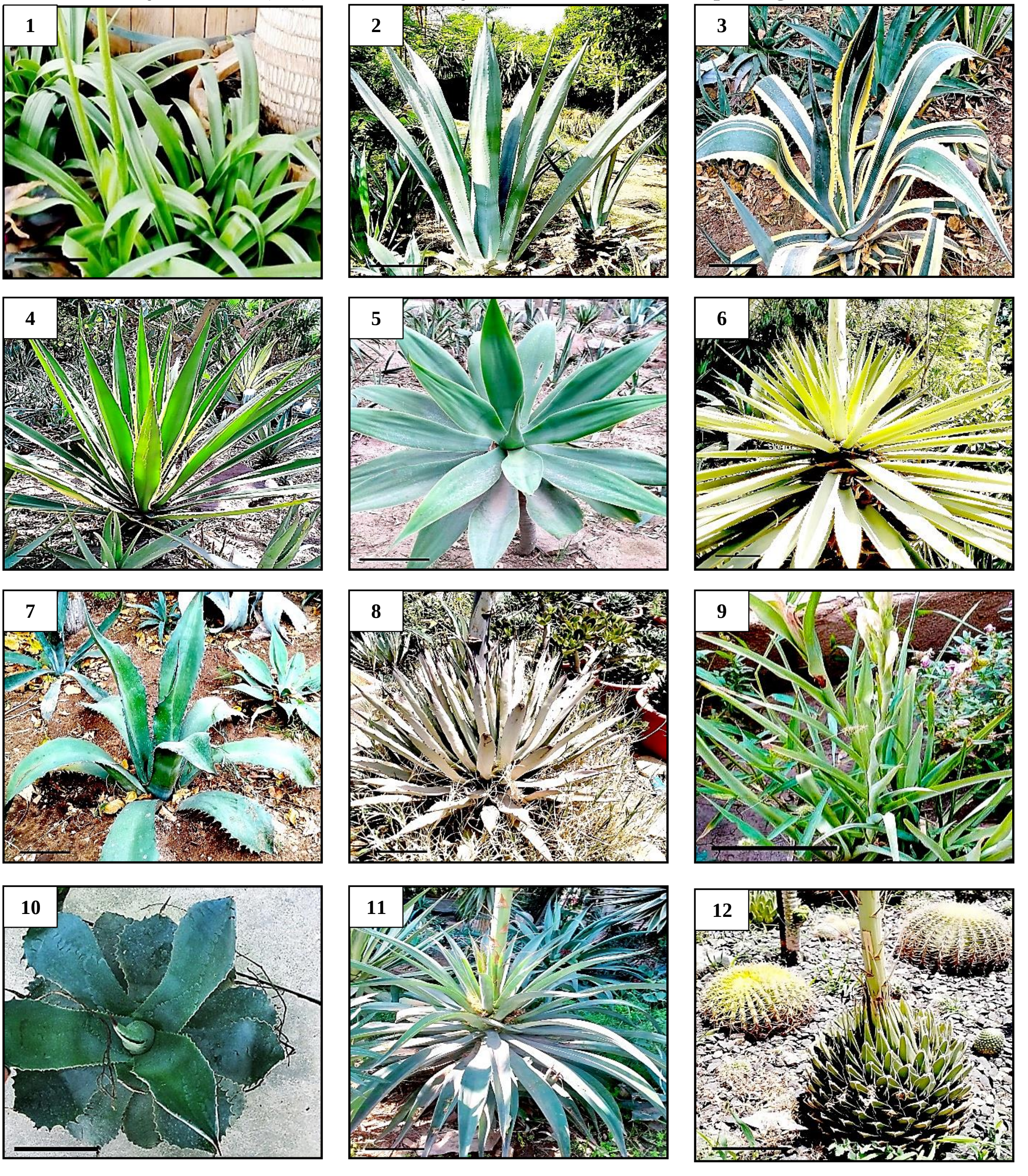
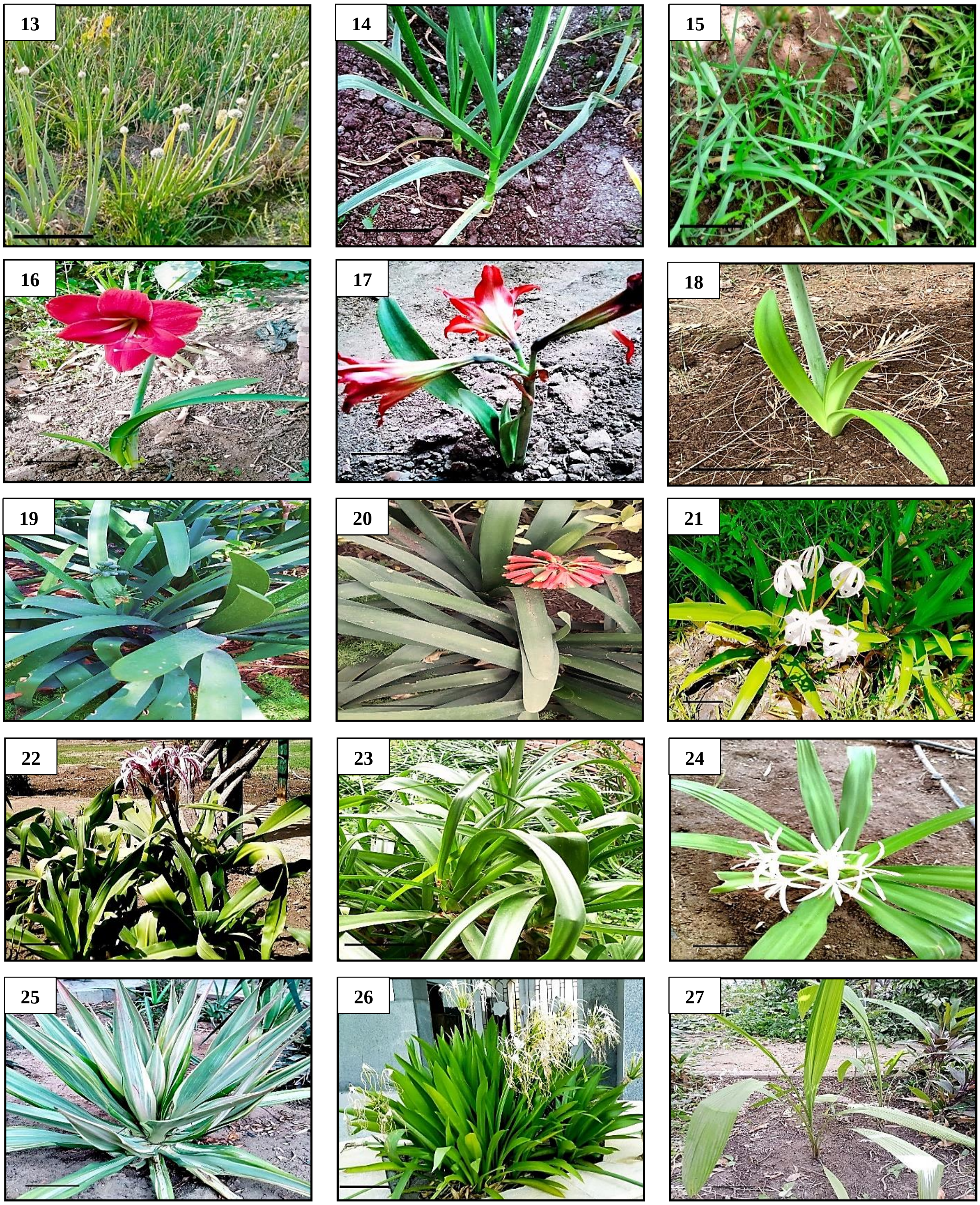
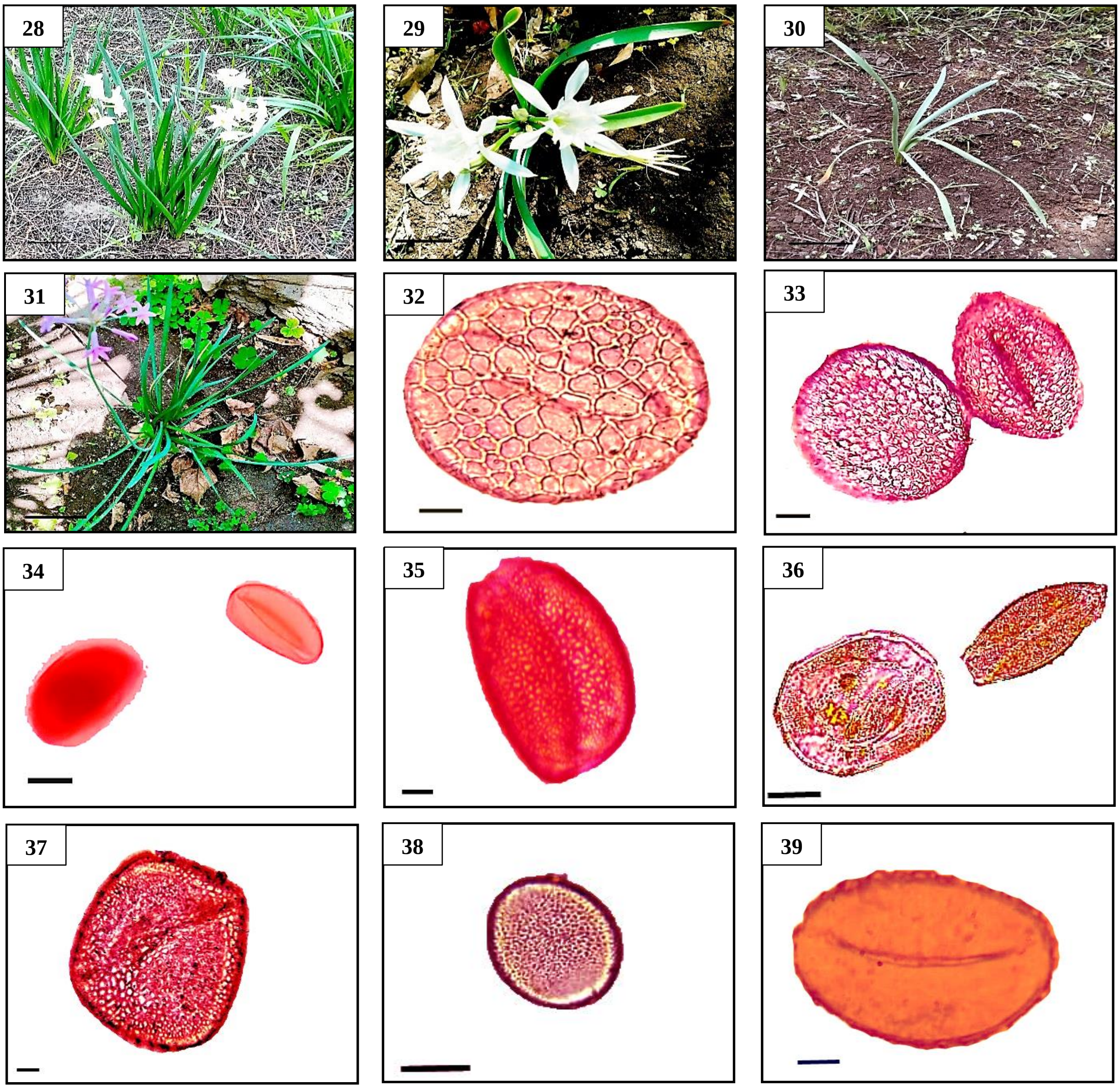


Plate I. Photomacrographs of whole plant of the studied taxa. **1.** *Agapanthus africanus*, Scale = 2cm. **2.** *Agave americana*, Scale = 2cm. **3.** *Agave americana* var *marginata*, Scale = cm. **4.** *Agave angustifolia* var. *marginata*, Scale = 2cm. **5.** *Agave attenuata*, Scale = 2cm. **6.** *Agave decipiens*, Scale = 2cm. **7.** *Agave salmiana* var. *ferox,* Scale = 2cm. **8.** *Agave macroacantha*, Scale = 2cm. **9.** *Agave polianthes*, Scale = 2cm. **10.** *Agave pygmaea*, Scale = 2cm. **11.** *Agave sisalana*, Scale = 2cm. **12.** *Agave victoriae-reginae*, Scale = 2cm.



Cont. Plate I. Photo macrographs of whole plant of the studied taxa. **13.** *Allium cepa*, Scale = 2cm. **14.** *Allium sativum*, Scale = 2cm. **15.** *Allium tuberosum*, Scale = 2cm. **16.** *Amaryllis belladonna*, Scale = 2cm. **17.** *Amaryllis reginae*, Scale = 2cm. **18.** *Amaryllis vittata*, Scale = 2cm. **19.** *Clivia miniata*, Scale = 2cm. **20.** *Clivia nobilis*, Scale = 2cm. **21.** *Crinum asiaticum, Scale* = 2cm. **22.** *Crinum augustum*, Scale = 2cm. **23.** *Crinum bulbispermum*, Scale = 2cm. **24.** *Crinum jagus*, Scale = 2cm. **25.** *Furcraea foetida*, Scale = 2cm. **26.** *Hymenocallis littoralis*, Scale = 2cm. **27.** *Molineria capitulata*, Scale = 2cm.



Cont. Plate I. 28-31: Photomacrographs of whole plant of the studied taxa. **28.** *Narcissus tazetta*, Scale = 2cm. **29.** *Pancratium arabicum,* Scale = 2cm. **30.** *Pancratium maritimum,* Scale = 2cm. **31.** *Tulbaghia violacea*, Scale = 2cm.

32-39: Photomacrographs of the different types of pollen grains of studied taxa. **32.** Showing reticulate and disulcate pollen grain in *Agave victoriae-reginae*, Scale = 20µm. **33.** Showing reticulate and disulcate pollen grain in *Agave sisalana*, Scale = 10µm. **34.** Showing oblate pollen grain in *Molineria capitulata*, Scale = 50µm. **35.** Showing oblate-spheroidal and monosulcate pollen grain in *Clivia nobilis***, Scale** = 10µm. **36.** Showing oblate-spheroidal, granulate and disulcate pollen grain in *Crinum jagus*, Scale = 50µm. **37.** Showing oblate-spheroidal, reticulate and monosulcate pollen grain in *Amaryllis reginae*, Scale = 10µm. **38.** Showing sub-prolate pollen grain in *Tulbaghia violacea*, Scale = 10µm. **39.** Showing sub-prolate, psilate, and monosulcate pollen grain in *Allium tuberosum*, Scale = 20µm.

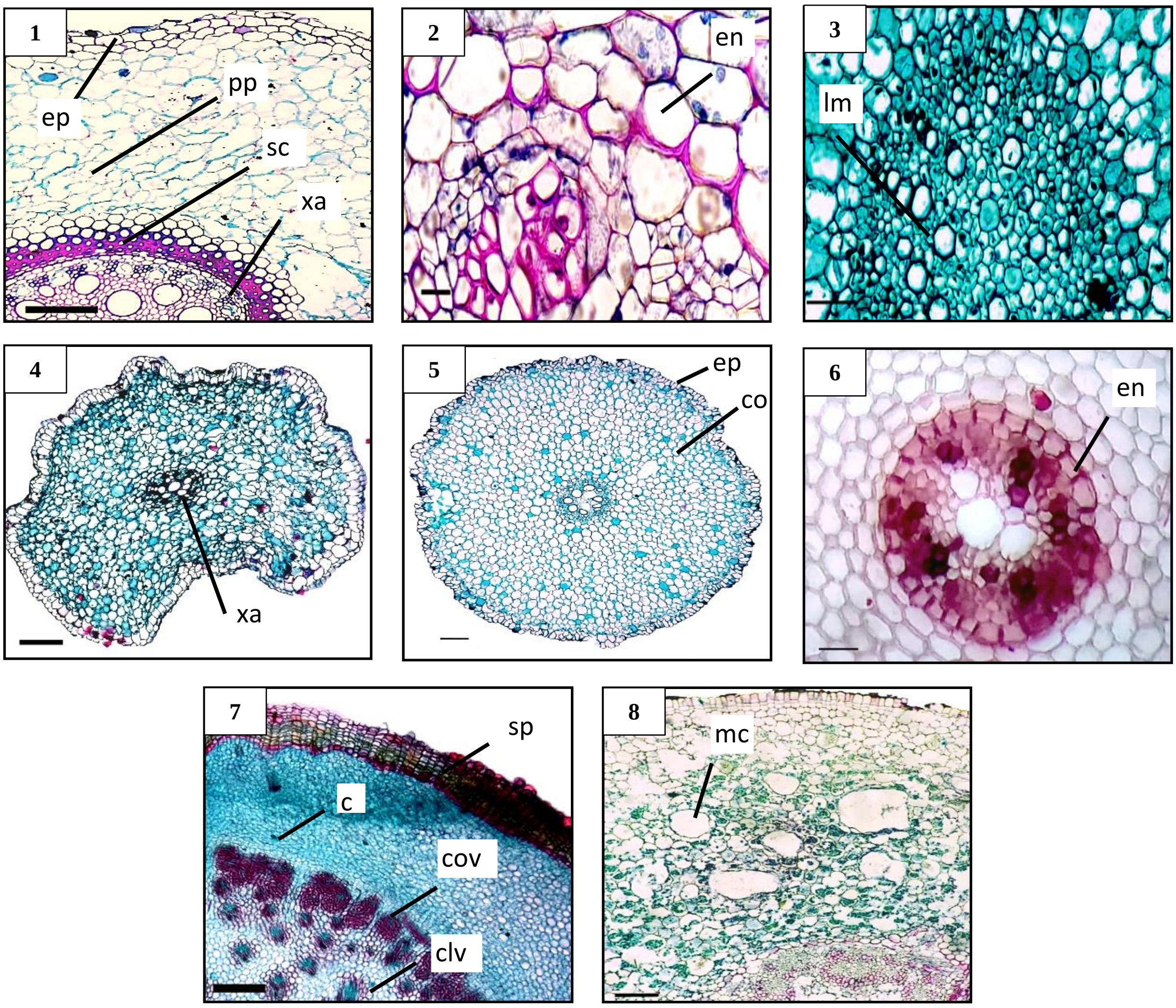
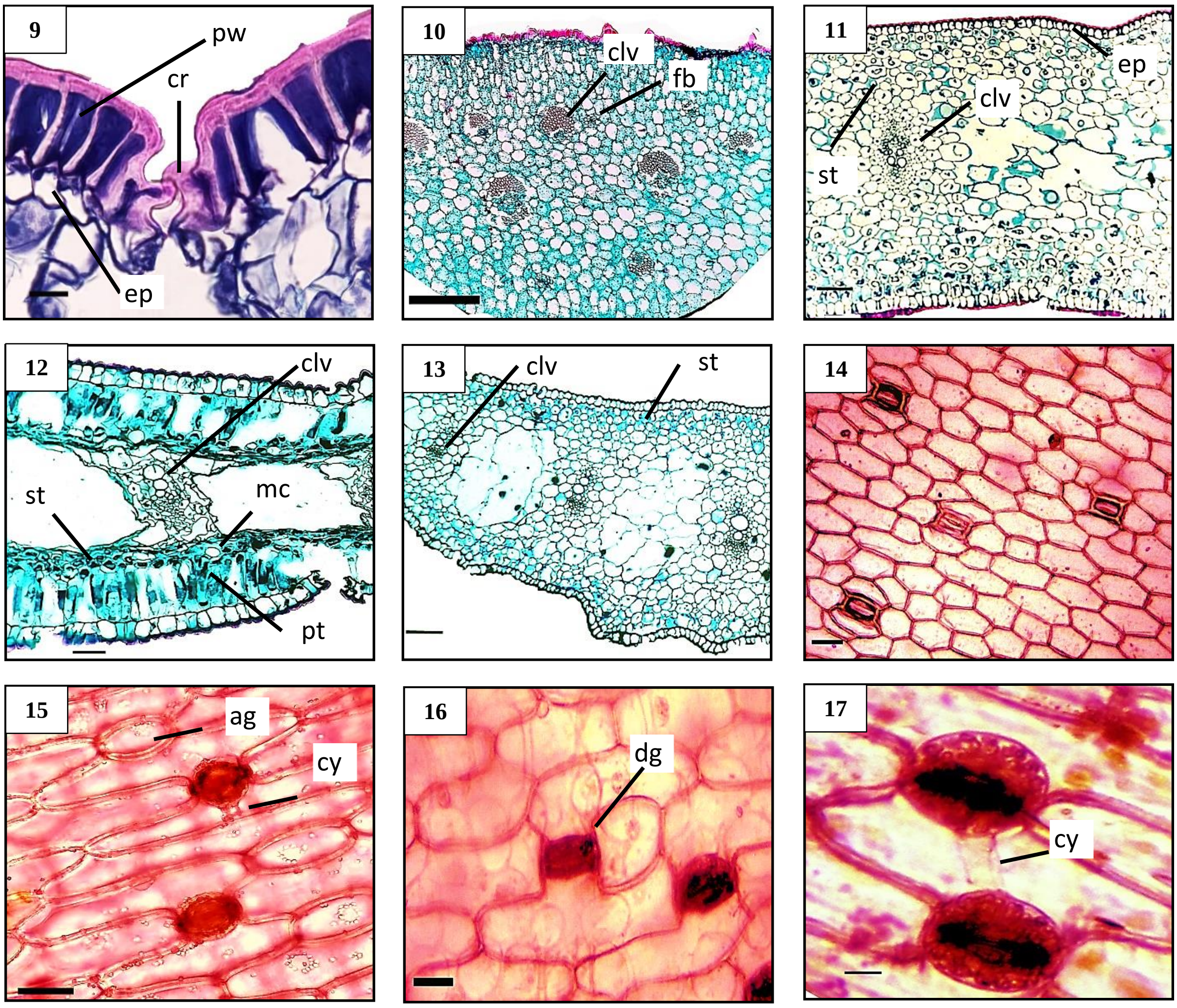


Plate II. 1-6: Photomicrographs of the root cross section of the studied taxa. **1.** Showing multiseriate epidermis and the xylem arches in *Agave angustifolia* var. *marginata*, Scale = 50µm. **2.** Showing the endodermal layer thickening on both inner periclinal and anticlinal walls in *Molineria capitulata*, Scale = 50µm. **3.** Showing non-lignified endodermis, pith consists of polyhedral parenchyma and late metaxylem in *Clivia miniata*, Scale = 50µm. **4.** Showing the five xylem arches in *Narcissus tazetta*, Scale = 50µm. **5.** Showing cortical tissue with polyhedral parenchyma and pith of polyhedral parenchyma in *Tulbaghia violacea*, Scale = 190µm. **6.** Showing the endodermal layer thickening on anticlinal walls in *Allium tuberosum*, Scale = 50µm.

7-8: Photomicrographs of the stem cross section of the studied taxa. **7.** Showing subepidermal periderm, a ring of cambial cells surrounding the vascular bundles, closed collateral vascular bundles with lignified sheath and concentric amphivasal bundles in *Agave macroacantha*, Scale = 100µm. **8.** Showing mucilage cells in cortex in *Molineria capitulata*, Scale = 50µm.

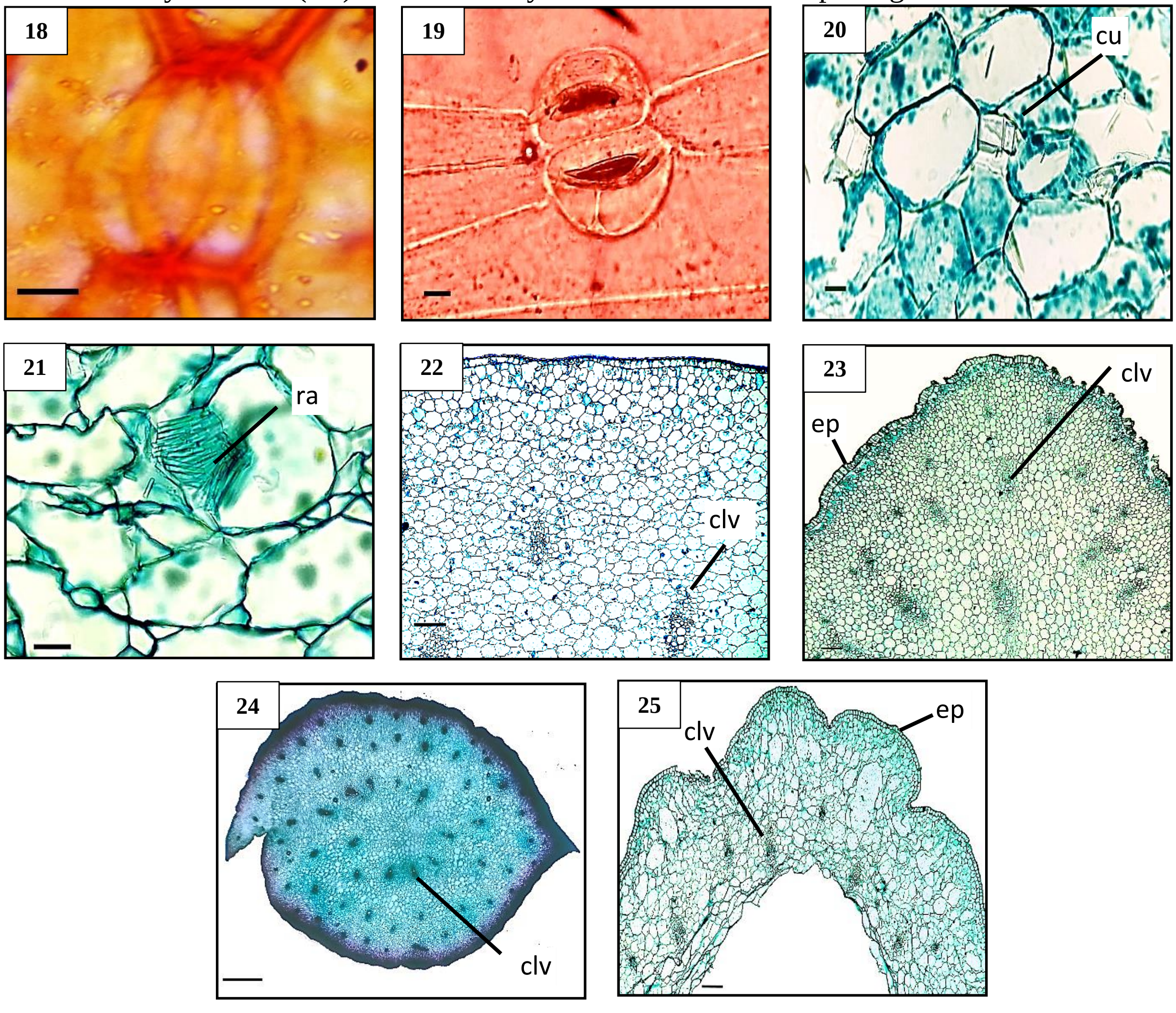
Abbreviations **c:** Cambial cells. **clv:** Closed collateral vascular bundle. **co:** Cortex. **cov:** Concentric amphivasal vascular bundle. **en:** endodermis. **ep:** Epidermis. **lm:** Late metaxylem. **mc:** Mucilage cell. **pp:** Polyhedral parenchyma. **sc:** Sclerenchyma. **sp:** Subepidermal periderm. **xa:** Xylem arch.



Cont. Plate II. 9-13: Photomicrographs of the leaf vertical section of the studied taxa. **9.** Showing sunken stomata with guard cell cuticular ridges and epidermal cells with thick outer periclinal wall in *Agave victoriae-reginae*, Scale = 10µm. **10.** Showing vascular bundles with lignified bundle sheath and fiber bundles in *Agave americana*, Scale = 100µm. **11.** Showing radial and tangential elongated epidermal cells, isobilateral mesophyll tissue of spongy tissue and vascular bundles with non-lignified bundle sheath in *Clivia nobilis*, Scale = 50µm. **12.** Showing isobilateral mesophyll tissue of palisade and spongy tissue and linear closed collateral vascular bundles in *Pancratium arabicum*, Scale = 50µm. **13.** Showing isobilateral mesophyll tissue of spongy tissue and linear closed collateral vascular bundles with non-lignified bundle sheath in *Tulbaghia violacea*, Scale = 50µm.

14-17: Photomicrographs of the leaf epidermal surface view of the studied taxa. **14.** Showing scattered tetracytic stomata in *Furcraea foetida*, Scale = 50µm. **15.** Showing arranged anomocytic stomata with abnormalities (aborted guard cells and cytoplasmic connection between normal stomata and epidermal cells) in *Clivia nobilis*, Scale = 50µm. **16.** Showing anomocytic stomata with abnormalities (degenerated guard cells) in *Crinum jagus*, Scale = 50µm. **17.** Showing anomocytic stomata with abnormalities (cytoplasmic connection between two normal stomata) in *Crinum augustum*, Scale = 50µm.

Abbreviations **ag:** Aborted guard cells. **clv:** Closed collateral vascular bundle. **cr:** Cuticlar ridge. **cy:** Cytoplasmic connections. **dg:** Degenerated guard cells. **ep:** Epidermis. **fb:** Fiber bundle. **mc:** Mucilage cell. **pt:** Palisade tissue. **pw:** Periclinal wall. **st:** Sponge tissue.



Cont. Plate II. 18-19: Photomicrographs of the leaf epidermis surface view of the studied taxa. **18.** Showing abnormality as lateral contiguous of two aborted stomata an in *Amaryllis reginae*, Scale = 10µm. **19.** Showing abnormality as lateral contiguous of two normal stomata in *Allium tuberosum*, Scale = 50µm. **20.** Cubic crystal in *Agave ferox* leaf cross section, Scale = 10µm.

21-25: Photomicrographs of the scape cross section of the studied taxa. **21.** Raphides crystal in *Agave ferox*, Scale = 10 µm. **22.** Showing cortical tissue of polyhedral parenchyma and angular collenchyma and scattered vascular bundles with non-lignified bundle sheath in *Clivia nobilis*, Scale = 100µm. **23.** Showing polyhedral parenchymatous cortical tissue and polyhedral parenchymatous pith and vascular bundles arranged in three rings in *Pancratium arabicum*, Scale = 200µm. **24.** Showing spiral shape distribution of vascular bundles in *Hymenocallis littoralis*, Scale = 5000µm. **25.** Showing vascular tissue with closed collateral vascular bundles arranged in two rings and hollow pith in *Amaryllis vittata*, Scale = 200µm.

Abbreviations **clv:** Closed collateral vascular bundle. **cu:** Cubic crystals. **ep:** Epidermis. **pi:** Pith. **pt:** Palisade tissue. **pw:** Periclinal wall. **ra**: Raphides crystal.

Table 2. The investigation of the 131 morphological & anatomical characters, their states and codes for numerical analysis.

	No.	Character	Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Macrmorphological Characters																																		
Whole	**1**	Habit	Shrub 1, Herb 2	2	1	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
	2	Apical Dormancy	Absent 0, Present 1	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1
	3	Texture	Glabrous 1, Hairy 2, Spiny 3	1	3	3	3	1	3	3	3	1	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
Root	**4**	Type	Fibrous 1, Contractile 2	2	2	2	2	2	2	2	2	1	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
Stem	**5**	Type	Normal 1, Rhizome 2, Bulb 3	2	1	1	1	1	1	1	1	3	1	1	1	3	3	3	3	3	3	2	2	3	3	3	3	1	3	2	3	3	3	2
	6	Shape	Cylindrical 1, Discoid 2, Irregular 3	3	1	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	3	3	2	2	2	2	1	2	3	2	2	2	3
Leaves	**7**	Cataphyll	Absent 0, Present 1	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
	8	Insertion	Cauline 1, Radical 2	1	1	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	1	1	2	2	2	2	1	2	1	2	2	2	1
	9	Arrangement	Spiral 1, Opposite 2, Alternate 3	2	1	1	1	1	1	1	1	3	1	1	1	3	3	2	2	2	2	2	2	1	1	2	1	1	1	2	2	2	2	2
	10	Base	Sessile 1, Sheathing 2, Petiolate3	2	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	3	2	1	2	2
	11	Colour	Green 1, Greenish Grey 2, Green with Colored Margins or Strips 3	1	2	3	3	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1
	12	Shape	Ovate 1, Lanceolate 2, Elliptic 3, Linear 4, Tubular 5	4	2	2	2	1	2	2	4	2	1	2	2	5	4	4	4	4	4	4	4	4	4	4	4	2	4	3	4	4	4	4
	13	Surface	Plane 1, Plicate 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
	14	Strength	Erect 1, Pendulous 2	1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2
	15	Apex	Obtuse 1, Acute 2, Acuminate 3, Spiny 4	2	4	4	4	3	4	4	4	2	4	4	4	2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	1

	No.	Character	Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	16	Margin	Entire 1, Undulate 2, Spiny 3	1	3	3	3	1	3	3	3	1	3	3	1	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1
Scape	**17**	Strength	Erect 1, Pendulous 2	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	18	Texture	Glabrous 1, Wooly 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
	19	Colour	Green 1, Yellow 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	3	1	1	1	1	2	1	1	1	1
	20	Solidness	Hollow 1, Solid 2, Solid down, Hollow upper 3	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	1	1	2	2	2	2	2	2	2	2	2	3	2	2	1
	21	Inflorescence Position	Terminal 1, Basal 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
Flower	**22**	Characteristic Odour	Absent 0, Present 1	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1
	23	Type of Inflorescence	Panicle 1, Raceme 2, Umbel 3, Spike 4	3	1	1	1	2	1	1	1	2	1	1	2	3	3	3	3	3	3	3	3	3	3	3	3	1	3	4	3	3	3	3
	24	Average No. of Flowers Per Infl.	(≤50) 1, (>50) 2	2	2	2	2	2	2	2	2	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
	25	Spathe Colour	Green 1, Greenish White 2, Greenish Purple 3, White 4, Brown 5	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4	3	3	3	2	2	2	3	2	2	1	2	5	2	2	2	3
	26	Spathe No.	(> 5) 1, (5) 2, (3) 3, (2) 4, (1) 5	4	5	5	5	5	5	5	5	5	5	5	5	3	4	4	4	4	4	2	2	4	4	4	4	5	4	1	5	4	4	4
	27	Spathe Shape	Ovate 1, Triangular 2, Lanceolate 3	1	2	2	2	2	2	2	2	2	2	2	2	1	1	1	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	2
	28	Spathe Texture	Glabrous 1, Hairy 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
	29	Spathe Apex	Acute 1, Acuminate 2, Caudate 3	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
	30	Bracts	Absent 0, Present 1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1
	31	Pedicel Strength	Erect 1, Pendulous 2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	No.	Character		Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Flower	32	Pedicel Outline in T. S		Circular 1, Angular 2, Irregular 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	2	3	2	2	2	1
	33	Pedicel Texture		Glabrous 1, Hairy 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
	34	Hypanthium (Floral Tube)		Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0
	35	Corona		Absent 0, Perianth Corona 1, Filament Corona 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	2	2	1
	36	Perianth Leaf	Colour	Green 1, Greenish Yellow 2, Yellow 3, White 4, Whitish Red 5, Orange 6, Red 7, Blue 8, Purple 9	8	2	1	1	1	1	1	2	4	1	1	1	4	4	4	5	7	4	6	6	4	7	4	4	2	4	3	4	4	4	9
	37		Strength	Erect 1, Pendulous 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	2	1	2	1	1	1	1	1
	38		Shape	Ovate 1, Lanceolate 2, Spathulate 3, Elliptic 4	4	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	3	1
	39	Perianth Leaf	Texture	Glabrous 1, Hairy 2, Glaucent 3, Pubescent 4	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	3	3	3	1	1	1	1	1	1	1	1	4	1	1	1	1
	40		Arrangement	Free 1, United 2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
	41		Apex	Obtuse 1, Acute 2, Acuminate 3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	1	2	2	1	2
	42		Veins Colour	Green 1, Coloured 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	2	1	2	2	1
	43	Stamens	No.	Six 1, Infinity 2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	44		Fertility	Sterile 1, Fertile 2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	45		Position (Insertion)	On Receptacle 1, Adnate to Perianth leaf (Epitepalous) 2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	46		Arrangement	Free 1, United by Filament 2, United by Anther 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	1	1	1	1

	No.	Character	Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	47	Anther Shape	Absent 0, Elongated 1, Arc Shape 2, Sagittate 3	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	3
	48	Anther Fixation	Absent 0, Basifixed 1, Dorsifixed 2, Versatile 3	2	3	3	3	3	3	3	3	0	3	3	3	1	2	1	3	2	3	3	3	2	2	2	2	3	3	2	3	3	3	3
	49	Filament Length to Anther	Absent 0, Short 1, Equal 2, Long 3, Very Long 4	3	2	2	2	2	2	2	2	0	2	2	2	3	3	3	4	4	4	4	4	4	4	4	4	2	4	1	4	4	4	3
	50	Pollen Grains Shape	Absent 0, Oblate 1, Oblate-Spheroidal 2, Spheroidal 3, Sub-prolate 4	4	3	3	3	3	3	3	3	0	3	3	3	4	4	4	2	2	2	2	2	2	2	2	2	3	1	1	2	2	2	4
	51	Pollen Grains Sculpture	Absent 0, Psilate 1, Granulate 2, Reticulate 3	3	3	3	3	3	3	3	3	0	3	3	3	1	1	1	3	3	3	2	3	2	2	2	2	3	3	3	3	3	3	1
	52	Pollen No. of Aperture	Absent 0, Mono-Sulcate 1, Di-Sulcate 2	1	2	2	2	2	2	2	2	0	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1
	53	Ovary Insertion	Superior 1, Inferior 2	1	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
	54	Placentation Type	Axile 1, Parietal 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
	55	Ovary in T. S.	Circular 1, 3-lobed 2, Angular 3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	1	1	1	1	2	2	2	3	2	2	1
	56	Style Solidness	Hollow 1, Solid 2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
	57	Stigma No.	(1) 1, (3) 2	1	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	1	1	1	1	2	2	2	2	2	2	1
	58	Stigma Shape	Simple 1, Branched 2, Oblong 3	1	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	1	1	1	1	2	2	3	2	2	2	1
Fruit	**59**	Fruit Type	Capsule1, Berry 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	2	1	1	1	1

Micromorphological Characters																																			
	No.	**Character**		**Character State**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
Root Anatomy																																			
	60	Outline in T. S		Circular 1, Oval 2, Irregular 3	2	3	1	3	3	2	1	3	1	1	1	3	1	1	1	1	2	1	1	1	2	1	1	1	1	1	3	3	2	1	1
Dermal Tissue	**61**	Number of Layers		Uniseriate1, Multiseriate 2	1	2	1	2	2	2	2	2	1	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
	62	Shape of Outer Layer		Radial Elongated 1, Tangential Elongated 2, Polygonal 3	2	2	2	2	2	2	2	2	2	2	1	2	3	3	3	2	2	2	3	3	3	3	3	3	2	2	2	2	2	1	1
Ground Tissue	**63**	Cortex Tissues	Periderm	Absent 0, Present 1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
	64		Exodermis	Absent 0, Present 1	0	0	1	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1	1	1	0
	65		Types of cells	Polyhedral parenchyma 1, Polyhedral parenchyma & Sclerenchyma 2	1	2	2	2	2	2	2	2	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
	66	Idioplast	Crystals	Absent 0, Elongated 1, Raphides2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	67		Starch	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	68		Mucilage	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	0	0	0
	69	Endodermis Thickening		Absent 0, Outer Periclinal Walls 1, Anticlinal Walls 2, Inner Periclinal & Anticlinal Walls 3, Peripheral (on Both Walls) 4	0	4	4	4	4	4	4	4	0	4	4	4	2	2	2	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0
	70	Pith		Polyhedral Parenchyma 1, Polyhedral Parenchyma & Late Metaxylem 2	1	2	2	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2	2	2	1	1	2	1	1	2	1	1	1	1	1
Vascular Tissue	**71**	Pericycle Layers		Uniseriate 1, Biseriate 2, Multiseriate 3	1	1	2	2	2	2	3	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	72	Xylem Arches No.		(5-15) 1, (> 15) 2	1	2	2	2	2	2	2	2	1	2	2	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1

		No.	Character	Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Stem Anatomy																																			
		73	Outline in T. S	Circular 1, Oval 2, Irregular 3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	2	1	1	1	1	1	2	1	1	1	1
Dermal Tissue		**74**	Cuticle Thickness	Absent 0, Thin 1, Thick 2	0	2	2	0	2	2	2	0	0	2	2	2	1	1	1	0	0	0	0	2	1	1	1	0	0	0	1	0	0	2	2
		75	Cuticle Shape	Absent 0, Smooth 1, Papillated 2	0	2	2	0	1	2	1	0	0	2	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	1	0	0	1	1
		76	Radial Elongated	Absent 0, Present 1	0	1	1	0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	1	0	0	1	0
		77	Tangential Elongated	Absent 0, Present 1	0	1	1	0	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	1
		78	Papillae	Absent 0, Present 1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground Tissue	**Cortex**	**79**	Periderm	Absent 0, Present 1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	0	1
		80	Hypodermis	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		81	Parenchyma Cell Types	Polyhedral 1, Polyhedral & Aerenchyma 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1
		82	Cambial Cells	Absent 0, Present 1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1	1	0
	Idioplast	**83**	Crystals	Raphides or Elongated or Cubic 1, Raphides & Cubic or Elongated & Cubic 2	0	2	1	1	2	1	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	0	0	1	1	0	1	1	0	1	0
		84	Starch	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1
		85	Mucilage	Absent 0, Present 1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Vascular Tissue		**86**	Intracortical Roots	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1
		87	Endodermis Lignification	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		88	Cortical Bundles (Leaf Trace)	Absent 0, Present 1	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	0	1

	No.	Character	Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Vascular Tissue	**89**	Vascular Bundle Types	Closed Collateral 1, Closed Collateral & Concentric 2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	2	2
	90	Bundle Sheath Lignification	Absent 0, Present 1	0	0	1	0	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	91	Xylem Elements	Tracheids 1, Vessels 2	1	2	2	2	2	2	2	2	1	2	2	2	1	1	1	1	1	1	1	1	2	2	2	1	2	1	2	1	1	1	2
	92	Vascular Network	Absent 0, Present 1	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	0	0	0	1	1	1	0	1	1	1	1
Leaf Anatomy																																		
	93	Outline in V. S.	Flattened 1, Arc Shaped 2, V- Shaped 3, Folded 4	1	2	2	2	2	2	2	2	2	2	2	3	2	2	2	1	1	1	1	1	2	2	2	2	2	2	4	2	2	2	2
Dermal Tissue – Cuticle	**94**	Thickness	Thin 1, Thick 2	2	2	2	2	2	2	2	2	1	2	2	2	1	1	1	2	2	2	2	2	1	1	2	2	2	2	1	2	2	2	2
Dermal Tissue – Cuticle	**95**	Shape	Smooth 1, Papillated 2, Serrate 3	2	2	2	2	2	1	1	2	1	2	2	2	1	1	1	1	1	1	1	1	3	3	3	1	2	1	1	2	2	2	1
Dermal Tissue	**96**	Epidermal cell Shape in S.V.	Polygonal 1, Rhomboidal 2, Rectangular 3, Rectangular & Rhomboidal 4	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	2	3	3	3	2	2	4	3	1	3	1	2	3	3	2
Dermal Tissue – Stomata	**97**	Distribution in S.V.	Scattered 1, Arranged 2	2	1	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	2	2	2	2
Dermal Tissue – Stomata	**98**	Type in S.V.	Tetracytic 1, Anomocytic 2, Paracytic 3	2	1	1	1	1	1	1	1	3	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	3	2	2	2	2
Dermal Tissue – Stomata	**99**	Abnormal Stomata in S.V.	Absent 0, Present 1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1

		No.	Character	Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Epidermal Cell	**100**	Trichomes in S.V.	Absent 0, Present (Glandular & Non glandular Unicellular) 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		101	Radial Elongated in V. S	Absent 0, Present 1	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		102	Tangential Elongated in V. S.	Absent 0, Present 1	1	0	1	1	1	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0	0	0	0
		103	Papillae in V. S.	Absent 0, Present 1	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		104	Outer Periclinal Wall Thickening in V. S.	Thin 1, Thick 2	1	2	2	2	1	2	2	2	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Stomata	**105**	Occurrence	Amphistomatic 1, Hypostomatic 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
		106	Guard Cell Cuticular Ridge	Absent 0, Present 1	0	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		107	Stomata Elevation	Sunken 1, Leveled 2, Raised 3	2	1	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2
Ground Tissue	Mesophyll Tissue	**108**	Occurrence	Dorsiventral 1, Isobilateral 2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		109	Palisade Tissue	Absent 0, Present 1	0	1	0	0	0	1	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
		110	Inter Fascicular Tissue	Parenchyma 1, Polyhedral Parenchyma & Angular Collenchyma 2, Polyhedral Parenchyma & Sclerenchyma3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	2	3	1	1	1	1

		No.	Character	Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Vascular Tissue	**Vascular Bundle**	**111**	Types	Closed Collateral 1, Closed Collateral & Fibers 2	1	2	2	2	1	2	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
		112	Arrangement	Scattered 1, Linear 2, Zigzag 3	2	1	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	3	2	2	2	2
		113	Bundle Sheath Lignification	Absent 0, Present 1	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Idioplasts		**114**	Crystals	Absent 0, Raphides or Cubic or Elongated 1, Elongated & Cubic or Raphides & Cubic 2	0	2	1	2	2	2	2	1	0	2	2	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	2	1	0
		115	Starch	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		116	Mucilage	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0
Scape Anatomy																																			
		117	Outline in T. S	Circular 1, Oval 2, Angular 3	2	1	2	1	1	2	1	1	1	1	2	2	1	1	1	1	1	2	3	3	2	2	2	2	1	3	2	2	2	2	1
Dermal Tissue		**118**	Cuticle Thickness	Thin 1, Thick 2	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2	2
		119	Cuticle Shape	Smooth 1, Papillated 2, Serrate 3	3	2	2	2	2	2	2	2	2	1	2	1	3	3	3	1	1	2	2	2	3	2	2	3	2	3	3	1	2	2	1
	Epidermal Cell	**120**	Radial Elongated	Absent 0, Present 1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
		121	Tangential Elongated	Absent 0, Present 1	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	0	0	1	1	1	1	0	0	1
		122	Papillae	Absent 0, Present 1	0	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0
		123	Trichomes	Absent 0, Present (Branched Non glandular) 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0

		No.	Character		Character State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		124	Stomata Elevation		Sunken 1, Leveled 2	2	2	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
Ground Tissue		**125**	Types of Cortical Tissues		Polyhedral Parenchyma 1, Parenchyma & Sclerenchyma 2, Polyhedral Parenchyma, Angular Collenchyma & Sclerenchyma 3	3	3	3	3	1	3	2	3	2	2	3	3	1	1	1	2	1	2	2	2	2	1	2	2	2	2	1	1	1	1	2
Ground Tissue		**126**	Idioplast	Crystals	Absent 0, Raphides or Elongated 1, Raphides & Cubic 2	0	0	1	0	1	1	1	2	1	2	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ground Tissue		**127**	Idioplast	Mucilage	Absent 0, Present 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0
Ground Tissue		**128**	Cortical Bundles		Absent 0, Present 1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground Tissue		**129**	Pith		Hollow 1, Solid (Polyhedral Parenchyma) 2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	1	1	1	2	2	2	2	2	2	2	2	2	1	2	2	1
Vascular Tissue	**Vascular Bundle**	**130**	Distribution		Scattered 1, Spiral Shape 2, In 4 or 5 Rings 3, In 3 Rings 4, In 2 Rings 5	4	1	1	1	1	1	1	1	1	1	1	1	4	5	5	5	5	5	1	1	3	3	3	3	1	2	5	4	4	4	5
Vascular Tissue	**Vascular Bundle**	**131**	Sheath Lignification		Absent 0, Present 1	0	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1

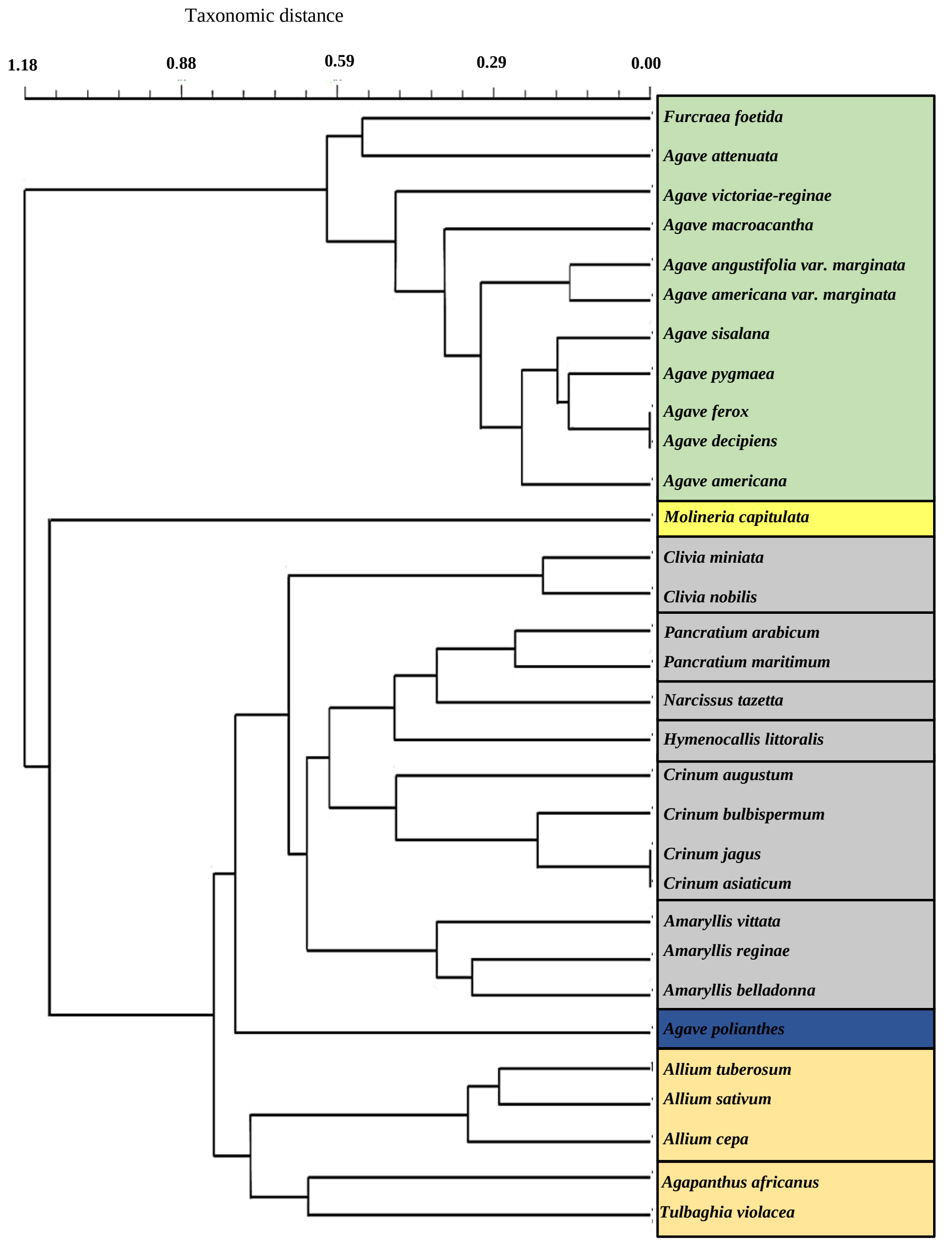


Fig. 1. UPGMA phenogram by using ntsys-pc program showing clustering of the studied taxa based on the 59 macromorphological character states, illustrating average taxonomic distance among the studied taxa.

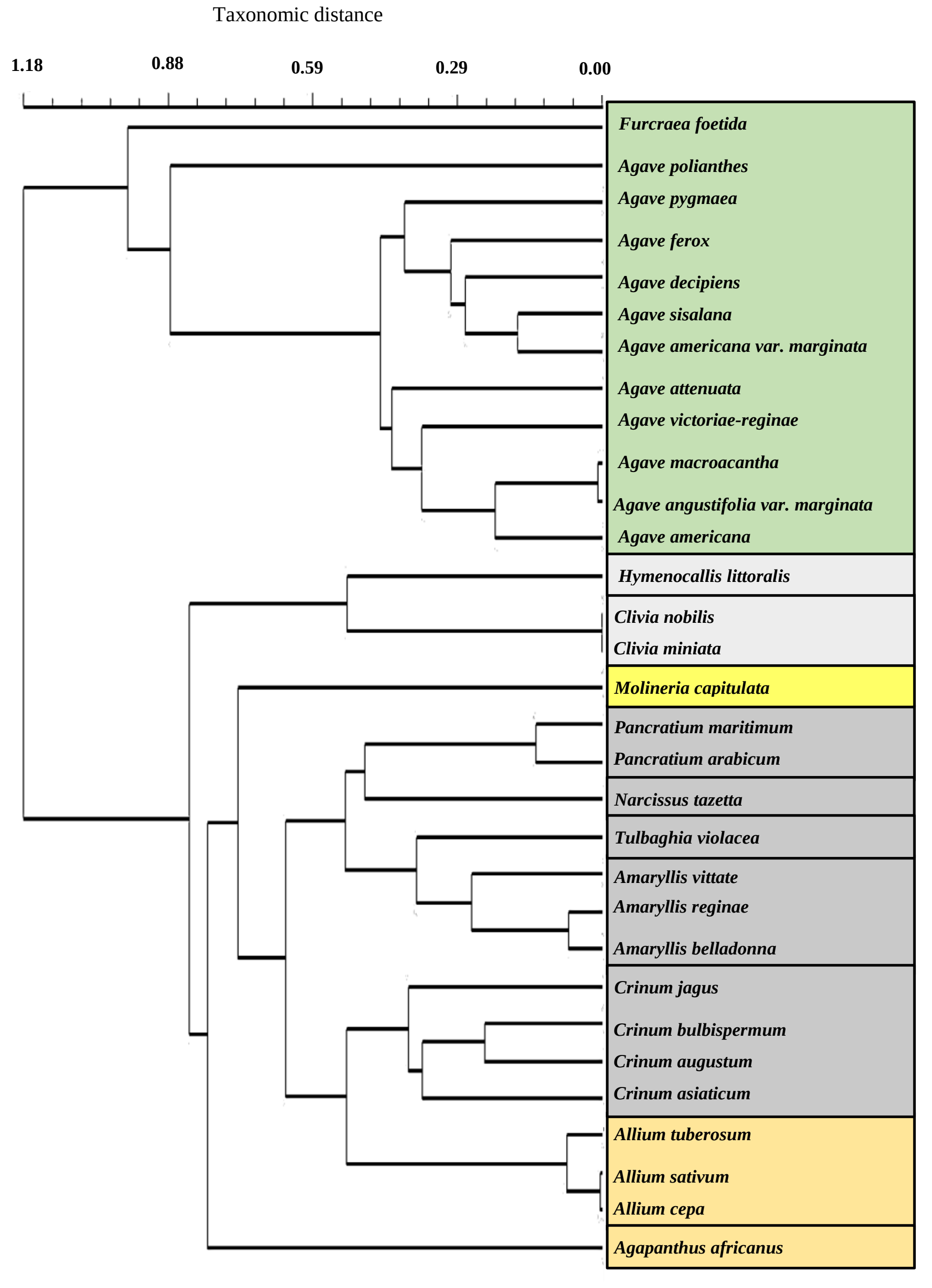


Fig. 2. UPGMA phenogram by using ntsys-pc program showing clustering of the studied taxa based on the 72 micromorphological character state, illustrating averagetaxonomic distance between the studied taxa.

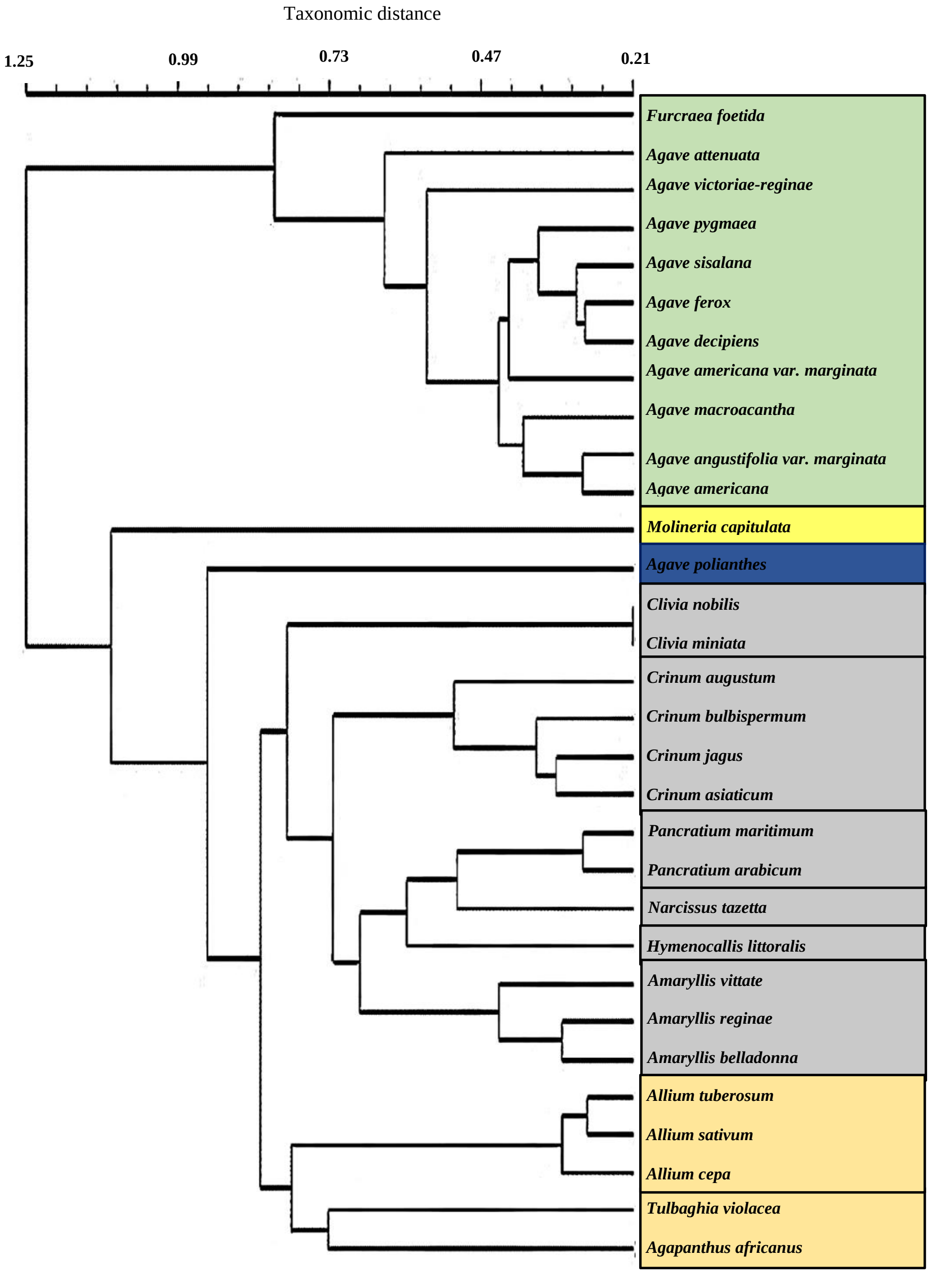


Fig. 3: UPGMA phenogram by using ntsys-pc program showing clustering of the studied taxa based on the 131 macro- and micromorphological character state, illustrating average taxonomic distance between the studied taxa.

Micromorphologically; root with multiseriate epidermis and presence of more than 15 xylem arches (Plate II, 1). Stem with subepidermal periderm, presence of cortical bundles, cambial ring surrounding the vascular tissue, tissue and two types of vascular bundles (Plate II, 7). Leaf arc shaped covered by thick papillated cuticle, amphistomatic with scattered sunken tetracytic stomata (Plate II, 14), guard cells with cuticular ridges, epidermal cells with thick outer periclinal wall (Plate II, 9) and presence of raphides and cubic crystals (Plate II, 20) and the vascular tissue consists of closed collateral vascular bundles and fiber bundles (Plate II, 10). Scape with angular collenchyma, sclerenchyma and presence of rod shape, cubic and raphides crystals (Plate II: 21). Also, APG II (2003) placed the taxa of *Agave* in separated family Agavaceae (*s. str*.). Bogler *et al.* (2006), Chase *et al*. (2009), APG III (2009), Da Cunha Neto & Martins (2012), Reveal (2012), Thiede (2016) and APG IV (2016) placed the two genera *Agave* and *Furcraea* by using molecular data in the subfamily Agavoideae under the family Asparagaceae. Recently, Weakley (2020) classify the genus *Agave* as Agavaceae.

In the second cluster of the UPGMA tree based on all the macro- and micromorphological characters (Fig. 3) supports the separation of genus *Molineria capitulata* as subfamily Hypoxidoideae under family Amaryllidaceae. The separation of this species is ascertained by the separate analysis of each parameter alone. *Molineria capitulata* is separated as a distinct identity from the other species in the same cluster through unique macromorphological characters *viz* hairy palm-like plant with long petiole, leaves elliptic longitudinally ribbed, scape yellow and wooly, inflorescence spike with flowers subtended by many hairy brown spathes with acuminate apex, stamens six united by anthers with short filaments, pollen grains oblate (Plate I, 34) and ovary with oblong stigma. In addition to the micromorphological characters *viz.* root endodermal layer thickening on inner periclinal and anticlinal walls (Plate II, 2), crystals raphides and vascular tissue consists of 12 xylem arches. Stem with hypodermal layer, cortex with mucilage cells (Plate II, 8) and lignified endodermis. Leaf folded in outline, radially elongated epidermal cells with raised scattered paracytic stomata, presence of glandular unicellular trichomes, mesophyll tissue of isobilateral sponge tissue on both surfaces and vascular bundles with lignified bundle sheath.

Previously, *Molineria* was placed with another genera; *Forbesia*, *Curculigo*, *Ianthe*, *Rhodohypoxis* and *Hypoxis* within family Hypoxidaceae (Baker 1878) based on the presence of inferior ovary. While Pax & Hoffman (1930) classified the same genera in the tribe Hypoxideae, subfamily Hypoxidoideae, family Amaryllidaceae depending on the habit of the plant and the type of inflorescence. In Hutchinson’s classification (1934), restricted the Amaryllidaceae to bulbous plants with umbel inflorescence, thereby he excluded the tribe Hypoxideae and elevated it as family Hypoxidaceae order Haemodorales. Takhtajan (1969) classified Hypoxidaceae in order Liliales. Huber (1969) studied the anatomy of the seeds of *Curculigo* and *Hypoxis* spp. and considered Hypoxidaceae to represent a predominantly branch of the Asparagales, with a closer relationship to the Asteliaceae. In Kubitzki' system (1990) he assumed that Hypoxidaceae and Amaryllidaceae are separate families under the same order Asparagales. Mabberly (1997) recognised eight genera: *Hypoxidia*, *Hypoxis*, *Curculigo*, *Pauridia*, *Empodium*, *Molineria*, *Rhodohypoxis* and *Spilocene* under family Hypoxidaceae. This has been accepted by subsequent authors; Rudall *et al.*, 1997 (Kubitzki, 1998). Recently, *Molineria capitulata* is considered a species that belongs to family Hypoxidaceae (Talukdar *et al*. 2015; Ooi *et al*. 2016; Gusmalawi & Mayasari 2017 & Silalahi *et al*. 2018; Meerow 2000; Eswani *et al*. 2010; Kocyan *et al*. 2011; Liu *et al*. 2012; Diana *et al*. 2021; Ho Dinh & Nguyen 2022; Roza *et al*. 2022; Tao *et al*. 2023 and Fuse *et al.* 2023).

Although, *Agave polianthes* (=*Polianthes tuberosa*) is characterized by raceme inflorescence and inferior ovary which are considered the most important characters of family Agavaceae. The present study clearly separated this species from other *Agave* species and grouped it with species of the family Amaryllidaceae in the separate analysis of each parameter and also all parameters in combination. The clustering of *Agave polianthes* in the second cluster that includes the species of family Amaryllidaceae away from the first cluster that includes *Agave* species through unique macromorphological characters *viz.* bulbous herb with fibrous root, discoid stem with cataphylls, leaf radical alternate with acute apex and entire margin and micromorphological characters *viz.* root with cortex consists of only polyhedral parenchyma, non-lignified endodermis, uniseriate pericycle and eight xylem arches. Leaf epidermal cells with leveled arranged paracytic stomata, mesophyll isobilateral with sponge tissue on both surfaces and vascular tissue of one type of vascular bundles. The foregoing data were confirmed by the placement of *Agave polianthes* (=*Polianthus tuberosa*) in the family Amaryllidaceae (Baker 1888; Rose 1903-1905 and Baily 1939). On the other hand, Hutchinson (1959) and Dahlgren *et al.* (1985) placed the genus *Polianthes* under the family Agavaceae based on the type of inflorescence. Traub (1953) and Hutchinson (1959) also included it in the family Agavaceae according to cytological studies. In addition, Hernández-Sandoval (1993, 1995), Bogler & Simpson (1996) and Thiede & Eggli (1999, 2001) transferred the species of *Polianthes* to the genus *Agave* based on morphological and molecular studies. Recently, according to APG III (2009), *Polianthes* was treated in Asparagaceae. In the present study, the UPGMA trees based on macro- and micromorphological characters clearly separate the species from the other *Agave* species and agree with returning the species name to *Polianthes tuberosa*.

The remaining species in the second cluster are divided into two groups (Fig. 3). The first group is divided into six subgroups including all taxa under the genera *Clivia, Crinum, Pancratium, Narcissus, Hymenocallis* and *Amaryllis*. Where the clustering of *Clivia miniata* and *C. nobilis* together based on the following macro- and micromorphological characters. Both are glabrous herbs with irregular rhizome covered by cataphylls, linear cauline leaves with sheathing base, scape glabrous and solid, umbel inflorescence, flowers with united tepals (hypanthium), stamens six free epitepalous with arc-shaped versatile anther, pollen grains oblate-spheroidal monosulcate (Plate I, 35). Root with multiseriate epidermis, cortex of parenchymatous tissue with mucilage cells and non-lignified endodermis, pith of polyhedral parenchyma and late metaxylem and uniseriate pericycle (Plate II, 3). Stem cortex of parenchymatous tissue with raphides crystals and starch grains, vascular tissue of two types of vascular bundles, presence of vascular network. Leaf epidermal cells with leveled arranged anomocytic stomata with abnormalities such as (aborted guard cells, cytoplasmic connection between normal stomata and epidermal cells (Plate II, 15) and cytoplasmic connection between two normal stomata), mesophyll isobilateral of spongy tissue with mucilage cells, interfascicular region of parenchyma (polyhedral & aerenchyma) and angular collenchyma, vascular tissue of linear closed collateral vascular bundles with non-lignified sheath (Plate II, 11). Scape with papillated radial elongated epidermal cells covered by thick papillated cuticle, stomata leveled, cortex of polyhedral parenchyma and angular collenchyma, scattered vascular bundles with non-lignified sheath (Plate II, 22). These criteria are in accordance with the placements of genus *Clivia* at tribe Clivieae (Traub 1963), tribe Haemantheae (Dahlgren *et al*. 1985, Meerow 1995; Meerow & Snijman 1998; APG III 2009 and Meerow 2023), sub-family Amaryllidoideae at the same family Amaryllidaceae (APG III 2009 and Meerow 2023).

In the same context the grouping of *Crinum asiaticum, C. augustum, C. bulbispermum* and *C. jagus* at same subgroup due to similarity in their macromorphological characters: bulbous glabrous herbs with contractile roots, leaves radical with acuminate apex and undulate margin, scape solid, stamens six free epitepalous, pollen grains oblate-spheroidal granulate disulcate (Plate I, 36), ovary inferior and fruit capsule. In addition to micromorphological characters: root with polygonal epidermal cells, cortex of polyhedral parenchymatous tissue and uniseriate pericycle. Stem with cortical bundles. Leaf arc-shaped in outline, amphistomatic with arranged leveled anomocytic stomata with abnormalities such as (cytoplasmic connection between two normal stomata, aborted guard cells, and degenerated guard cells) (Plate II, 16 & 17). Scape with radial elongated epidermis, stomata leveled, vascular bundles arranged in four or five rings. The foregoing data were confirmed by Hutchinson (1934), Traub (1963) and Dahlgren *et al*. (1985) in placing the taxa of *Crinum* at the same tribe Crineae, subfamily Amaryllideae. Meerow (1995), Müller-Doblies & Müller-Doblies (1996) and Meerow & Snijman (1998) place the species of *Crinum* at subtribe Crininae tribe Amaryllideae. APG III (2009), Meerow (2023) and APG IV (2016) classification systems placed the taxa of *Crinum* at the same subfamily Amaryllidoideae.

Pancratium arabicum is clustered with *P. maritimum* at same subgroup due to sharing macromorphological characters *viz*. bulbous glabrous herbs with contractile roots, leaves radical with acute apex and entire margin, umbel inflorescence, flowers with hypanthium and corona, pollen grains oblate-spheroidal reticulate monosulcate and fruit capsule. Micromorphologically, stem cortex of polyhedral parenchyma with starch grains, presence of cambial ring encloses the vascular tissue, vascular bundles of two types and presence of vascular networks. Leaf amphistomatic with arranged leveled anomocytic stomata with abnormalities such as (lateral contiguous of the two stomata, aborted stomata, and cytoplasmic connection between two stomata), mesophyll isobilateral of palisade and spongy tissues with mucilage cells, vascular bundles linear closed collateral (Plate II, 12). Scape with radial elongated epidermis covered with thick papillated cuticle, stomata leveled, cortex of polyhedral parenchymatous tissue, vascular bundles arranged in three rings (Plate II, 23). The present study confirmed those of Traub (1963), Dahlgren *et al*. (1985), Meerow (1995), Müller-Doblies & Müller-Doblies (1996) and Meerow & Snijman (1998) in placing the *Pancratium* in tribe Pancratieae subfamily Amaryllideae. In addition the APG III (2009) and Meerow (2023) classification systems support the placing of *Pancratium* at tribe Pancratieae at the same subfamily Amaryllidoideae based on morphological and molecular characters.

In this study *Narcissus tazetta* is distinguished as a separate subgroup based on the following unique macro- and micromorphological characters *viz*. fibrous roots, scape solid at the lower part hollow at the upper part, presence of one spathe, presence of perianth corona, root with five xylem arches (Plate II, 4) and scape epidermis of radial elongated cells. The *Narcissus tazetta* was previously and recently classified in tribe Narcisseae at the same subfamily Amaryllidioideae based on morphological and molecular characters (Hutchinson 1934; Traub 1963; Dahlgren *et al*. 1985; Meerow 1995; Müller-Doblies & Müller-Doblies 1996; Meerow & Snijman 1998; APG III 2009; APG IV 2016 and Meerow 2023).

Hymenocallis littoralis is delimited from all taxa of the family Amaryllidaceae (first group) in all analysis in this study (Figs 1, 2 & 3). This species is distinguished as a separate subgroup due to macro- and micromorphological characters: leaves spirally arranged, triangular spathe, flowers with filament corona, stamens with elongated anther and united by filaments, pollen grains oblate. Scape angular in outline with smooth cuticle, vascular bundles are distributed in spiral shape (Plate II, 24). This delimitation is congregant with previous results based on comparative organography and chromosome characters carried by Traub (1963) and morphological, cytological and chemical characters carried by Dahlgren *et al*., (1985), where they were placed it in tribe Euchareae, subfamily Amaryllidioideae. While Meerow (1995) and Meerow & Snijman (1998) classified *Hymenocallis* as a tribe Hymenocallideae based on phylogenetic analysis of rbcL sequence and nrDNA (ITS) sequence data. otherwise, Müller-Doblies & Müller-Doblies (1996) placed it at subtribe Hymenocallidinae tribe Eucharideae based on Molecular data. Also, APG III (2009); APG IV (2016); Fishchuk (2021) and Meerow (2023) placed it at tribe Hymenocallideae at the same subfamily Amaryllidoideae based on morphological and molecular evidences.

The three species of *Amaryllis* (*A. vittata*, *A. belladonna* and *A. reginae*) of tribe Amaryllideae subfamily Amaryllidoideae are grouped together in same subgroup in all analyses in this study (Figs. 1, 2 & 3) and as a separated species from the other species of the family Amaryllidaceae. They are clustered with each other due to that they shared macromorphological characters *viz*. bulbous glabrous herbs with contractile roots, leaves radical with sheathing base, umbel inflorescence, flowers with hypanthium, united tepals, stamens six free epitepalous, pollen grains oblate-spheroidal reticulate monosulcate (Plate I, 37), ovary inferior with single hollow style and branched stigma. In addition to micromorphological characters *viz*.: root cortex with mucilage cells. Stem cortex of polyhedral parenchyma with starch grains, presence of intracortical roots and cortical bundles, vascular tissue consists of two types of vascular bundles and presence of vascular networks. Leaf amphistomatic with arranged leveled anomocytic stomata with abnormalities such as (lateral contiguous of two aborted stomata (Plate II, 18), aborted stomata and cytoplasmic connection between two stomata), mesophyll isobilateral of spongy tissue with mucilage cells, interfascicular region of parenchyma (polyhedral parenchyma & aerenchyma) and angular collenchyma, vascular bundles linear closed collateral. Scape with leveled stomata, vascular tissue consists of closed collateral vascular bundles arranged in two rings and hollow pith (Plate II, 25). Dahlgren *et al*. (1985) placed *Amaryllis* under tribe Crinae subfamily Amaryllideae, Meerow (1995), Müller-Doblies & Müller-Doblies (1996) and Meerow & Snijman (1998) grouping the *Amaryllis* species in subtribe Amaryllidinae tribe (Amaryllideae). APG III (2009) and Meerow (2023) classification systems placed the taxa of *Amaryllis* at subtribe Amaryllidinae tribe Amaryllideae at the same subfamily Amaryllidoideae, also APG IV (2016) put them at tribe Amaryllideae subfamily Amaryllidoideae based on the molecular evidences.

As far as *Allium* species grouped with related genera *Agapanthus* and *Tulbaghia* in subfamily Allioideae family Amaryllidaceae (Xie *et al*. 2022 and Meerow 2023). In the present work it was grouped together as shown by the analysis based on Macromorphological characters and further confirmed by the analysis based on the combined parameters. These species are macromorphologically characterized by glabrous herbs, presence of cataphylls, scape erect glabrous, inflorescence umbel with flowers subtended by glabrous spathe and superior ovary with single style. Micromorphologically; a few characters exist between these species. They are characterized by root cortex consisting of polyhedral parenchyma. Leaf epidermis with arranged anomocytic stomata with aborted stomata abnormalities, mesophyll isobilateral of spongy tissue, vascular tissue consists of linear closed collateral vascular bundles with non-lignified sheath. Scape epidermis with leveled stomata. Some research tends to retain the genus *Allium* and its allied genera to family Liliaceae (Pax & Hoffmann 1930; Butt *et al.* 2009; Suleria *et al.* 2013; Mnayer *et al.* 2014; Tilahun *et al.* 2021; Bacelar *et al.* 2021 and Maslova & Elizaryeva 2022). While others recognize these taxa as separate family Alliaceae (Agardh 1858; Airy Shaw 1966 and Kubitzki 1990). The problem with the taxa of Alliaceae is that they resemble members of Amaryllidaceae in having an umbellate inflorescence, but have superior ovary as do Liliaceae. The combination of these characters when taken into consideration justified the formation of Alliaceae (Mathew 1978). Although previously Hutchinson (1934, 1973) include them in the family Amaryllidaceae because of its umbel-like inflorescence surrounded by scarious spathes or bracts in tribe Allieae under Amaryllidaceae. Recently, most authors *viz*. Friesen *et al*. 2006; Chase *et al*. 2009; APG III 2009; Fritsch *et al*. 2010; Li *et al.* 2010; Govaerts *et al*. 2013; APG IV 2016; Herden *et al.* 2016; Khassanov 2018; Hyeok-Jae *et al*. 2019; Brullo *et al*. 2019; Baasanmunkh *et al.* 2020; Xie *et al*. 2020; Khan *et al*. 2021; Bartolucci *et al*. 2022; Xie *et al*. 2022 and Meerow 2023 reassess the taxonomic position of these genera and placed them in the subfamily Allioideae, tribe Allieae and Agapantheae, family Amaryllidaceae.

Agapanthus africanus and *Tulbaghia violacea* (tribe Agapantheae, subfamily Allioideae) are grouped together in the phenogram produced by the analysis of all attributes. The grouping of these two species is in agreement with the analysis based on macromorphological characters but contradicts their position in the analysis based on micromorphological characters. Both species are shared macromorphological characters: glabrous herbs with contractile roots, stem irregular rhizome with cataphylls, leaf linear with sheathing base and entire margin, scape erect glabrous, umbel inflorescence, united tepals with green veins, stamens six free epitepalous, pollen grains sub-prolate monosulcate (Plate I, 38), ovary superior and fruit capsule. Only a few micromorphological similarities exist between *Agapanthus africanus* and *Tulbaghia violacea*. Both are characterized by; root cortex consists of polyhedral parenchyma and pith of polyhedral parenchymatous tissue (Plate II, 5). Stem with subepidermal periderm and cortical bundles. Leaf amphistomatic with leveled anomocytic stomata with abnormalities (aborted stomata, cytoplasmic connection between two stomata, and lateral contiguous of two stomata), mesophyll isobilateral tissue of spongy tissue, presence of linear closed collateral vascular bundles with non-lignified bundle sheath (Plate II, 13). The present study agrees with their delimitation proposed by Hutchinson (1959), Fay & Chase (1996), Duncan (2002), Chase *et al.* (2009) and Büneker *et al*. (2016). *Agapanthus africanus* and *Tulbaghia violacea* were transferred from the family Alliaceae to the family Amaryllidaceae based on the presence of umbel inflorescence, and by phylogenetic analysis of DNA sequences (Hutchinson 1959 and Fay & Chase 1996). However, the grouping of these two species under family Amaryllidaceae does not support the view of Kubitzki (1998) and Sobolewska *et al*. (2020) regarding the two species as family Agapanthaceae due to the presence of superior ovary and steroidal saponinis and absence of alkaloids. These characters distinguished the Agapanthaceae from the Amaryllidaceae s.s., which has an inferior ovary, lacks steroidal saponins and contains alkaloids. Meerow *et al.* (1999) placed *Agapanthus* in the family Agapanthaceae, as sister family to the Amaryllidaceae, based on cladistic analysis of plastid DNA sequence data. Shipunov (2007) placed Amaryllidaceae along with Agapanthaceae in the order Liliales within Alliaceae. Takhtajan (2009) similarly accepted the Agapanthaceae, Alliaceae and Amaryllidaceae as separate families. While Takaidza *et al.* (2015) treated *Tulbaghia* as a small bulb herb in the family Alliaceae with onions and garlic. According to molecular evidence, the APG II (2003) circumscribed the Agapanthaceae as a separate monogeneric family, sister to the Alliaceae and Amaryllidaceae. The Alliaceae, Agapanthaceae and Amaryllidaceae make up the Alliaceae clade within the Asparagales (Meerow *et al*. 1999; Fay *et al*. 2000 and Pires *et al.* 2006).

In all analyses in this study *Allium cepa*, *A. sativum* and *A. tuberosum* are separated together in the same subgroup. due to that they are shared macromorphological characters; bulbous glabrous herbs with fibrous roots, discoid stem with cataphylls, radical leaves with sheathing base, umbel inflorescence, flowers with white tepals, stamens free epitepalous, pollen grains sub-prolate psilate monosulcate (Plate I, 39), ovary superior and fruit capsule. Although they are shared micromorphological characters; root with polygonal epidermal cells, presence of exodermis, cortex of parenchymatous tissue with mucilage cells and starch grains, endodermis lignified on anticlinal walls (Plate II, 6). Stem with smooth tangential elongated epidermis, cortex of polyhedral parenchymatous tissue, presence of a cambial ring encloses the vascular tissue, presence of intracortical roots and cortical bundles and presence of vascular networks. Leaf of rhomboidal epidermal cells with arranged anomocytic stomata with abnormalities (cytoplasmic connection between two stomata, lateral contiguous of two normal stomata (Plate II, 19), degenerated stomata, and aborted stomata), mesophyll isobilateral with mucilage cells, vascular bundles linear closed collateral. Scape with radial elongated epidermis with leveled stomata and covered by serrate cuticle.

Conclusions

Relationships between the studied species of the family Amaryllidaceae (*s.l.*) based on macro- and micromorphological variations support the delimitation of the examined species in two separate families; family Agavaceae which include the genera *Agave* and *Furcraea* and family Amaryllidaceae which divided into three subfamilies; Hypoxidoideae, Amaryllidoideae and Allioideae. Moreover, the present study based on macro- and micromorphological character supports the transfer of *Molineria capitulata* from family Hypoxidaceae to subfamily Hypoxidoideae, family Amaryllidaceae and does not support the grouping of *Agave polianthus* in family Agavaceae and confirm return the species name to *Polianthes tuberosa.* Also, the present study is in agreement with delimitation of the subfamily Amaryllidoideae in six tribes as follow: tribe Amaryllideae (*Amaryllis* species), tribe Clivieae (*Clivia* species), tribe Crinae (*Crinum* species) tribe Hymenocallideae (*Hymenocallis littoralis),* tribe Narcisseae (*Narcissus tazetta*) and tribe Pancratieae (*Pancratium* species). However, the present study confirmed the inclusion of *Allium* species in tribe Allieae and *Agapanthus africanus* and *Tulbaghia violacea* in tribe Agapantheae belong to subfamily Allioideae in the family Amaryllidaceae.

References

Adanson M. (1763) *Familles des plantes*, Vol. II. Vincent, Paris, pp. 1-640.

Agardh J.G. (1858) *Theoria systematic plantarum*. C.W.K. Gleerup, Lund, 404 pp.

Airy Shaw H.K. (1966) *A Dictionary of flowering plants and ferns*, 7th ed. Willis JSED Cambridge University press, Cambridge, London, 1214 pp.

APG (2003) An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society* 1141: 399-436.

APG (2009) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* 1161: 105-121 .

APG (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 1181: 1-20.

Arroyo S.C. and Cutler D.F. (1983) Evolutionary and taxonomic aspects of the internal morphology in Amaryllidaceae from South America and Southern Africa. *Kew Bulletin* 39: 467- 498.

Artyushenko Z.T. (1970) *Amarillisovye (Amaryllidaceae Jaume St.-Hilaire) of USSR*. Nauka, Leningrad, pp. 31-35.

Baasanmunkh S., Lee J.K., Jang J.E., Park M.S., Friesen N., Chung S., and Choi H.J. (2020) Seed morphology of *Allium* L. (Amaryllidaceae) from central Asian countries and its taxonomic implications. *Plants* 9(9): 1239.

Bacelar P.A.A., Feitoza L.L., Valente S.E., Gomes R.L.F., Martins L.V., Almeida P.M. and Peron A.P. (2021) Variations in heterochromatin content reveal important polymorphisms for studies of genetic improvement in garlic (*Allium sativum* L.). *Brazilian Journal of Biology* 83: e243514.

Bahadur S., Ahmad M., Mir S., Zafar M., Sultana S., Ashfaq S. and Arfan M. (2018) Identification of monocot flora using pollen features through scanning electron microscopy. *Microscopy Research and Technique* 81(6): 599-613.

Bailey L.H. (1949) *Manual of Cultivated Plants*. Macmillan directory of leading private Company, New York, 1116 pp.

Bailey L.H. and Bailey E.Z. (1976) *Hortus third: A concise dictionary of plants cultivated in the United States and Canada.* Collier Macmillan, New York, 1918 pp.

Baker F. (1888) Anthropological notes on the human hand. *American Anthropologist* 1(1): 51-76.

Baker J.G. (1878) XVII. Report on the Liliaceæ, Iridaceæ, Hypoxidaceæ, and Hæmodoraceæ of Welwitsch's Angolan Herbarium, 2nd Series. *Transactions of Linnean Society of London* 1(5): 245-273.

Bartolucci F., Iocchi M., De Castro O., and Conti F. (2022) Typification and correct place of publication of the name *Allium kermesinum* (Amaryllidaceae). *Novon* 30(1): 6-8.

Bentham G. and Hooker J.D. (1883) *Genera plantarum*, Vol. 3. L. Reeve & Co., Londini, pp. 711-740.

Bhattacharya K.R., Majumdar M.R. and Bhattacharya S.G. (2011) *A textbook of palynology,* 3rd ed. New Central Book Agency, India, 352 pp.

Björnstad I.N. (1973) A revision of the genus *Pancratium* L. (Amaryllidaceae) in Africa South of the Sahara. *Norwegian Journal of Botany* 20: 281-291.

Bogler D. and Simpson B. (1996) Phylogeny of Agavaceae based on ITS rDNA sequence variation. *American Journal of Botany* 83: 1225-1235.

Bogler D.J., Pires J.C. and Francisco-Ortega J. (2006) Phylogeny of Agavaceae based on ndhF, rbcL, and its sequences. *Journal of Systematic and Floristic Botany* 22(1): 313-328.

Boulos L. (2005) *Flora of Egypt*, Vol. 4. *Monocotyledons (Alismataceae-Orchidaceae)*. Al Hadara publishing, Cairo, Egypt, 417 pp.

Brown R. (1810) *Prodromus florae Novae Hollandiae et Insulae Van-Diemen, exhibens characteres plantarum*. Londini, 590 pp.

Brullo S., Brullo C., Cambria S., Del Galdo G.G., and Salmeri C. (2019) *Allium albanicum* (Amaryllidaceae), a new species from Balkans and its relationships with *A. meteoricum* Heldr. & Hausskn. ex Halácsy. *PhytoKeys* 119:117-136.

Büneker H.M., Bastian R.E., Soares K.P. and Costa C.M. (2016) The genus *Tocantinia* (Amaryllidaceae, Amaryllidoideae) and two new species from Brazil. *Balduinia* 53: 1-14.

Butt M.S., Sultan M.T., Butt M.S., and Iqbal J. (2009) Garlic; nature's protection against physiological threats. *Critical Reviews in Food Science and Nutrition* 49(6):538-551.

Chase M.W., Reveal J.L., and Fay M.F. (2009) A subfamilial classification for the expanded asparagalean families Amaryllidaceae, Asparagaceae and Xanthorrhoeaceae. *Botanical Journal of the Linnean Soc*iety 161(2): 132-136.

Cheadle V.I. (1969) Vessels in Amaryllidaceae and Tecophilaeaceae. *Phytomorphology* 19: 8-16.

Cronquist A. (1988) *The evolution and classification of flowering plants,* Vol. 6. New York Botanical Garden, Bronx, 555 pp.

Da Cunha Neto I.L. and Martins F.M. (2012) Anatomy of the vegetative organs of *Agave sisalana* Perrine ex. Engelm. (Agavaceae). *Revista Caatinga* 25: 72-78.

Dahlgren R.M.T., Clifford H.T. and Yeo P.F. (1985) *The Families of the Monocotyledons* (*Structure, Evolution and Taxonomy*). Springer-Verlag. Berlin, Heidelberg, New York and Tokyo, 520 pp.

Diana R., Mercury Y.H. and Sutedjo. (2021) Inventory of herbs plants at three different locations in forest education of Mulawarman University, Samarinda, East Kalimantan, Indonesia. *Journal of Agriculture and Applied Biology* 2(1): 11-19.

Dönmez E.O. and Işik S. (2008) Pollen morphology of Turkish Amaryllidaceae, Ixioliriaceae and Iridaceae. *Grana* 47(1): 15-38.

Duncan G. (2002) *Grow Agapanthus: A guide to the species, cultivation and propagation of the genus Agapanthus*. National Botanical Institute, Cape Town, 32 pp.

Dunn G. and Everitt D.G. (1982) *An introduction to mathematical taxonomy*. Cambridge University Press, New York, 159 pp.

Eames A.J. (1929) *The role of floral anatomy in the determination of angiosperm phylogeny*. Proceedings of the international congress of plant sciences, Ithaca, pp. 423-427.

Eswani N., Abd Kudus K., Nazre M., Noor A. A. and Ali M. (2010) Medicinal plant diversity and vegetation analysis of logged over hill forest of Tekai Tembeling Forest Reserve. *Journal of Agricultural Science* 2(3):189-210.

Fay M.F. and Chase M.W. (1996) Resurrection of Themidaceae for the *Brodiaea alliance*, and recircumscription of Alliaceae, Amaryllidaceae and Agapanthoideae. *Taxon* 45:441-451.

Fay M.F., Rudall P.J., Sullivan S., Stobart K.L., de Bruijn A.Y., Reeves G., Qamaruz-Zaman F., Hong W-P., Joseph J., Hahn W.J., Conran J.G. and Chase M.W. (2000) *Phylogenetic studies of asparagales based on four plastid DNA loci*. In: Wilson, K. L., Morrison, D. A., (Eds.) *Monocots Systematics and Evolution*, Vol. 1. CSIRO Publishing, Melbourne, pp. 360-371.

Fishchuk O. (2021) Comparative flower morphology in *Hippeastrum striatum* (Lam.) HE Moore. (Amaryllidaceae). *Ukrainian Journal of Ecology* 11(1): 273-278.

Fisher J.B. and French J.C. (1978) Internodal meristems of monocotyledons: Further studies and a general taxonomic summary. *Annals of Botany* 42(1): 41-50.

Friesen N., Fritsch R.M. and Blattner F.R. (2006) Phylogeny and new intrageneric classification of *Allium* (Alliaceae) based on nuclear ribosomal DNA ITS sequences. *Journal of Systematic and Floristic Botany* 22(1): 372-395.

Fritsch R.M., Blattner F.R. and Gurushidze M. (2010) New classification of *Allium* L. subg. *Melanocrommyum* (Webb & Berthel.) Rouy (Alliaceae) based on molecular and morphological characters. *Phyton* 49: 145-320.

Fuse S., Sirimongkol S., Pooma R. and Tamura M.N. (2023) A New Species of *Curculigo* (Hypoxidaceae) from Thailand. *Acta Phytotaxonomica et Geobotanica* 74(1): 29-32.

Gordon-Gray K.D. and Wright F.B. (1969) *Cyrtanthus breviflorus* and *Cyrtanthus luteus* (Amaryllidaceae): observations with particular reference to Natal populations. *South African Journal of Botany* 35: 35-62.

Govaerts R., Kington S., Friesen N., Fritsch R., Snijman D.A., Marcucci R., Silverstone-Sopkin P.A. and Brullo S. (2013) *World checklist of Amaryllidaceae*. Royal Botanic Gardens, Kew, Richmond. Available from: https://doi.org/10.1038/s41597-021-00997-6/ (accessed: Feb-Apr 1805).

Gray S.F. (1821) *A natural arrangement of british plants*, Vol. 2. Baldwin, London, 760 pp.

Gusmalawati D. and Mayasari E. (2017) Karakteristik fisikokimiawi sari buah tapus (*Curculigo latifolia* Dryand) dengan metode ekstraksi osmosis. *Jurnal ilmiah teknik dan informatika* 3(2).

Herbert W. (1837) *Amaryllidaceae: preceded by an attempt to arrange the monocotyledonous orders and followed by a treatise on cross-bred vegetables, and supplement*. J. Ridgway and sons. London, 429 pp.

Herden T., Hanelt P., and Friesen N. (2016) Phylogeny of *Allium* L. subgenus *Anguinum* (G. Don. ex WDJ Koch) N. Friesen (Amaryllidaceae). *Molecular Phylogenetics and Evolution* 95: 79-93.

Hernández-Sandoval L. (1993) Character analysis of the American Genera of Asparagales, a systematic study of Beaucarnea (Nolinaceae) and the taxonomic revision of Hemiphylacus (Hyacinthaceae). Ph. D. Thesis. Botany Departament, University of Texas, Austin. 201 pp.

Hernández-Sandoval L. (1995) Análisis cladístico de la familia Agavaceae. *Boletín de la Sociedad Botánica de México* 56: 57-68.

Ho V., Dinh T. and Nguyen T. (2022) Taxonomic assessment of *Curculigo orchioides* using matK and rbcL DNA barcodes. *SABRAO Journal of Breeding and Genetics* 54(2): 407-415.

Huber H. (1969) Die Samenmerkmale und Verwandtschaftsverhaltnisse der Liliifloren. *Mitteilungen der Botanischen Staatssammlung München* 8: 219-538.

Hutchinson J. (1934) *The families of flowering plants, arranged according to a new system based on their probable phylogeny*. Monocotyledonae. Macmillan, London, 243 pp.

Hutchinson J. (1959) *The families of flowering plants*, Vol. 2, 2nd ed. The Clarendon Press, Oxford, 510 pp.

Hutchinson J. (1973) *The families of flowering plants*. 3rd ed, The Clarendon Press, Oxford, 968 pp.

Hyeok-Jae C.H.O.I., Sungyu Y.A.N.G., Jong-Cheol Y.A.N.G., and Friesen N. (2019) *Allium ulleungense* (Amaryllidaceae), a new species endemic to Ulleungdo Island, Korea. *Korean Journal of Plant Taxonomy* 49(4): 294-299.

Jaume St-Hil. (1805) *Exposition des familles naturelles et de la germination des plantes*, Vol.1. Treuttel et Würtz, Paris, 117 pp.

Jussieu A.L.D. (1789) *Genera plantarum secundum ordines naturales disposita*. Herrissant, Paris, France, 498 pp.

Kauff F., Rudall P. and Conran J. (2000) Systematic root anatomy of Asparagales and other monocotyledons. *Plant Systematics and Evolution* 223: 139-154.

Khan N., Fritsch R. M., Sultan A. and Khan T. (2021) *Allium* (Amaryllidaceae) species in Pakistan: two new records and a new species from zhob (Balochistan). *Pakistan Journal of Botany* 53 (5): 1759-1765.

Khassanov F.O. (2018) Taxonomical and ethnobotanical aspects of *Allium* species from Middle Asia with particular reference to subgenus *Allium*. In: Shigyo M. & Khar A., Abdelrahman M. (Eds.) *The Allium Genomes*. Springer Cham, University of Edinburgh, Scotland, pp. 11-21.

Kocyan A., Snijman D.A., Forest F., Devey D.S., Freudenstein J.V., Wiland-Szymańska J., and Rudall P.J. (2011) Molecular phylogenetics of Hypoxidaceae–Evidence from plastid DNA data and inferences on morphology and biogeography. *Molecular Phylogenetics and Evolution* 60(1): 122-136.

Kubitzki K. (1990) *The families and genera of vascular plants. Lilianae (except Orchidaceae)*, Vol. III. Springer, Berlin, 488 pp.

Kubitzki K. (1998) Agapanthaceae. In: Kubitzki, K. (Ed.) *The Families and Genera of Vascular Plants*, Vol. III. Springer-Verlag, Berlin, Heidelberg, New York, pp. 58-60.

Li Q.Q., Zhou S.D., He X.J., Yu Y., Zhang Y.C., and Wei X.Q. (2010) Phylogeny and biogeography of *Allium* (Amaryllidaceae: Allieae) based on nuclear ribosomal internal transcribed spacer and chloroplast rps16 sequences, focusing on the inclusion of species endemic to China. *Annals of Botany* 106(5): 709-733.

Lindley J. (1836) *A natural system of botany; A Systematic View of the Organisation, Natural Affinities and Geographical Distribution of the Whole Vegetable Kingdom*, Vol. 12. Longman, London, 565 pp.

Lindley J. (1846) *The vegetable kingdom: the structure, classification, and uses of plants, illustrated upon the natural system*. Bradbury and Evans, London, 974 pp.

Linnaeus C. (1753) *Hexandria Monogynia*. In: Linnaeus C. (Ed.) *Species Plantarum*, Vol. I. The Ray Society, Verlag, London, pp. 413-433.

Liu K.W., Xie G.C., Chen L.J., Xiao X.J., Zheng Y.Y., Cai J. and Liu Z.J. (2012) *Sinocurculigo*, a new genus of Hypoxidaceae from China based on molecular and morphological evidence. *PLoS One* 7(6): e38880.

Mabberley D.J. (1997) *The Plant-Book*: *A portable dictionary of the vascular plants,* 2nd ed. Cambridge University Press, New York, 886 pp.

Maslova N.V. and Elizaryeva O.A. (2022) Rare species of the genus *Allium* L. (Alliaceae) from the flora of the Republic of Bashkortostan under cultivation within the city of Ufa. In IOP Conference Series: *Earth and Environmental Science* 981(4): 042075.

Mathew B.F. (1978) Amaryllidaceae In: Heywood V. H. (Ed.) *Flowering plants of the world*. Oxford University Press, New York, pp. 314-316.

Meerow A.W. (1995) Towards a phylogeny of the Amaryllidaceae. In: Rudall P.J., Cribb P.J. Cutler D.F., and C.J. Humphries (Eds.) *Monocotyledons: Systematics and Evolution*, Vol. 1. Royal Botanic Gardens, Kew, pp. 169-179.

Meerow A.W. (2000) 'Rio'(PPAF), 'Sampa'(PPAF), and 'Bahia'(PPAF), three new triploid amaryllis cultivars. *HortScience* 35(1): 147-149.

Meerow A.W. and Snijman D.A. (1998) *Amaryllidaceae*. In: Kubitzki K. (Ed.). *The families and genera of vascular plants*, Vol. 3. Springer-Verlag, Berlin, pp. 83-110.

Meerow A.W., Fay M.F., Guy C.L., Li Q.B., Zaman F.Q. and Chase M.W. (1999) Systematics of Amaryllidaceae based on cladistic analysis of plastid rbcL and trnL-F sequence data. *American Journal of Botany* 86 (9): 1325-1345.

Meerow A.W. (2023) Classification and phylogeny of Amaryllidaceae, the modern synthesis and the road ahead: a review. Boletín De La Sociedad Argentina De Botánica. *Journal of the Argentine Botanical Society* 58 (3): 1-19.

Metcalfe C.R. and Chalk L. (1950) *Anatomy of the dicotyledons: leaves, stem, and wood, in relation to taxonomy, with notes on economic uses*, Vol. 1. Clarendon Press, Oxford, England, 806 pp.

Mnayer D., Fabiano-Tixier A.S., Petitcolas E., Hamieh T., Nehme N., Ferrant C. and Chemat F. (2014) Chemical composition, antibacterial and antioxidant activities of six essentials oils from the Alliaceae family. *Molecules* 19(12): 20034-20053.

Müller-Doblies D. and Müller-Doblies U. (1996) Tribes and subtribes and some species combinations in Amaryllidaceae J. St. Hil. emend. Dahlgren et al. 1985. *Feddes Repertorium* 107 (5-6): 1-9.

Ooi D.J., Chan K.W., Sarega N., Alitheen N.B., Ithnin H. and Ismail M. (2016) Bioprospecting the curculigoside-cinnamic acid-rich fraction from *Molineria latifolia* rhizome as a potential antioxidant therapeutic agent. *Molecules* 21(6): 682.

Pax F. (1888) Amaryllidaceae. In: Engler A. & Prantl K. (Eds.) *Die Naturlichen Pflanzenfamilien*, Vol. II, 5. Wilhelm Englman, Leipzig, pp 97-124.

Pax F. and Hoffman K. (1930) Amaryllidaceae. In: Engler A & Prantl K. (Eds.) *Die Naturlichen Pflanzenfamilien*, Vol. II, 15, a. Wilhelm Englman, Leipzig, pp. 391-430.

Pires J.C., Maureira I.J., Givnish T.J., Systma K.J., Seberg O., Peterson G. and Chase M.W. (2006) Phylogeny, genome size, and chromosome evolution of Asparagales. *Journal of Systematic and Floristic Botany* 22(1): 287-304.

Reveal J.L. (2012) An outline of a classification scheme for extant flowering plants. *Phytoneuron* 37: 1-221.

Rohlf F.J. (2005) Geometric morphometrics simplified. *Trends in Ecology & Evolution* 20(1): 13-14.

Rose J.N. (1903-1905) Studies of Mexican and Central American plants. *Contribution from the United States national Herbarium* 8(4): 1-55.

Roza D., Selly R., Hayati D.Z. and Fadhilah G. (2022) Identification and antioxidant activity test for fractionated compound from ethanol extract of the singkut rhizome (*Molineria latifolia* Dryand). *RASĀYAN Journal of Chemistry* 15(02): 1035-1039.

Rudall P.J., Furness C.A., Chase M.W. and Fay M.F. (1997) Microsporogenesis and pollen sulcus type in Asparagales (Lilianae). *Canadian Journal of Botany* 75(3): 408-430.

Shah G.L. and Gopal B.V. (1970) Structure and development of stomata on the vegetative and floral organs of some Amaryllidaceae. *Annals of Botany* 34(3): 737-749.

Sharawy S.M. and Khalifa S.F. (2018) The nature of the inferior ovary in some monocotyledonous families. *Journal of Plant Development* 25: 2-42.

Shipunov A. (2007) A Systema Naturae, The Classification of living organisms, Vol. 5.704. *Nature Precedings* 241.2: 1-128. doi:10.1038/npre.2007.241.2

Shipunov A.B. (2009) A Systema Naturae or the outline of living world classification. *Protistology* 6(1): 3-13.

Shipunov A.B. (2010) *Systema Angiospermarum*, Vol. 5.1. Available from: http://herba.msu.ru/shipunov/ang/old/v5-1.

Shipunov A.B. (2021) *Systema Angiospermarum*, Vol. 5.32. Available from: http://ashipunov.info/shipunov/ang/current/syang.pdf.

Silalahi M., Nisyawati N. and Anggraeni R. (2018) Studi etnobotani tumbuhan pangan yang tidak dibudidayakan oleh masyarakat lokal sub-etnis batak toba, di desa peadungdung sumatera utara, indonesia. *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan* 8(2): 242.

Sneath P.H. and Sokal R.R. (1973) *Numerical Taxonomy. The Principles of Numerical Classification*. Freeman and Co., San Francisco, 573 pp.

Sobolewska D., Galanty A., Grabowska K., Makowska-Wąs J., Wróbel-Biedrawa D., and Podolak I. (2020) Saponins as cytotoxic agents: an update (2010-2018). Part I-steroidal saponins. *Phytochemistry Reviews* 19: 139-189.

Solerder H. (1908) *Systematic anatomy of the dicotyledons*: *A handbook for laboratories of pure and applied botany*, Vol 2. Clarendon Press, Oxford, 557 pp.

Suleria H., Butt M.S., Anjum F.M., Ashraf M., Quayyum M.M.N., Khalid N., and Younis M.S. (2013) Aqueous garlic extract attenuates hypercholesterolemic and hyperglycemic perspectives; rabbit experimental modeling. *Journal of Medicinal Plants Research* 7(23):1709-1717.

Täckholm V. (1974) *Students' Flora of Egypt*, 2nd ed. Cairo University, Cairo, Egypt, pp. 628-654.

Takaidza S., Pillay M. and Mtunzi F.M. (2015) Biological activities of species in the genus *Tulbaghia*: A review. *African Journal of Biotechnology* 14(45): 3037-3043.

Takhtajan A. (1969) *Flowering Plants. Origin and Dispersal*. Oliver & Boyd. Edinburgh, 310 pp.

Takhtajan A. (2009) *Flowering Plants*. Springer Dordrecht, Netherlands, 871 pp.

Talukdar A.D., Verma D., Roy D.K. and Choudhury M.D. (2015) A New Variety of *Molineria prainiana* (Hypoxidaceae) from Northeast India. *Journal of Japanese Botany* 90: 61- 65.

Tao L., Duan H., Tao K., Luo Y., Li Q. and Li L. (2023) Complete chloroplast genome structural characterization of two *Phalaenopsis* (Orchidaceae) species and comparative analysis with their alliance. *BMC genomics* 24(1): 1-15.

Thiede J. and Eggli U. (1999) Einbeziehung von Manfreda Salisbury, *Polianthes* Linné und *Prochnyanthes* S. Watson in *Agave* Linné (Agavaceae). *Kakteen und andere Sukkulenten* 50 (5): 109-113.

Thiede J. and Eggli U. (2001) Einbeziehung von Manfreda Salisbury und *Polianthes* Linné in *Agave* Linné (Agavaceae): weitere Umbenennungen. *Kakteen und andere Sukkulenten* 52: 166-167.

Thiede J. (2016) Phylogenetic status of the genus *Agave* (Asparagaceae) according to APG III. Third International Symposium on *Agave*. Guadalajara, Jalisco, Mexico. Available from: http://isa.proagave.mx/programa-de-orales-finales/

Thorne R.F. (1976) *A Phylogenetic Classification of the Angiospermae. Evolutionary morphology of the rattlesnake style*, Vol. 9. Plenum, New York, pp. 35-106.

Tilahun M., Tena W. and Desta B. (2021) Effects of Different Nitrogen and Sulfur Fertilizer Rates on Growth, Yield, Quality and Nutrient Uptake of Onion (*Allium cepa* L.) at Shewa Robit, North Shewa, Ethiopia. *Open Biotechnology Journal* 15(1):59-67. http://dx.doi.org/10.2174/1874070702115010059

Traub H.P. (1963) *Genera of the Amaryllidaceae*. American Plant Life Society. La Jolla, 85 pp.

Traub H.P. (1953) The tribes and genera of the Agavaceae. *Plant Life* 9: 134-137.

Weakley A.S. (2020) *Flora of the Southeastern United States*: University of North Carolina Herbarium; Arkansas, North Carolina Botanical Garden: Chapel Hill, NC, USA.

Xie D.F., Tan J.B., Yu Y., Gui L.J., Su D.M., Zhou S.D. and He X.J. (2020) Insights into phylogeny, age and evolution of *Allium* (Amaryllidaceae) based on the whole plastome sequences. *Annals of Botany* 125(7): 1039-1055.

Xie D.F., Cheng R.Y., Price M., Chen J.P., Lei J.Q., Zhang Y.Y., and He X.J. (2022) *Allium heterophyllum* (Amaryllidaceae), a new species from Henan, China. *PhytoKeys* 190: 53-67.