Plant Systematics

Practical book

Editors:
Dr.rer.nat. Fuad Bahrul Ulum, S.Si, M.Sc
Dra. Dwi Setyati, M.Si
Mukhamad Su’udi, Ph.D

Biology department
Faculty of mathematic and sciences
Jember University
2022

Table of contents

Introduction

The course of plant systematics describes concepts of Plant systematic: Describe the principal concept of plant taxonomy, herbarium and its curation, evolution and phylogeny. There are also implementation scientific methods for Plant systematic through a Project-based Method by observing the plant collection of the botanical garden then the result will be presented as a book report. The second task is submitting a complete and correct specimen of the herbarium.

This practical book aims to provide students with a strong foundation in the study of Plant Systematic in the form of practical activities. The following topics will be covered the concept of plant classification, introduction of common plants for the basic knowledge of identification, plant identification, description, and creation of a simple phylogenetic tree. The learning outcome of the practical course in Plant systematic are:

Knowledge: Able to analyze the principle of molecular biology, cells, and organism (LO 3)

Skills: Able to **implement** biological concepts in laboratory work and/or field studies independently and/or in groups (LO 6)

Plant classification methods

Topic: Flower and fruits as an object of key classification

Topic outcome:

Students can explain the basic concept of plant systematics

Students can construct the taxon of specimen samples based on the morphological characters of flowers, fruit, and seeds.

Introduction

Classification is the arrangement of entities (in this case, taxa) into some type of order. The purpose of classification is to provide a system for cataloguing and expressing relationships between these entities. Taxonomists have traditionally agreed upon a method for classifying organisms that utilize categories called ranks. These taxonomic ranks are hierarchical, meaning that each rank is inclusive of all other ranks beneath it. See the figure below for the example:

Major Taxonomic Ranks	Taxa
Kingdom	Plantae
Phylum ("Division" also acceptable)	Magnoliophyta
Class	Liliopsida (Monocots)
Order	Arecales
Family	Arecaceae
Genus (plural: genera)	*Cocos*
Species (plural: species)	*Cocos nucifera*

Plant classification is the science of naming organisms and placing them in a hierarchical structure, each level is given a name (e.g., kingdom, division (phylum), class, order, family, genus, species). Taxonomic units at a given level are termed taxa (singular taxon). Names of higher order taxa (e.g., kingdom, phylum, class, order, family, genus) are uninominal (i.e., each name is a single word). Names of species are binomial (e.g., Magnolia virginiana), and names of taxa below the rank of species (e.g., subspecies, varieties) are comprised of three or more words (e.g., Panicum virgatum var. cubense). Any given organism can be classified throughout the hierarchy. For example, the species sweet bay magnolia (Magnolia virginiana) is in the genus Magnolia, the family Magnoliaceae, the order Magnoliales, the class Magnoliopsida, the division Magnoliophyta, and the kingdom Plantae. Arranging scientific plant names in a hierarchical classification allows related organisms to be classified close together (e.g., all true pines are in the genus Pinus), and this assists with information retrieval.

Flower

A major diagnostic feature of angiosperms is the flower. The flower is a modified reproductive shoot, basically a stem with an apical meristem that gives rise to leaf primordia. Unlike a typical vegetative shoot, however, the flower shoot is determinate, such that the apical meristem stops growing after the floral parts have formed. At least some of the leaf primordia of a flower are modified as reproductive sporophylls (leaves bearing sporangia). Flowers are unique, differing, e.g., from the cones of gymnosperms, in that the sporophylls develop either as stamens or carpels.

The basic parts of a flower from the base to the apex are pedicle, perianth, and pistil. The pedicel is the flower stalk. (If a pedicel is absent, the flower attachment is sessile.) Flowers may be subtended by a bract, a modified, generally reduced leaf; a smaller or secondary bract, often borne on the side of a pedicel, is termed a bracteole or bractlet (also called a prophyll or prophyllum). Bracteoles, where present, are typically paired. [In some taxa, a series of bracts, known as the epicalyx, immediately subtends the calyx (see later discussion), as in Hibiscus and other members of the Malvaceae.]

The receptacle or floral receptacle (also termed a torus, although “torus” can also be used for a compound receptacle; is the tissue or region of a flower to which the other floral parts are attached. The receptacle is typically at the very tip of the floral axis (derived from the original apical meristem). In some taxa the receptacle can grow significantly and assume an additional function. From the receptacle arise the basic floral parts. The perianth (also termed the perigonium) is the outermost, nonreproductive group of modified leaves of a flower. If the perianth is relatively undifferentiated, or if its components intergrade in form, the individual leaflike parts are termed tepals. In most flowers the perianth is differentiated into two groups. The calyx is the outermost series or whorl of modified leaves. Individual units of the calyx are sepals, which are typically green, leaflike, and function to protect the young flower. The corolla is the innermost series or whorl of modified leaves in the perianth. Individual units of the corolla are petals, which are typically colored (nongreen) and function as an attractant for pollination. Some flowers have a hypanthium (floral tube), a cuplike or tubular structure, around or atop the ovary, bearing along its margin the sepals, petals, and stamens.

Many flowers have a nectary, a specialized structure that secretes nectar. Nectaries may develop on the perianth parts, within the receptacle, on or within the androecium or gynoecium (below), or as a separate structure altogether. Some flowers have a disk, a discoid or doughnut-shaped structure arising from the receptacle. Disks can form at the outside and surround the stamens (termed an extrastaminal disk), at the base of the stamens (staminal disk), or at the inside of the stamens and/or base of the ovary (intrastaminal disk). Disks may be nectar-bearing, called a nectariferous disk.

The androecium refers to all of the male organs of a flower, collectively all the stamens. A stamen is a microsporophyll, which characteristically bears two thecae (each theca comprising a pair of microsporangia). Stamens can be leaflike (“laminar”), but typically develop as a stalklike filament, bearing the pollen-bearing anther, the latter generally equivalent to two fused thecae.

The gynoecium refers to all of the female organs of a flower, collectively all the carpels. A carpel is the unit of the gynoecium, consisting of a modified megasporophyll that encloses one or more ovules. Carpels typically develop in a conduplicate manner. A pistil is that part of the gynoecium composed of an ovary, one or more styles (which may be absent), and one or more stigmas (see later discussion). In some taxa, e.g. Aristolochiaceae and Orchidaceae, the androecium and gynoecium are fused into a common structure, known variously as a column, gynandrium, gynostegium, or gynostemium. A stalk that bears the androecium and gynoecium is an androgynophore, e.g., Passifloraceae. A stalk-like structure that bears stamens alone is termed an androphore (e.g., some Eriocaulaceae); one that bears one or more pistils is a gynophore or stipe.

Fruits

Fruits are the mature ovaries or pistils of flowering plants plus any associated accessory parts. Accessory parts are organs attached to fruit but not derived directly from the ovary or ovaries, including the bracts, axes, receptacle, compound receptacle (in multiple fruits), hypanthium, or perianth. The term pericarp (rind, in the vernacular) is used for the fruit wall, derived from the mature ovary wall. The pericarp is sometimes divisible into layers: endocarp, mesocarp, and exocarp (see fleshy fruit types, discussed later).

Fruit types are based first on fruit development. The three major fruit developments are simple (derived from a single pistil of one flower), aggregate (derived from multiple pistils of a single flower, thus having an apocarpous gynoecium), or multiple (derived from many coalescent flowers; see later discussion). In aggregate or multiple fruits, the component derived from an individual pistil is called a unit fruit. The term infructescence may be used to denote a mature inflorescence in fruit.

Seed

Aspects of seed morphology can be important systematic characters used in plant classification and identification. Some valuable aspects of seed morphology are size and shape, as well as the color and surface features of the seed coat, the outer protective covering of seed derived from the integument(s). The seed coat of angiosperms consists of two, postgenitally fused layers, an outer testa derived from the outer integument (itself sometimes divided into layers, an inner endotesta, middle mesotesta, and outer exotesta) and an inner tegmen derived from the inner integument (which can be divided into similar layers, the endotegmen, mesotegmen, and exotegmen). A seed coat that is fleshy at maturity may be termed a sarcotesta (although this may be confused with an aril, which is separate from the integuments; see later discussion). Also important in seed morphology are the shape, size, and color of the hilum, the scar of attachment of the funiculus on the seed coat, and of the raphe, a ridge on the seed coat formed from an adnate funiculus. Some seeds have an aril (adj. arillate), a fleshy outgrowth of the funiculus, raphe, or integuments (but separate from the integuments) that generally functions in animal seed dispersal. Arils may be characteristic of certain groups, such as the Sapindaceae.

Similar to the aril is a caruncle or strophiole, a fleshy outgrowth at the base of the seed; caruncles also function in animal seed dispersal, such as the carunculate seeds of Viola, violets, with regard to seed dispersal by ants.

Materials 1:

Flower and fruits of

1. Trengguli (Cassia fistula)
2. Bunga Telang (Clitoria Ternatea)
3. Lamtoro (Leucaena leucocephala)

Working procedures:

1. Write the name of the plant in the column provided on the observation sheet;
2. Write down all the morphological characteristics of the object on the observation sheet;
3. Define the family level of the specimen!;
4. Write down the classification of each specimen based on the character of the flower;
5. Then classify them based on the type of fruits.

Materials 2:

Use the reproduction structure of these specimens:

1. Pinus (Pinus merkusii): Strobilus fertil/Seed
2. Bunga Pukul Empat (Mirabilis jalapa): flower and fruit
3. Pinang (Areca catechu): Fruit
4. Red beans (Phaseolus vulgaris): Seed

Working procedures 2:

1. Observe the reproductive organs from the specimen of *Pinus merkusii* and *Mirabilis jalapa*;
2. Write your observation result in table 1;
3. Based on the reproductive organ, determine the Division of each specimen.

4. Next, carefully open the seed of Phaseolus vulgaris and the fruit of Areca;
5. Pay attention to the cotyledons, then complete table 2.

Observation result sheet: (Appendix 1)

Question:

1. The specimen of Trengguli (Cassia fistula), Bunga Telang (Clitoria Ternatea). and Lamtoro (Leucaena leucocephala) belongs to the same taxon in the family Fabaceae. Describe the morphological characteristics of members of the family/tribe Fabaceae.

1. Fabaceae is divided into 3 subfamilies, namely Mimosoideae, Caesalpinioideae and Papilionoideae/Faboideaa. What is the subfamily of the bunga telang, trengguli and lamtoro? Are the three specimens belong to the same subfamily or are they different? Give an explanation!

2. Pinus sp and bunga pukul empat are included in different taxon divisions. Explain why?.

3. Name the taxon "class" of kacang merah and pinang and explain why?

Morphological characteristics and Classification of Bryophyta

Topic: 1. Morphological characteristics of Bryophyta

2. Classification of Bryophyta

Topic outcome:

1. Students can describe the morphological characters of Bryophyta
2. Students can determine the classification of Bryophyta based on their correct taxon

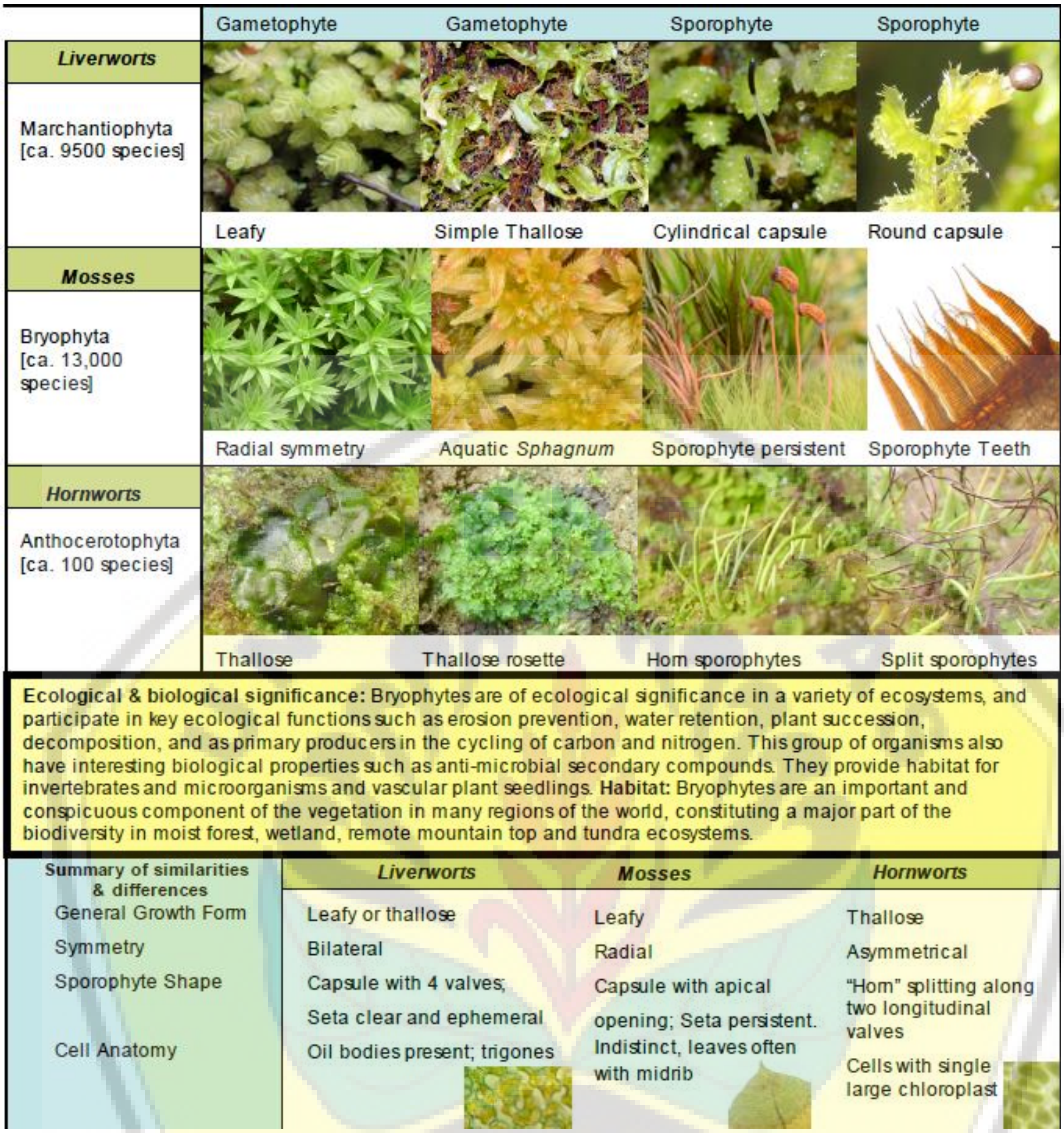
Introduction

The term ‘bryophyte’ has its origin in the Greek language, referring to plants that swell upon hydration (see Section 8.1). ‘Bryophytes’ is a generic name for plants characterized by a life cycle featuring alternating haploid and diploid generations with a dominant gametophyte (Box 1.1). Bryophytes are the only land plants with a dominant, branched gametophyte, which exhibits a diversity of morphologies unparalleled in tracheophytes. This feature was long considered indicative of a unique shared ancestry, but the notion of the monophyly of bryophytes has now been strongly challenged.

Extant bryophytes belong to either liverwort (Marchantiophyta), mosses (Bryophyta in the strict sense) or hornworts (Anthocerotophyta). These lineages share several characteristics, some of which have been retained by all other land plants (e.g. an embryo which gives land plants their name ‘embryophytes’), and others that are unique (e.g. an unbranched sporophyte, with a single spore producing tissue, or sporangium). As in other extant land plants, the gametophyte lacks stomata. The three major bryophyte lineages differ from one another in a variety of attributes, most conspicuously in the architecture of the vegetative (gametophyte) body and the sporophyte, to the extent that they are easily distinguished in the field.

Liverworts, mosses, and hornworts differ from the vascular plants in lacking true vascular tissue and in having the gametophyte as the dominant, photosynthetic, persistent, and free-living phase of the life cycle. The ancestral gametophyte of the land plants was likely thalloid, similar to that of the hornworts and many liverworts. The sporophyte of the liverworts, mosses, and hornworts is relatively small, ephemeral, and attached to and nutritionally dependent upon the gametophyte (see later discussion).

The relationships of the liverworts, mosses, and hornworts to one another and to the vascular plants remain unclear. Many different relationships among the three lineages have been proposed, one recent of which is seen in the Figure below:



Source: Comparison between Mosses, Liverworts and Hornworts by: José Gudiño

Materials:

Specimen of Bryophyta from Jember University (Politrichum, Octoblepharum, Radulina)

Equipment:

1. Luv magnification 15X
2. Microscope stereo
3. Petri disc
4. Pinset
5. Object and cover glass

Working procedures:

1. Prepare the equipment and materials;
2. Observe the available specimens, write down the classification, and then write down the morphological characteristics carefully.
3. Draw the Specimen on the Observation Sheet;
4. Find the characteristics of the specimen

Observation result sheet: (Appendix 1)

Morphological characteristics and Classification of Pteridophyta

Topic: 1. Morphological characteristics of Pteridophyta

2. Classification of Pteridophyta

Topic outcome:

1. Students can determine the classification of Pteridophyta based on thier correct taxon
2. Students are able to explain Morphological characteristics and Classification of Pteridophyta

Introduction

The word Pteridophyta is of Greek origin. Pteron means "feather" and Phyton means plant. The plants of this group have feather-like fronds (leaves). The Pteridophytes are an assemblage of flowerless, seedless, spore-bearing vascular plants that have successfully invaded the land. Pteridophytes have a long fossil history on our planet. They are known from as far back as 380 million years. Fossils of pteridophytes have been obtained from rock strata belonging to Silurian and Devonian periods of the Palaeozoic era. So the Palaeozoic era is sometimes also called the "Age of Pteridophyta". The fossil Pteridophytes were herbaceous as well as arborescent. The tree ferns, giant horse tails and arborescent lycopods dominated the swampy landscapes of the ancient age. The present-day lycopods are the mere relicts the Lepidodendron like fossil arborescent lycopods. Only present-day ferns have the nearby stature of their ancestors. Psilotum and Tmesipteris are two surviving remains of psilopsids, conserve the primitive features of the first land plants.

In the plant kingdom, pteridophytes occupy a position in between bryophytes and gymnosperms, and therefore they have some similarities with the bryophytes on the one hand and with the gymnosperms on the other hand. The similarities with bryophytes are: the presence of sterile jacket around the antheridium and archegonium, the requirement of water and moisture for the fertilization. While with gymnosperms are sporophytic plant bodies and it's independent nature, differentiation of sporophytes into root, shoot and leaves, and presence of vascular tissues for conduction etc.

The presence of vascular elements in pteridophytes makes their grouping with gymnosperms and Angiosperms as Trachaeophyta. The reproduction by spores and similar events of life cycle place them among lower plants. The lower plants algae, fungi, bryophytes and pteridophytes were earlier grouped together as cryptogams. Bryophytes, Pteridophytes and Gymnosperms are also classified as Archegoniatae due to the presence of a common reproductive body archegonium.

Classification

The latest classification proposed by A. R. Smith (2006) and co-workers

Scientists of three different countries from the USA, A.R. Smith, K.M. Preyer and P.G. Wolf (Sweden), E. Schuettpelz and H Schneider (Germany) presented a revised classification of extant ferns. They divided all vascular plants into two groups on the basis of phylogenetic studies. Recent phylogenetic studies have revealed a basal dichotomy within vascular plants, separating the lycophytes (less than 1% of extant vascular plants) from the euphyllophytes. Living euphyllophytes, in turn, comprise two major clades: the spermatophytes (seed plants), which are in excess of 260,000 species (Thorne, 2002; Scotland & Wortley, 2003), and the monilophytes (ferns, sensu Pryer& al., 2004b), with about 9,000 species, including horsetails, whisk ferns, and all eusporangiate and leptosporangiate ferns. Plants that are included in the lycophyte and fern clades (Monilophytes) are all spore-bearing or "seed-free", and because of this common feature their members have been lumped together historically under various terms, such as "pteridophytes" and "ferns and fern allies"—paraphyletic assemblages of plants.

The focus of this reclassification is exclusively on ferns. Within ferns, they recognized four classes (Psilotopsida; Equisetopsida; Marattiopsida; Polypodiopsida), 11 orders, and 37 families.

Class 1. Psilotopsida
- A . Order Ophioglossales.
  - 1. Family Ophioglossaceae.
- B . Order Psilotales.
  - 2. Family Psilotaceae

Class 2. Equisetopsida
- C . Order Equisetales.
  - 3. Family Equisetaceae.

Class 3. Marattiopsida
- D . Order Marattales.
- 4. Family Marattiaceae .

Class 4. Polypodiopsida
- E . Order Osmundales
  - 5. Family Osmundaceae.
- F . Order Hymenophyllales.
  - 6. Family Hymenophyllaceae
- G . Order Gleicheniale.
  - 7. Family Gleicheniaceae.
  - 8. Family Dipteridaceae
  - 9. Family Matoniaceae.
- H . Order Schizaeales.
  - 10. Family Lygodiaceae.
  - 11. Family Anemiaceae
  - 12. Family Schizaeaceae.
- I . Order Salviniales
  - 13. Family Marsileaceae.
  - 14. Family Salviniaceae
- J . Order Cyatheales.
  - 15. Family Thyrsopteridaceae.
  - 16. Family Loxomataceae.
  - 17. Family Culcitaceae
  - 18. Family Plagiogyriaceae.
  - 19. Family Cibotiaceae
  - 20. Family Cyatheaceae
  - 21. Family Dicksoniaceae
  - 22. Family Metaxyaceae
- K . Order Polypodiales
  - 23. Family Lindsaeaceae
  - 24. Family Saccolomataceae
  - 25. Family Dennstaedtiaceae
  - 26. Family Pteridaceae
  - 27. Family Aspleniaceae
  - 28. Family Thelypteridaceae
  - 29. Family Woodsiaceae
  - 30. Family Blechnaceae
  - 31. Family Onocleaceae
  - 32. Family Dryopteridaceae
  - 33. Family Lomariopsidaceae

34. Family Tectariaceae
35. Family Oleandraceae
36. Family Davalliaceae
37. Family Polypodiaceae

Materials :

Specimen of Pteridophyta from Jember University (Equisetum, Psilotum, Lygodium, Selaginella, Pteris)

Equipment:

1. Luv magnification 15X
2. Microscope stereo
3. Petri disc
4. Pinset
5. Object and cover glass

Working procedures:

1. Prepare the equipment and materials;
2. Observe the available specimens, write down the classification, and then write down the morphological characteristics carefully.
3. Draw the Specimen on the Observation Sheet;
4. Find the characteristics of the specimen

Observation result sheet: (Appendix 1)

Morphological characteristics and Classification of Gymnospermae

Topic: 1. Morphological characteristics of Pinophyta

2. Classification of Pinophyta

Topic outcome:

1. Students can determine the classification of Pteridophyta based on their correct taxon
2. Students are able to explain Morphological characteristics and Classification of Pinophyta

Introduction

Recent cladistic analyses using multiple gene sequences have provided strong evidence that the Spermatophyta (seed plants) are composed of two sister groups: Gymnospermae and Angiospermae. The Gymnospermae, or gymnosperms (after gymnos, naked + sperm, seed), are called that because the ovules are not enclosed by a surrounding carpel layer (thus, being "naked") at the time of pollination. (Note that the developing seeds are often enclosed, e.g., by megasporophylls or ovuliferous scales, after pollination.) Gymnosperms are essentially nonflowering seed plants.

Knowledge of relationships within the gymnosperms is still in flux, but some phylogenetic studies show the cycads (Cycadophyta) as the most basal lineage, followed by the Ginkgo group (Ginkgophyta), then the conifers (Coniferae). Interestingly, recent analyses place the Gnetales either as sister to the conifers or within the conifers, often as the sister group to the Pinaceae. However, the precise placement of the Gnetales is still contested and needs further investigation. (See Mathews 2009.)

Cycadophyta—Cycads

The Cycadophyta (also known as Cycadales), or cycads, are a relatively ancient group of plants that were once much more common than today and served as fodder for plant-eating nonavian dinosaurs. Extant cycads are now fairly restricted in distribution, consisting of approximately 320–340 species in 11 genera. Cycads are found in southeastern North America, Mexico, Central America, some Caribbean islands, South America, eastern and southeastern Asia, Australia, and parts of Africa. Many cycads throughout the world are of economic importance in being used as a source of food starch (sometimes termed "sago"), typically collected from the apex of the trunk just prior to a flush of leaves or reproductive structures.

Some cycads, especially Cycas revoluta, the "sago palm," are planted horticulturally. Cycads are an apparently monophyletic lineage consisting of plants with a mostly short, erect stem or trunk, rarely tall and palmlike (as in the strangely named Microcycas). The trunk bears spirally arranged, mostly pinnately compound leaves. Only the genus Bowenia has bipinnately compound leaves. The trunks of cycads do not usually exhibit lateral (axillary) branching; thus, the loss of axillary branching on the aerial trunk is diagnostic for the cycads. Interestingly, cycad pinnae (Cycas) or leaves (some Zamiaceae; e.g., Bowenia) exhibit circinatevernation (Figure 5.14B) as in many ferns, perhaps a primitive retention that was lost in other seed plants. Reproductively, all cycad individuals are either male or female; this plant sex is termed dioecious.

All cycads have pollen cones or strobili (also called male cones/strobili). Recall that cones are determinate shoot systems, consisting of a single axis that bears sporophylls, modified leaves with attached sporangia. Pollen cones consist of an axis bearing microsporophylls, each of which bears numerous microsporangia. These microsporangia produce great numbers of haploid microspores, each of which develops into a pollen grain, an immature, endosporic, male gametophyte. Interestingly, the pollen of all cycads (like the Ginkgophyta,to be discussed) release motile sperm cells within the ovule of a seed cone, a vestige of an ancestrally aquatic condition.

Recent evidence (e.g., Rai et al., 2003) suggests that cycads are best grouped as two families: Cycadaceae and Zamiaceae, differing primarily in the absence of seed cones in the former. In the Cycadaceae, seeds are produced on the margins of numerous megasporophylls, which are aggregated not in cones but at the trunk apex in dense masses. In contrast, all members of the Zamiaceae have seed [ovulate] cones or strobili (also called female cones/strobili). Seed cones (Figures 5.15C–E, 5.16C,D,F-I) consist of an axis bearing megasporophylls, each of which bears two seeds (Figure 5.16E,H,I). There is variation in the size and shape of the seed cones, megasporophylls, and seeds within groups. See Johnson and Wilson (1990c) for general information, Rai et al. (2003) and Hill et al. (2003) for a phylogenetic analyses. Cycadaceae—Cycad family (Greek koikas or kykas, for a kind of palm). 1 genus (Cycas, incl. Epicycas)/100–110 species. The Cycadaceae consist of dioecious trees to perennial herbs. The roots are often vesicular-arbuscular mycorrhizal; some adventitious roots are “coralloid,” being ageotropic (growing upward), branched and shaped like coral, and containing symbiotic, nitrogen-fi xing cyanobacteria in the outer tissues. The stem is unbranched or dichotomously branched, either an aerial trunk, covered with persistent leaf bases, or subterranean from adventitious buds, the stem apex at groundlevel. The leaves are spiral, petiolate (petiole margins with prickles), pinnately compound, evergreen, and coriaceous, forming by means of circinate vernation, in which involute leafl ets are coiled early in development; mature leafl ets have a single midvein; nonphotosynthetic, rigid cataphylls are typically produced in fl ushes alternately with photosynthetic leaves. The pollen cones are large, terminal from the trunk apex, with numerous microsporophylls, each abaxially bearing numerous, spherical microsporangia. The seed-bearing reproductive structures are not organized in determinate cones, consisting of numerous stalked, apically toothed to pinnately divided megasporophylls surrounding the trunk apex. The seeds are large, [1] 2–8, born marginally on each megasporophyll; the embryo has 2 cotyledons.

Members of the Cycadaceae are distributed in E. Africa, E. and S.E. Asia, and N. Australia. Economic importance includes cultivated ornamentals (esp. Cycas revoluta, sago-palm), food derived from the pith of the trunk (known as “sago,” made into a fl our, bread, that of some spp. toxic/carcinogenic), and edible seeds (after removal of toxins; e.g., C. media, of Australia, New Guinea). See Norstog and Nicholls (1997), Hill (1998 onwards; web site), Johnson and Wilson (1990b), and Jones (2002) for general information; Hill et al. (2004) and Walters and Osborne (2004) for classifi cation and nomenclature; and Hill et al. (2003) for a phylogenetic analysis. The Cycadaceae are readily distinguished in consisting of dioecious trees or perennial herbs, having trunks or subterranean stems, with large, coriaceous, evergreen, pinnate leaves (vernation involute circinate), and large, determinate pollen cones, the ovulate reproductive structures not organized as cones, consisting of numerous toothed to divided megasporophylls arising from apex of trunk, each bearing one or more marginal ovules/seeds.

Coniferae—Conifers

The Coniferae, or conifers (also known as Pinophyta or Coniferophyta), are an ancient group of land plants that were once dominant in most plant communities worldwide. Today, they have largely been replaced by angiosperms, but still constitute the primary biomass of various “coniferous” forests. Conifers comprise a monophyletic group of highly branched trees or shrubs with simple leaves, the latter a possible apomorphy shared with the ginkgophytes. Leaves of conifers are often linear, acicular (needle-like), or subulate (awl-shaped; see Chapter 9), although they are sometimes broad and large. In some conifers the leaves are clustered into short shoots, in which adjacent internodes are very short in length. An extreme of this is the fascicle, e.g., in species of Pinus, the pines. A fascicle is a specialized short shoot consisting of stem tissue, one or more needle-shaped leaves, and persistent basal bud scales. A second, apparent apomorphy of the conifers, including the Gnetales (discussed later), is the loss of sperm cell motility. This distinguishes the conifers from the cycads and ginkgophytes, which have flagellated sperm cells. Conifers, like all extant seed plants, have pollen tubes, within which the male gametophytes develop. As in cycads and Ginkgo, these pollen tubes are haustorial, consuming the tissues of the nucellus (megasporangial tissue) for up to a year or so after pollination. One difference, however, (likely correlated with sperm nonmotility) is that the male gametophyte of conifers delivers the sperm cells more directly to the egg by the growth of the pollen tube to the archegonial neck, and release of nonmotile sperm cells near the egg. This type of pollen tube and sperm transfer in conifers is known as siphonogamy, as opposed to zooidogamy. (Because there is more than one archegonium per seed, multiple fertilization events may occur, resulting in multiple young embryos, but usually only one survives in the mature seed.) Reproductively, conifers produce pollen cones and seed cones, either on the same individual (monoecy) or, less commonly, on different individuals (dioecy). As with all vascular plants, cones consist of an axis that bears sporophylls. As in cycads, pollen cones consist of an axis with microsporophylls. The microsporophylls bear microsporangia, which produce pollen grains. The pollen grains of some (but not all) conifers are interesting in being bisaccate, in which two bladder-like structures develop from the pollen grain wall. These saccate structures, like air bladders, may function to transport the pollen more efficiently by wind. They may also function as flotation devices, to aid in the capture and transport of pollen grains by a pollination droplet formed in the nonflowering seed plants.

Gnetales

The Gnetales, also referred to as the Gnetopsida or Gnetophyta, are an interesting group containing three extant families: Ephedraceae (consisting solely of Ephedra, with ca. 40 species), Gnetaceae (consisting solely of Gnetum [including Vinkiella], with ca. 30 species), and the Welwitschiaceae (monospecific, consisting of Welwitschia mirabilis). The Gnetales have often been thought to be the sister group to the angiosperms, the two groups united by some obscure features, possibly including whorled, somewhat “perianth-like” microsporophylls in structures that may resemble flowers (see Chapter 6). However, as reviewed earlier, recent molecular studies have placed the Gnetales within the conifers, usually sister to the Pinaceae. Although their classification is still contested, they are placed in the Coniferae here. The Gnetales are united by (among other things) the occurrence of (1) striate pollen; and (2) vessels with porose (porelike) perforation plates, as opposed to scalariform (barlike) perforation plates in basal angiosperms. The vessels of Gnetales were derived independently from those of angiosperms. The reproductive structures in various Gnetales show some parallels to the flowers of angiosperms. Species of Gnetum of the Gnetaceae are tropical vines (rarely trees or shrubs) with opposite (decussate), simple leaves, looking like an angiosperm but, of course, lacking true flowers. Welwitschia mirabilis of the Welwitschiaceae is a strange plant native to deserts of Namibia in southwestern Africa. An underground caudex bears only two leaves, these becoming quite long and lacerated in old individuals. Pollen and seed cones are born on axes arising from the apex of the caude). Ephedra of the Ephedraceae is a rather common desert shrub and can be recognized by the photosynthetic, striate stems and the very reduced scalelike leaves, only two or three per node. Pollen or seed cones may be found in the axils of the leaves. See Kubitzki (1990a,b,c,d) for information on the Gnetales. Recently, the occurrence of a type of double fertilization was verified in species of the Gnetales. Double fertilization in Ephedra entails the fusion of each of two sperm cells from a male gametophyte with nuclei in the archegonium of the female gametophyte. One sperm fuses with the egg nucleus and the other fuses with the ventral canal nucleus. In fact, the fusion product of sperm and ventral canal cell may even divide a few times mitotically, resembling angiospermous endosperm (Chapter 6), but this does not persist. Thus, double fertilization, which has long been viewed as a defining characteristic of the angiosperms alone, was recently interpreted as a possible apomorphy of the Gnetales and angiosperms together (formerly called the “anthophytes”). This notion is rejected with the current acceptance of seed plant relationships as seen in Figure 5.1, in which the Gnetales are nested within the conifers. Thus, double fertilization in the Gnetales and angiosperms presumably evolved independently.

Classification of Gymnospermae

Cycadaceae (1/100-110)
Zamiaceae (10/220-230)
Ginkgophyta
Ginkgoaceae (1/1)
Coniferae [Pinophyta]
Pinopsida
Pinaceae (12/225)
Cupressopsida
Araucariaceae (3/32)
Cupressaceae (32/130)
Phyllocladaceae (1/5)
Podocarpaceae (17/167)
Sciadopityaceae (1/1)
Taxaceae (incl. Cephalotaxaceae) (6/28)
Gnetales
Ephedraceae (1/40)
Gnetaceae (1/30)
Welwitschiaceae (1/1)

Materials:
Specimen of Gymnospermae from Jember University (Cycas, Agathis, Araucaria, Pinus, Thuja, Gnetum)
Location and route: 1. FMIPA - KP - FKIP G3 - FKIP G1

Equipment:
1. Luv magnification 15X
2. Microscope stereo
3. Petri disc
4. Pinset
5. Object and cover glass

Working procedures:
1. Prepare the equipment and materials;
2. Observe the available specimens, write down the classification, and then write down the morphological characteristics carefully.
3. Draw the Specimen on the Observation Sheet;
4. Find the characteristics of the specimen

Observation result sheet: (Appendix 1)

Morphological characteristics and Classification of Magnoliophyta - Liliopsida

Topic: 1. Morphological characteristics of Magnoliophyta –Liliopsida
2. Classification of Magnoliophyta -Liliopsida

Topic outcome:

1. Students can determine the classification of Liliopsidaa based on thier correct taxon
2. Students are able to explain Morphological characteristics and Classification of Liliopsida

Introduction

Woody or herbaceous plants. Secretory cells with oily contents ordinarily present in the parenchymatous tissues. Vessels with scalariform or simple perforations or vessels wanting. Sieve-element plastids usually containing protein crystalloid (Pc-type) or fi laments (Pf-type), often also starch, in some families only starch (S-type). Stomata commonly paracytic. Flowers bisexual or less often unisexual, frequently spiral or spirocyclic, actinomorphic. Stamens mostly numerous. Tapetum usually secretory. Microsporo genesis successive or simultaneous. Pollen grains 2-celled or less often 3-celled, 1-colpate, 2-colpate, 3–6-colpate, rugate, porate, or often inaperturate. Gynoecium mostly apocarpous. Ovules bitegmic or much less often unitegmic, usually crassinucellate. Endosperm cellular or nuclear. Seeds mostly with small or minute embryo and copious endosperm, sometimes accompanied or largely replaced by perisperm. Cotyledons typically 2, but occasionally 3 or 4 (Degeneriaceae, Idiospermaceae). Commonly producing neolignans and/or benzyl isoquinoline alkaloids, but without ellagic acid and iridoid compounds. The subclass Magnoliidae includes a number of relatively very archaic orders and families of fl owering plants. All of them are extremely heterobathmic, that is, they have a very disharmonious combination of both primitive and derived characters. Different families of the magnoliids developed in different directions. Although all of them most probably evolved from a common ancestral stock. The basal group of fl owering plants are superorder Nymphaeanae, which include the most archaic families, beginning with Amborellaceae and ending with Ceratophyllaceae.

Materials :
Specimen of Liliopsida from Jember University (Raphis, Chrysalidocarpus, Costus, Canna, Pistia, Bambu, Caryota, Heliconia, Musa, Roystonea)
Location : FMIPA , Kantor Pusat

Equipment:
1. Luv magnification 15X
2. Microscope stereo
3. Petri disc
4. Pinset
5. Object and cover glass

Working procedures:
1. Prepare the equipment and materials;
2. Observe the available specimens, write down the classification, and then write down the morphological characteristics carefully.
3. Draw the Specimen on the Observation Sheet;
4. Find the characteristics of the specimen
5.

Observation result sheet: (Appendix 1)

Morphological characteristics and Classification of Magnoliophyta: Magnoliopsida

Topic: 1. Morphological characteristics of Magnoliopsida

2. Classification of Magnoliopsida

Topic outcome:

1. Students can determine the classification of Magnoliopsida

2. Students are able to explain Morphological characteristics and Classification of Magnoliopsida

Introduction

Embryo, when differentiated, always with one cotyledon. The cotyledon usually with two main vascular bundles. Leaf venation striate or of derived types, mostly arcuate-striate or longitudinally striate (parallel), less often palmate-striate or pinnate-striate, almost always more or less closed at the apex (the veins emerging from the leaf base usually run together again at their apices). Leaves are usually not clearly divided into petiole and lamina, less often more or less differentiated, but in these cases, the "petiole" and the "lamina" are not homologous to those of magnoliopsids (are of secondary origin), often with a sheathing base. Leaf traces are usually numerous. Prophylls (including bracteoles) are usually solitary and nearly always adaxial. Vascular bundles are usually without cambium or rarely with vestigial cambium only. The vascular system of the stem usually consists of many separate scattered bundles or sometimes of two or more rings of vascular bundles, and the axis mostly attains its full diameter early, after which no increase in thickness takes place; only in some groups does thickening of the axis occur by means of division and enlargement of ground parenchyma cells (so-called diffuse secondary growth), as in palms, or by means of special kind of cambium that arises in the parenchyma outside the primary vascular system, as in some herbaceous and woody Lilianae. Sieve-element plastids of P-type with several to numerous cuneate (triangular) crystalloid bodies (lacking in all magnoliopsids studied except Saruma and Asarum in Aristolochiaceae). Phloem without parenchyma. Usually without clearly differentiated bark and pith. The primary root is usually ephemeral, dries out early in the growth of the plant, and is replaced by an adventitious root system that develops from the stem or (as in grasses) directly from the hypocotyl. Ontogenetically root cap and root epidermis are of different origin. Usually herbs, but often secondarily arborescent plants (primary woody plants are absent among the monocots). Flowers usually 3-merous, sometimes 4- or 2-merous, very rarely 5-merous. Nectaries predominantly septal. Pollen grains mostly 1-colpate (sulcate) or of derived types, often 1-porate. The Liliopsida most probably originated from some very ancient vesselless herbaceous member of Magnoliopsida that had atactostelic vascular system, P-type sieve-element plastids, 3-merous fl owers, apocarpous gynoecium with laminar-diffuse (scattered) placentation, bitegmic and crassinucellate ovules (with parietal tissue between the female gametophyte) and the nucellar epidermis, and primitive 2-celled and 1-colpate pollen grains. Unfortunately there is no convincing dicotylidonous sister group to the monocotyledons. According to some authors the nearest group are nymphaeids. Some of the relatively most archaic monocots have some similarities with the nymphaeids (Hallier 1905; Schaffner 1929, 1934; Eber 1934; Takhtajan 1954, 1959, 1969, 1987; Kaul 1967; Cronquist 1968, 1981, 1988). As long ago as 1905, Hallier suggested that the Nymphaeaceae (s.1.) were the "ancestors of the whole division of monocotyledons" though later (1912) he changed his opinion. According to Arber (1920: 309), the Nymphaeaceae "descended from a stock closely related to that which gave rise to the monocotyledons." Similar ideas have also been expressed by some other botanists. The nymphaeoids and some archaic monocots do indeed have some important characters in common. In the morphology of their gynoecia the families Butomaceae and Limnocharitaceae resemble the Cabombaceae, and in their laminar-diffuse placentation they recall the Nymphaeaceae. There are also some other important similarities, including atactostelic vascular cylinder and especially root ontogeny (see Voronin 1964) as well as the development of female gametophytes, stomatal patterns, seed anatomy, and the arrangement of the fi rst leaves (prophylls) on lateral axes. However, the sieve-element plastids of the nymphaeids are of S-type, and they are too specialized to be considered the ancestors of monocots. It is much more probable that they evolved from some remote common ancestor that was already more or less adapted to a relatively wet (but not yet aquatic) habitat. Henslow (1911) considered the distinctive features of monocots the result of the primary adaptation to an aquatic habitat while Jeffrey (1917: 415) in his classical "Anatomy of Woody Plants" suggested an aquatic or amphibious way of life might have led to the loss of cambial activity. Henslow's hypothesis has been criticized by Sargant (1903, 1904), who concluded that many of the characteristic features of the monocots may be easier explained as having arisen as a result of adaptation to a geophilous habit. But apparently nearer to the truth was Parkin (1923: 59), who suggested "the golden mean" between the two hypotheses. He writes: "Respecting the relative merits of an aquatic or geophilous ancestry of monocotyledons, the two views may be somewhat reconciled by regarding the earliest ones as neither markedly aquatic nor extremely geophilous—in fact, marsh plants with stout rhizomes. Some of their descendants have become completely hydrophytic, others sharply geophytic, while others have returned to the arborescent habit by fresh means." Apparently the ancient common ancestor of both the Nymphaeidae and monocots was a hygrophilous or perhaps even amphibious geophyte in which geophyly arose under wet terrestrial conditions – most probably under the forest canopy or in the forest margin. But as is well known, underground storage is usually a response to a resting season, and geophytes are abundant and highly diversifi ed in areas with a pronounced resting season (see Bews 1927). Therefore, they could originate in a climate having a marked dry season (Sargant 1903; Stebbins 1974). The class Liliopsida includes 4 subclasses, 31 orders, 120 families, more than 3,000 genera, and about 65,000 species.

Materials:

Specimen of Magnoliopsida from Jember University (Trengguli, Mundu, Mengkudu, Krangkungan, Kembang Sepatu, Glodogan, Glethak, Kemuning, Si Kejut, dan Kacang Pagar)

Location: FMIPA

Equipment:
1. Luv magnification 15X
2. Microscope stereo
3. Petri disc
4. Pinset
5. Object and cover glass

Working procedures:
1. Prepare the equipment and materials;
2. Observe the available specimens, write down the classification, and then write down the morphological characteristics carefully.
3. Draw the Specimen on the Observation Sheet;
4. Find the characteristics of the specimen

Observation result sheet: (Appendix 1)

Plant description

Topic 1. Morphological characteristic observation

2. Description

Topic outcome: Students are able to describe sequentially a type of plant based on the morphological character of the plant

Introduction

A description is an analytic statement describing features that characterise the taxon in question, including macro-morphological to anatomical, biochemical, karyological and molecular aspects. A description should ideally be as thorough as possible. In the ICN glossary, a description is defined as: "a published statement of a feature or features of an individual taxon; a description (or a diagnosis) is required for valid publication of a name of a new taxon (Art. 38.1(a) and 38.3); a validating description need not be diagnostic". The current version of the ICN is clear regarding the distinction between diagnosis and description so the definition of both terms does not currently seem to be a problem. The same approach is confirmed in Turland (2019: 18). It should be remarked that the ICN is focused on nomenclature and not on taxonomy, and does not aim to judge whether descriptions and diagnoses adequately represent the taxa (Nicolson, 1991). Furthermore, we highlight that the discussion presented here refers to Plant Taxonomy, not to other groups of organisms also covered by the ICN, i.e., algae and fungi.

From a historical point of view, Linnaeus (1751), in his Philosophia botanica, defined a description in the Adumbratio 326 (p. 256) as follows: "*Descriptio […] est totius plantae character naturalis, qui describat omnes ejusdem partes externas*", and then he gave more details on how to set up and improve a description: for Linnaeus, a description is an analytic statement clearly and conceptually distinct from a diagnosis, which is a synthetic statement. More recently, Ghiselin (1997), in the glossary at the end of his book, stated that a description "enumerates the properties of things, irrespective of whether or not the properties in question are defining" and a diagnosis "enumerates properties that are useful in identification", thus highlighting the descriptive aspect of a description, which aims at completeness, and the comparative aspect of a diagnosis, which aims at succinctness. Furthermore, a diagnosis reflects the "type method" that represents the epistemological point of contact between Taxonomy and Nomenclature (Candolle, 1867; Mayr, 1989; Witteveen, 2015, 2017, 2018). More reflections on this topic can be found in Simpson (1961), Wiley (1981) and Winston (1999).

Despite the explicit and satisfactory differentiation in the ICN, we argue that the distinction of a diagnosis and a description is not clear to many taxonomists these days, especially the younger ones. New taxa, especially new species, are often described supported only by descriptions, without a diagnosis (e.g., Berry & Galdames, 2013; Van der Maesen, 2013; Palchetti & al., 2018; Shui & al., 2019; Vaezi & al., 2019; Vladimirov & al., 2019), or other times diagnostic and descriptive information is joined under one or the other (e.g., Kuijt & Delprete, 2019). In some cases, a diagnosis is presented after a description (e.g., Arigela & al., 2019; Guzmán-Guzmán, 2019; Xiao & al., 2019), which we consider that further adds to the current state of confusion. Considering the fundamentally distinct purposes of diagnoses and descriptions (see above), we argue that it would be for the benefit of Plant Taxonomy, taxonomists and users of taxonomic classifications if both a diagnosis and a description were always provided to formalise new taxa and that, for consistency, diagnoses be presented before descriptions for each taxon.

Nevertheless, the importance of distinguishing diagnoses and descriptions goes much beyond the formalisation of new taxa. In fact, monographs and other taxonomic literature presenting morphological information should ideally present both diagnoses and descriptions for taxa. This would maximise the usefulness of those treatments, in allowing distinguishing a taxon from its relatives (e.g., a species from its congeners) in the most succinct manner, which is achieved by means of a diagnosis, and also in informing characters of the taxon in question as thoroughly as possible, which is achieved by means of a description. Synoptic works, which normally do not present descriptions of taxa, could nevertheless provide diagnoses for the taxa treated—those diagnoses, although succinct, would have enormous usefulness for the readership in order to comprehend the species concepts and delimitations adopted by the author. Currently, the vast majority of taxonomic works being published do not provide diagnoses for taxa that are not being newly described, a situation that we hope to change with the present letter.

Traditionally, the characters used for descriptions are morphologic, but with the development of new technologies, other types of information could be used, such as, e.g., chromosome number and morphology, physiological characters, biochemical characters, and DNA molecular data (e.g., Goldstein & DeSalle, 2011; Jörger & Schrödl, 2013; Renner, 2016; Bakker, 2017; Viruel & al., 2019). It is undeniable that non-morphological information can be very useful for supporting more stable and refined taxonomic classifications (Jörger & Schrödl, 2013), offering an important support to morphology (although sometimes contradicting it), and most probably will see crescent use among systematists. The use of these extra types of information is undoubtedly improving the informational content for Taxonomy and Systematics as a whole. Such integrative approaches are critically important, especially for the study of species complexes and cryptic species and constitute further support for the integration (but not substitution!) of non-morphological information to the elaboration of descriptions (Tripp & Lendemer, 2014). We acknowledge that information on micro- or nanomorphological features such as chromosomic and molecular data is not always available, but its inclusion in a description is desirable and should be done when possible.

As an illustrative example, Li & al. (2012) recently published a new fern genus, Gaga Pryer & al., presenting a description and mentioning, regarding the etymology of the new taxon, that "At nucleotide positions 598–601 in the matK gene alignment, all Gaga species have 'GAGA' […], a sequence pattern not seen at this site in any other cheilanthoid fern sampled", from which the name of the genus was dedicated to a famous American pop star. Li & al. (2012) were the first to use a nucleotide sequence from which they justified the etymology of a new genus name, but they omitted this important molecular information from the description they provided for the new genus. This very relevant molecular information could have been included in the description of the new taxon, instead in the Etymology section. Furthermore, it should be noted that the first paragraph of the description they provided for Gaga is clearly a diagnosis, which is, however, not referred to as such; this fact corroborates the prevailing view, which we highlight here, that diagnoses and descriptions are nowadays being confused by many among the scientific community.

In the case of diagnoses, however, we argue that the use of non-morphological information would undo their very purpose, i.e., to provide the most succinct and accessible means for the identification of the taxon in question. Therefore, we argue that diagnoses should use only morphological characters. The use of morphological diagnoses advocated here does not preclude that non-morphological characters be used to elaborate non-morphological diagnoses, e.g., a molecular diagnosis presenting a string of nucleotides that is unique to the taxon in question. Thus, contrary to the description, the combination of different types of characters is counterproductive for diagnoses.

The abandonment of the use of morphology for the description of new taxa and for the taxonomic classification as a whole has been suggested in some recent works (e.g., Cook & al., 2010). We feel that this would have extremely negative consequences to Taxonomy and consequently to Systematics because most of the taxonomic novelties (especially in Plant Taxonomy) are happening in contexts where molecular works are completely unavailable. Furthermore, people working with molecular phylogeny often lack experience and knowledge of taxonomic practices and nomenclature, and there is a well-known general trend of reduction (even extinction, in some environments) of taxonomists in research institutes, universities and even museums (Agnarsson & Kuntner, 2007; Ebach & al., 2011; Wägele & al., 2011; Sluys, 2013). The development of new techniques is increasing, not decreasing the demand for taxonomic expertise and correct specimen determinations (Will & Rubinoff, 2004; Packer & al., 2009; Taylor & Harris, 2012). In sum, abandoning morphology would bring no benefits to Plant Taxonomy and would effectively stall taxonomic advancement in the regions of the world precisely where most of the unknown biodiversity occurs. This would also have nefarious consequences for biodiversity conservation, not only because many narrowly endemic species would remain unknown to science, but also because without the use of morphology, it would become essentially impossible to recognise or determine rare and/or threatened species (Ely & al., 2017; Thomson & al., 2018).

Activity 1 Morphological characteristics

Materials: Weeds from Campus

Equipment : Luv magnification 10 – 15 X

Lokasi : in-door

Working procedures:

1. Observe the object carefully, both on the characteristics of vegetative and generative organs;
2. Write down the results of these observations on the Morphological Characteristics sheet below;

Observation result sheet: (Appendix 2)

Description

Working procedures:

1. Write down the Habitus of the plant concerned;
2. Next, write down all the morphological characteristics of all organs in order;
3. Write down all the morphological features. in the form of a one-paragraph narrative (description);
4. Check your description and arrange the description in sequence.

Observation result sheet: (Appendix 1)

Sample: Plant description

Habitus tree, chronic, living in the yard. Tap root system. The direction of growth is upright, branching monopodial, the shape of the stem is round, woody, hard, rough surface, gray brown color. Single leaf arrangement, imperfect, not having a midrib, small penump leaves like scales, soon fall; petiole cylindrical, thickened at the tip, 1⅓ - 2⅓ cm long, scaly tightly; elliptical leaf blade – jorong sometimes oblong – knife-like, 10 – 20 cm long, 4 – 8 cm wide, flat leaf edge, pointed tip, rounded base, pinnate leaf spines, skin-like rigidity, bare upper surface, scaly lower surface, The mother of the leaf bone clearly protrudes from the lower side to the tip of the leaf, the upper side of the leaf is shallowly grooved, the branches of the leaf bone are oblique to the top, more or less parallel to each other. Flowers are found on somewhat old branches in a series like a fan, growing sideways, hanging, each series consists of 6-12 buds, petals numbered 5; flower stalks cylindrical, thickened at the ends, 3-8 cm long, scaly tightly; there are tamMaterials petals which are initially attached to cover the flower buds, but then divide irregularly in 2 – 4 peduncles, but usually 3, 2 – 2½ cm long, scaly outer side, short hairy inner side, tight and smooth, fall off soon; flower buds spherical or spherical in shape - ovoid, blunt or rounded ends, sometimes with a slightly pointed apex; corolla composed of 5 petals, separated, petals yellowish white, elongated round shape – spatel shape, 3½ - 5 cm long, 2-3 cm wide, short hairy outer side, glabrous inner side; the stamens are numerous in 5 bundles, each bundle facing the petals, partially attached at the base, after the flower blooms it will release, the outer side is clearly grooved, the attachment of the stamens in the bundle is only or of the length of the stamen stalk, the top is free , each bundle consists of 9-12 stamens with pollen chambers at the end; ovule hitchhiking, spherical shape – elongated or ovoid, bear 5, length 0.6 – 0.7 cm, diameter 0.4 – 0.5 cm, tightly scaly; pistil stalk 3-5 cm, short hair with a small pistil. A single true fruit consisting of several fruit leaves, has several chambers, each chamber contains several seeds. The seeds are wrapped in arillus which has thick and juicy flesh that is delicious to eat, yellow in color.

Plant Identification

Topic: 1. Morphological characteristic

2. Identification

Topic outcome: Students are able to identify a plant species to a tribal or family taxon based on morphological characters

Introduction

Plant identification implies assigning a plant to a particular taxonomic group – ultimately to the species. The identification of plant specimens is its determination of being identical with or similar to another and already known plant. Identification is the determination of a taxon as being identical with or similar to another and already known elements; the determination may or may not be arrived at with the aid of literature or by comparison with the plant of known identity. No names need to be involved in the process of identifying a plant. The naming of a plant or nomenclature is different from identification. When an unknown plant is collected from a known locality, the common practice is to refer to a book accounting for the plants of that region. This contains usually the analytical keys and descriptions.

Methods of Plant Identification:

First Method:

The first step is the determination of the families to which the unknown plant belongs. Knowing the name of the family one can turn the keys to genera for determining the generic name and then for the specific identity of the plant to the species key.

Since, for many reasons, the identity and name of the plant obtained may be incorrect, it is always safe to check the description of the plant to ensure that there is a reasonable agreement between the characters observed in the unknown plant and those given in the description of the plant presumed to be.

Second Method:

The second method is the utilization of the latest floras and a check list of the particular region. These comprise usually an index to the plants known for the locality and generally provide another pertinent habit, distributional and frequency data. By the process of elimination, an unknown plant can be assigned to genera having one or more species, and identification may be completed by comparison of characters with those given in any standard work accounting of the plants of that area.

Third Method:

The third method is the identification by means of monographs or revisionary works accounting for the particular family or genus. Plant Characters before Its Identification:

Study the plant specimen to be identified in detail.

Mention the following characters:

1. Nature of specimen – herbaceous, or woody; annual or perennial.

2. Phyllotaxy and venation.

3. Inflorescence type – Capitulum (e.g. Asteraceae), Cyathium (e.g. Euphorbiaceae), Verticellaster (e.g. Lamiaceae) etc.

4. Flower and its parts – actinomorphic or zygomorphic.

5. Presence of epicalyx (e.g. Malvaceae).

6. Number of sepals and petals or tepals, their aestivation.

7. Petals free (e.g. polypetalae) or fused (e.g. gamopetalae).

8. Number of stamens and their position – antipetalous (e.g. Chenopodiaecae) alternipetalous or obdiplostemonous, (e.g. Caryophyllaceae). Staminal tube (e.g. Malvaceae).

9. Count number of carpel/carpels, style – gynobasic (e.g. Lamiaceae); stigmas.

10. Type of placentation.

Keys in Plant Identification:

A key is a device for easily identifying an unknown plant by a sequence of choices between two or more statements. A key is an artificial analytical device or arrangement where by a choice is provided between two contradictory characters resulting in the acceptance of one and the rejection of the other. Statements in the keys are based on the characters of the plants (mentioned above).

For example, a key might separate taxa using the following choices:

(1) Herbaceous versus woody if herbaceous, the woody plants are eliminated;

(2) The next choice, zygomorphic flowers versus actinomorphic, if zygomorphic, the plants with actinomorphic flowers are eliminated and so forth.

Punched card keys are used in the school, colleges etc. by the students. Punched card keys consist of cards of suitable size with names of all the taxa (all families, genera or species for which the key is meant) printed on each one of them.

Each card has a number and any one character printed near one of the corners. All the taxa showing this character are indicated by a perforation in front of their names, while those lacking this character are without any perforation.

Dichotomous Keys:

A dichotomous key presents two contrasting choices or couplet at each step. The key is designed so that one part of the couplet will be accepted and the other rejected. The first contrasting characters in each couplet are referred to as the primary key characters. These are usually the best contrasting characters. Characters following the lead are secondary key characters.

The dichotomous keys are of two types, viz., Indented key (Yoked key) and Bracketed key (Parallel key).

A dichotomous key in which the first part of a contrasting couplet is followed by all subsequent couplets; each subordinate couplet being indented one step further to the right for clarity of presentation. The indented key is the one most widely used in manuals for the identification of vascular plants. In the indented key, each of the couplets is indented a fixed distance from the left margin of the page.

Bracketed or Bracket Key or Parallel Key:

A dichotomous key in which contrasting parts of a couplet are numbered and presented together, without intervening couplets, although the brackets joining each couplet are now omitted.

Example:

The plants used in the example are common genera of the family: Ranunculaceae, viz., Clematis, Anemone, Ranunculus, Aquilegia and Delphinium.

A. Indented Key:

The first choice, with in the above genera is between “Fruit a group of achenes; flowers not spurred” and “Fruit a group of follicles; flowers spurred”, these paired statements being given the same indention.

If the latter choice is taken, the next choice, shown of the indention, is between “Flowers regular, spurs 5” and “Flowers irregular, spur ‘1’. Thus the plant in question has follicles and irregular flowers with a single spur, it must be a Delphinium.

B. Bracketed Key or Parallel Key:

In this the two couplets are always next to each other in consecutive lines on the page.

The same example of bracketed key is given below:

(i) Fruit a group of achenes; flowers unspurred (2)

(i) Fruit a group of follicles; flowers spurred ……… (4)

(2) Petals absent……………………………………… (3)

(2) Petals present………………. Ranunculus

(3) Sepals usually 4; involucre absent……… Clematis

(3) Sepals usually 5; involucre present……… Anemone

(4) Flowers regular; spurs 5…………….. Aquilagia

(4) Flowers irregular; spur 1 ………… Delphinium

The number at the right end of a line in the bracket key indicates the next numbered pair of choices to be considered.

The keys use the most conspicuous and clear-cut characters, without special regard to those considered taxonomically the most important. For this reason the sequence of taxa is often quite artificial, and such keys are frequently termed artificial keys. Artificial key is an identification key based on convenient phenotypic characters and not indicating phylogenetic relationships.

Natural key is an identification key constructed from a natural classification and indicating the supposed evolutionary relationships of the group within the branching sequences of the key.

Comparison of Indented Key and Bracketed Key:

Indented Key:

1. Each couplet has its 2 leads indented by the same amount from the left-hand margin of the page.

2. The first couplet to be consulted is the one least indented and which has its first lead at the head of the key.

3. The next appropriate couplet to be consulted is the one with its first lead immediately below the chosen lead of the previous couplet, its leads being the next least indented pair below the latter.

Bracketed Key:

1. Each couplet has its 2 leads immediately adjacent under the same left-hand number.

2. The first couplet to be consulted stands at the head of the key next to the number 1.

3. The next appropriate couplet to be consulted is indicated by the reference number to further down the key, placed on the right-hand side of the chosen lead.

Construction of Key:

In constructing a key following techniques may be followed:

1. Key should be dichotomous.

2. The first word of each lead of the couplet should be identical. For example, if the first lead of a couplet begins with the word fruit, the second lead of the same couplet must begin with the word fruit as in example.

3. The two parts of the couplet should be made up of contradictory statements so that one part will apply and the other part will not i.e., rejected.

4. Do not use overlapping ranges or vague generalities in the couplets.

5. The couplets should be of positive statement e.g., "leaves narrow versus leaves not narrow".

6. Use distinct and readily observable features.

7. The leads of consecutive couplets should not begin with the same word, since this may cause confusion.

8. It may be necessary to provide two sets of keys in some groups; flowering versus fruiting material, vegetative versus flowering, or staminate versus pistillate for dioecious plants.

9. Couplets of a key may be numbered or lettered, or may use some combination of lettering and numbering, or may be left blank in the case of indented keys.

Keys are traditional method of identification in taxonomy. If keys are well written with adequate specimens and carefully, then the specimen can be successfully identified. Keys, however, have several major disadvantages. The use of certain characters is required even if the character is not evident in the unknown specimen.

Activity 1: Morphological observation

Materials : Specimens of weeds from campus
Equipment : Luv magnification 10 – 15 X
Lokasi : in-door

Working procedures:
1. Observe the object carefully, both on the characteristics of vegetative and generative organs;
2. Make a small note of another important characteristic that you. get, is likely a hallmark;
3. Based on the characteristics of these organs make a description;
4. Determine the important features for identification.

Observation result sheet: (Appendix 1)

Activity 2: Identification

Working procedures:
1. Put a mark (make a small note) for important features of the vegetative organs;
2. Then focus on observing only the generative organs;
3. Draw the flowers, focusing on the special features according to your notes!;
4. Based on the identity mentioned above, then determine the taxon (tribe-generic-species);
5. Repeat for the plant types from the other Materials;
6. Pay attention to the similarities they have to estimate the kinship between them.

Observation result sheet: (Appendix 1)

Activity 3 Key Identification

Topic outcome
1. Students can explain the key identification of plants and their use
2. Students can read the key identification of plants
3. Students can create a simple key identification (Parallel Dichotomy Key).

Topic 1:Practice reading Key identification of van Steenis

Equipment: Key identification book "Flora for the student in Indonesia" by van Steenis
Working procedures:
1. Find the chapter of GOLONGAN 6
2. Follow the keys until the Apocynaceae are found;
3. Write down the number and the letter:
4. Continue to search until you find the taxon by looking for the Genus number, read the sequel and write the reading direction as in point 3 above;
5. Do the same procedure for group 8 for the family Moraceae, and group 5 for the genus of Orchidaceae.

Observation result sheet: (Appendix 1)

Activity 4: Practice creating a simple key identification "parrarel key identification"

Materials: Weeds growing around the university (10 species or more) or use these plants:
1. Peanut (Arachis hypogaea)
2. Sunflower (Helianthus annuus)
3. Bugenvil (Bougainvillea spectabilis)
4. Alamanda (Allamanda cathartica L)
5. Pinus (Pinus merkusii)
6. Si Kejut (Mimosa pudica)
7. Sirih (Piper betle)
8. Bunga pukul 4 (Mirabilis jalapa)
9. Belinjo (Gnetum gnemon)

Equipment: Luv magnification 15x

Working procedures:
1. Observe the morphological characteristics of each plant material and record them in a table.
2. Based on these morphological characteristics, make a tree diagram in the following way:
    a. Determine a distinguishing feature so that the nine (9) types of plants can be grouped into two groups. Examples of distinguishing features include habitus, root system, leaf type, leaf arrangement, etc. By using such a distinguishing feature, the specimens can be clearly grouped into two smaller groups. Put arrows to indicate different groups in descending order. Write down the difference so it doesn't get confused in the next grouping;
    b. Observe and pay attention again to the members of each group that has been divided into two groups, then determine each feature again in each group so that each group can be further divided into two smaller groups.
    c. And so on until each group has only one individual
3. Make the Dichotomy Key based on the tree diagram that has been made!
4. Make the Dichotomy Key based on the tree diagram that has been made!

Observation result sheet: (Appendix 1)

Phylogenic tree

Topic outcome: Students are able to make phylogenetic trees and explain their relationship

Introduction

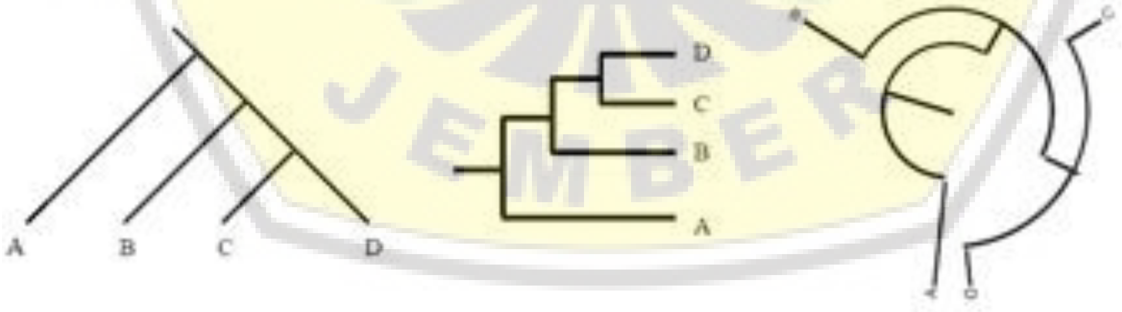
Definition of phylogenetic tree

A phylogenetic tree, also known as a phylogeny, is a diagram depicting the evolutionary lineages of various species, organisms, or genes from a common ancestor. Phylogeny is useful for organizing knowledge about biodiversity, for compiling classifications, and for providing insight into events that occurred during evolution. Furthermore, because these trees show descent from a common ancestor, and since most of the strongest evidence for evolution comes in the form of a common ancestor, one must understand phylogeny in order to fully appreciate the vast body of evidence supporting the theory of evolution.

Tree diagrams have been used in evolutionary biology since the time of Charles Darwin. Therefore, one might assume that, by now, most scientists would be very comfortable with "tree thinking" - reading and interpreting phylogeny. However, it turns out that the evolutionary tree model is somewhat counterintuitive and easily misunderstood. This may be the reason why biologists only in the last few decades have come to develop a rigorous understanding of phylogenetic trees. This understanding enables today's researchers to use phylogeny to visualize evolution, organize their knowledge of biodiversity, and structure and guide ongoing evolutionary research.

Shape of the phylogenetic tree

Trees can represent the same information but are oriented in different ways. The three trees in Figure 1, for example, have the same topology and with the same evolutionary implications. In each case, the first divergence event separated the lineage that gave rise to the A tip from the line that gave rise to the B, C, and D ends. The latter lineage then split into two lineages, one of which developed into the B end, and the other that gave rise to tips C and D. This means that C and D share a more recent ancestor with each other than with A or B. Therefore, C and D ends are more closely related to each other than A or B ends. Diagram also shows that ends B, C, and D all share a more recent common ancestor with each other than they do with ends A. Since ends B are the same distance (in terms of branch arrangement) from both C and D, we can say that B is closely related to C and D. Likewise, B, C, and D are all related to A.



Source: Baum, D. (2008). Reading a phylogenetic tree: the meaning of monophyletic groups. Nature Education, 1(1), 190.

Creating a phylogenetic tree

There are two ways to create a phylogeny tree, the first is simple (manually) and the second is by using software. In this practicum, a simple phylogenetic tree program is made based on the morphological characters of the plant specimens used. The phylogeny tree was compiled using software, namely FAMD (Fingerprint Analysis with Missing Data 1.31) and FigTree. FAMD is used to calculate variance related to finger printing data handling and analysis.

Analytical capabilities include distance-based analysis, bootstrap and consensus tree generation, allele frequency estimation, AMOVA, distance between populations, Shannon index. While FigTree is designed as a program to display phylogenetic tree graphics and as a program to generate genetic closeness numbers for publication.

Materials: Several types of plants around the campus that have been used in the practicum program for the diversity of mosses, ferns, gymnosperms, and angiosperms

The FAMD program can be accessed at the following link: http://www.famd.me.uk/famd.html

The Figtree program can be accessed at the following link: http://tree.bio.ed.ac.uk/software/figtree/

Tools: 15X magnification loupe (if necessary - bring an assistant)

Procedure:

1. Observe the specimen carefully, write down the morphological characters in the observation table.
2. Characters that appear are coded with the number 1, while characters that do not appear are marked with the number 0. For characters that are not known, they are marked with the code “N”
3. Complete the observation data by comparing all the morphological characters of the specimen and writing them down in the table.
4. Save the table in txt format using notepad.
5. Open FAMD program and import data.
6. Process the data to obtain similarity index data.
7. Save FAMD analysis data as 'outtree.ph'
8. Open the fig tree program and input the data 'outtree.ph'
9. Complete the description by activating the existing menu.
10. Good luck

Picture how it works

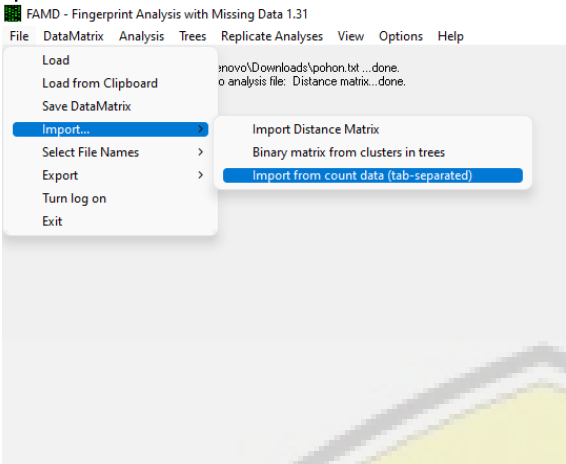
1. Input data

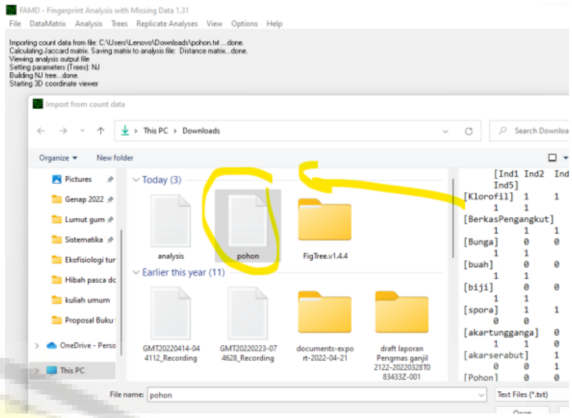
	[Ind1	Ind2	Ind3	Ind4	Ind5]
[Klorofil]	1	1	1	1	1
[BerkasPengangkut]	0	1	1	1	1
[Bunga]	0	0	1	1	1
[buah]	0	0	1	1	1
[biji]	0	0	1	1	1
[spora]	1	1	0	0	0
[akartunggganga]	0	0	1	1	0
[akarserabut]	1	0	0	0	1
[Pohon]	0	0	0	1	0
[herba]	0	0	0	0	1
[semak]	1	1	1	0	0

2. Formatting "phpnklompok_x.txt"

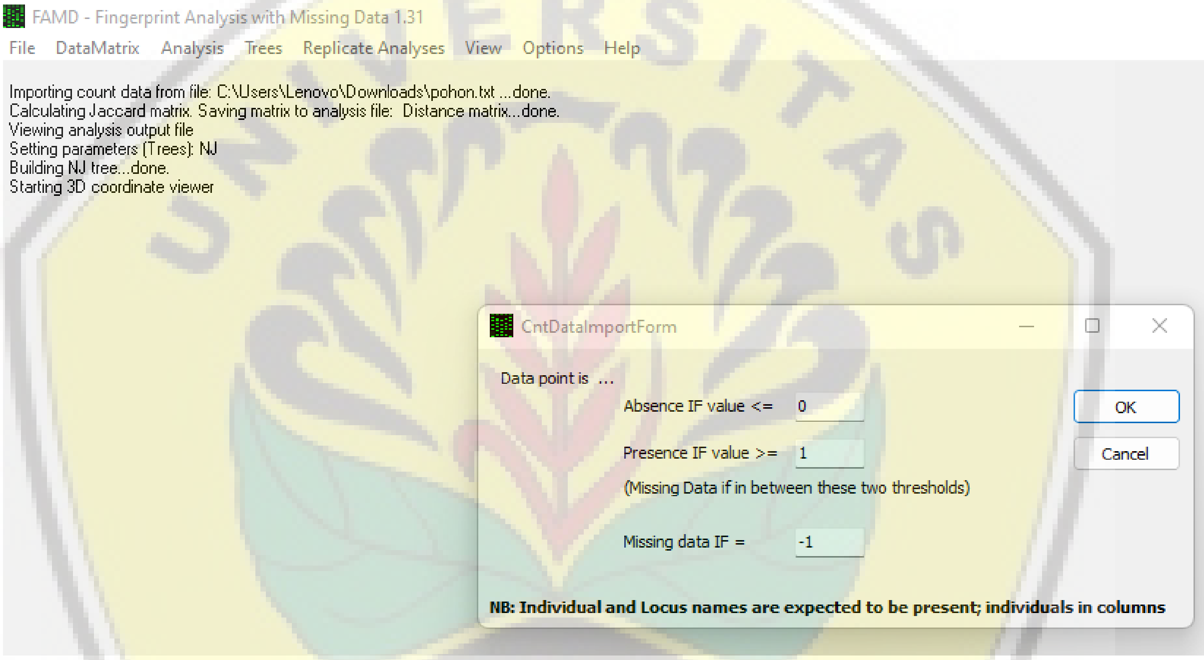
```
      [Ind1  Ind2   Ind3   Ind4   Ind5]
[Klorofil]  1      1      1      1      1
[BerkasPengangkut]      0      1      1      1      1
[Bunga]     0      0      1      1      1
[buah]      0      0      1      1      1
[biji]      0      0      1      1      1
[spora]     1      1      0      0      0
[akartunggganga]  0      0      1      1      0
[akarserabut]     1      0      0      0      1
[Pohon]     0      0      0      1      0
[herba]     0      0      0      0      1
[semak]     1      1      1      0      0
```

3. Input data into FMD

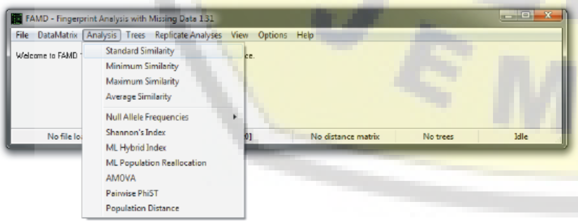


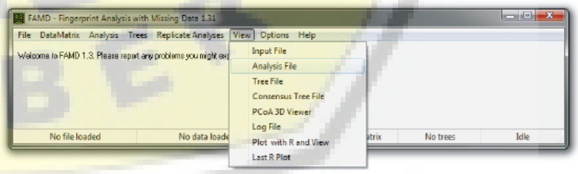


4. Define the code



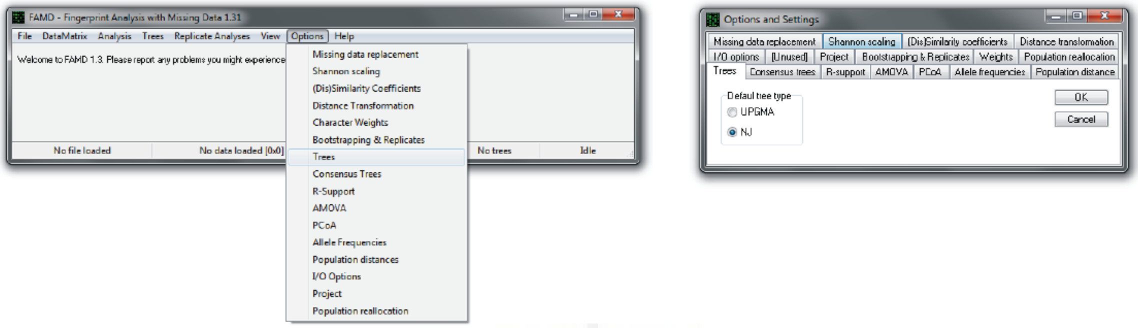
5. The process of similarity index



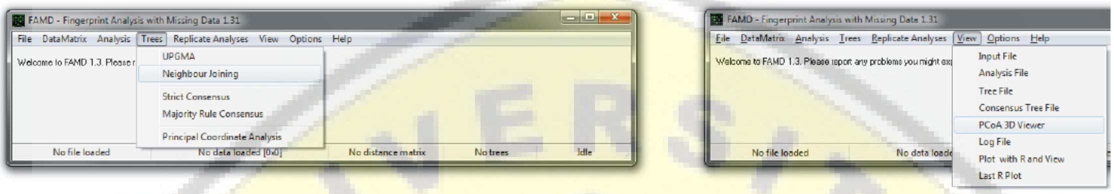


6. Set the opsi to analisis dan export

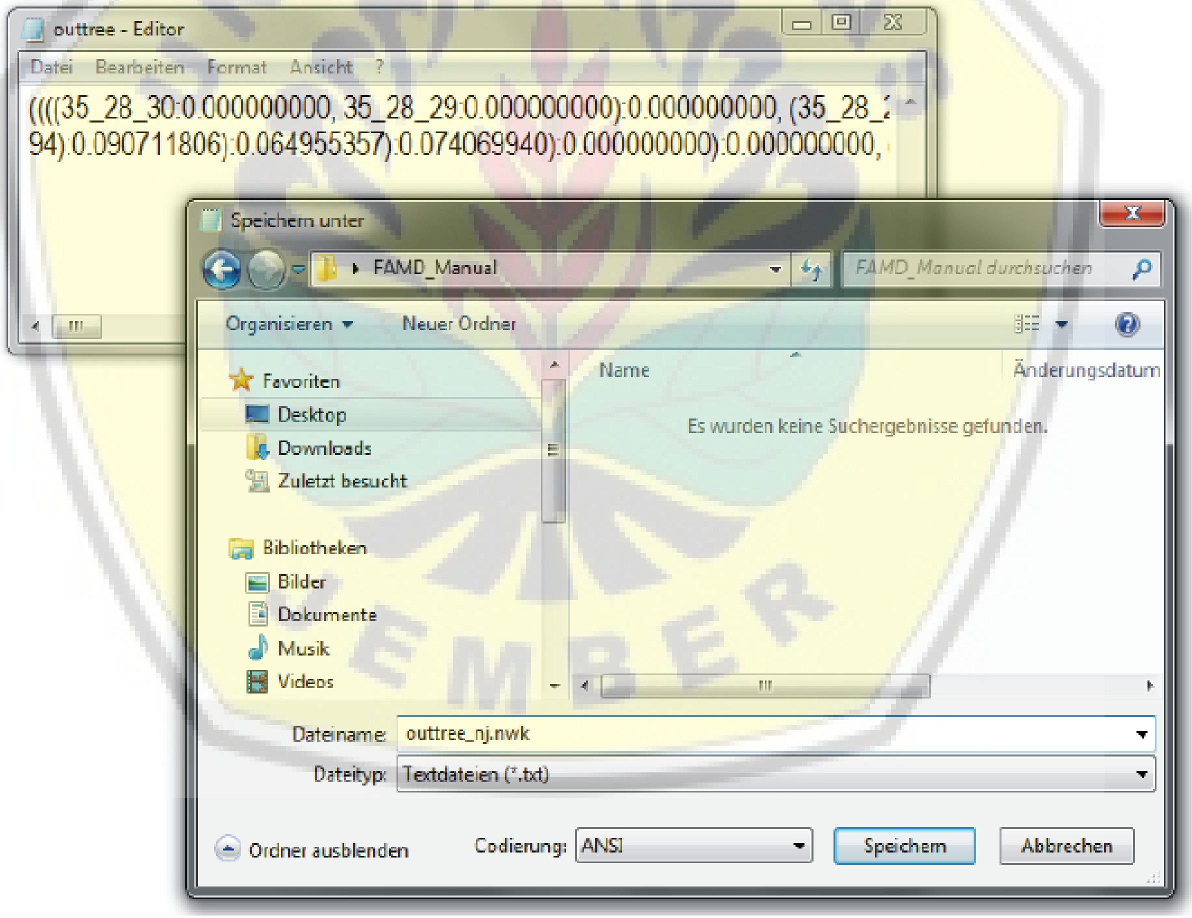
4 - set analyses options



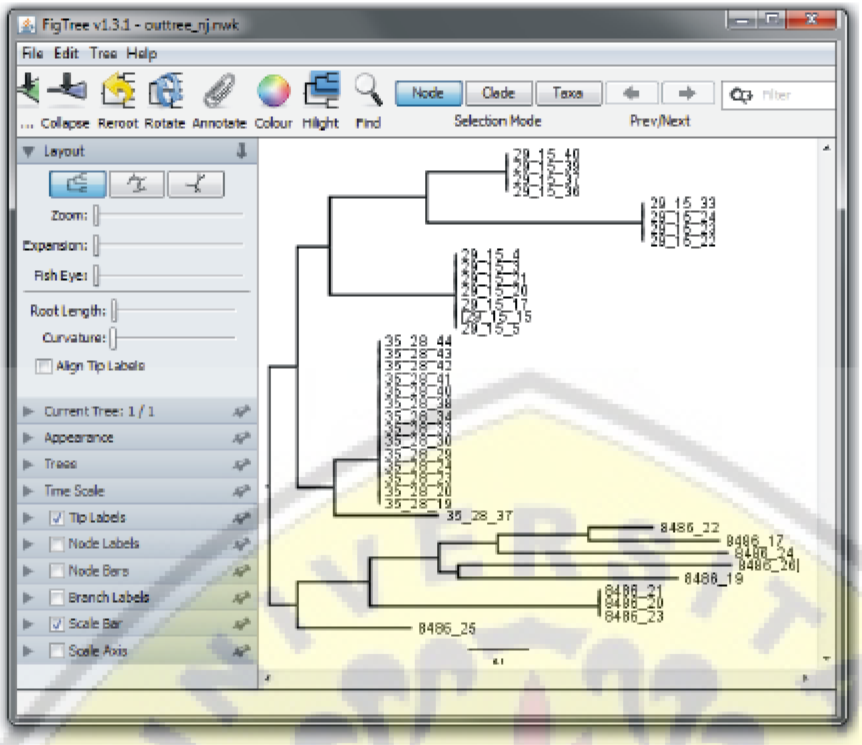
5 - compute PCoA/Neighbor-joining from the similarity matrix and view and export the results

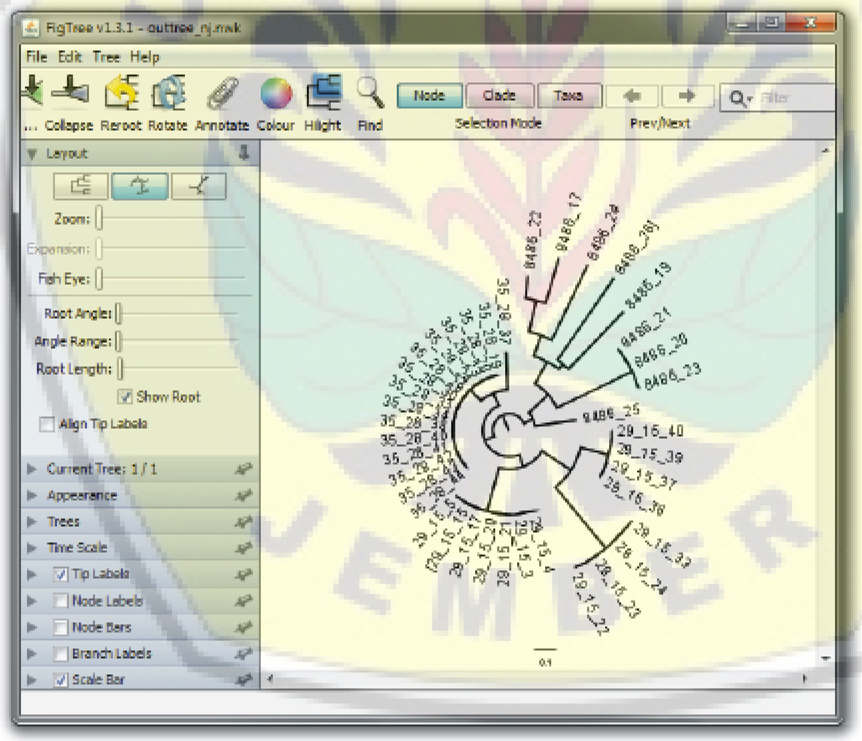


7. Open FigTree and input data



8. Display the tree and modify it by re-rooting and shape editing


FigTree v1.3.1 - outtree_nj.nwk
File Edit Tree Help
Collapse Reroot Rotate Annotate Colour Hilight Find
Node Clade Taxa
Selection Mode
Prev/Next
Filter
Layout
Zoom:
Expansion:
Fish Eye:
Root Length:
Curvature:
Align Tip Labels
Current Tree: 1 / 1
Appearance
Trees
Time Scale
Tip Labels
Node Labels
Node Bars
Branch Labels
Scale Bar
Scale Axis
35_28_37
8486_22
8486_19
8486_25


FigTree v1.3.1 - outtree_nj.nwk
File Edit Tree Help
Collapse Reroot Rotate Annotate Colour Hilight Find
Node Clade Taxa
Selection Mode
Prev/Next
Filter
Layout
Zoom:
Expansion:
Fish Eye:
Root Angle:
Angle Range:
Root Length:
Show Root
Align Tip Labels
Current Tree: 1 / 1
Appearance
Trees
Time Scale
Tip Labels
Node Labels
Node Bars
Branch Labels
Scale Bar
8486_25
29_16_40

Field trip to Botanical Garden Eka Karya Bali

Topic outcome:

1. Students are able to describe the diversity of plants in the Eka Karya Bali Botanical Gardens

2. Students are able to verify the label of species and family of the specimen collection in the Eka Karya Bali Botanical Gardens

Introduction

Bali Botanic Garden is Indonesia's largest Botanic Garden containing the island's biggest collection of wild orchids and receiving over half-a-million visitors each year. Nestled in the refreshingly cool, mountainous region of Bedugul in central Bali, the 157-hectare Garden is an easy day trip, around 90 minutes drive north of Denpasar. The sprawling, peaceful Garden is a mix of green, open space, landscaped gardens, unique plant collections and remnant tropical forest set against the misty slopes of Tapak Hill.

Bali Botanic Garden is recognised as a leading research centre of plant biodiversity and conservation in Indonesia, conducting research in the field of horticulture, plant biodiversity and conservation with a focus on rare and endangered species from Eastern Indonesia. Seeds and plants are accepted only if their provenance is known and only if they have been collected and imported legally. Plants that have the potential for invasiveness, and genetic pollution or could introduce pests or diseases are carefully screened and evaluated before acceptance. The botanic garden offers some scientific services and facilities in support of plant research and conservation, including a seed bank, herbarium, tissue culture laboratory, greenhouses, nursery, library and plant database. More than 2,400 species of plants can be found in the Bali Botanic Garden. This 'warehouse' of plant genetics could be very useful in future if required for restoration purposes.

Equipment: Field practical book and Camera

Working procedures:

1. All participants join a group, each group will be accompanied by an assistant.
2. Every student should read the file guide book that has been prepared by the lecturer
3. Each group will observe the types of plants found in the field based on points/sectors/tribes that have been determined in turn, namely Orchidaceae, Cactaceae, Gymnosperms, Begonoiaceae, Pteridophyta, and Arecaceae.
4. Find all living specimens according to the list!
5. Observe the specimen, then draw a schematic of the habitus and possible vegetative and generative organs and write down the morphological characteristics on the Observation Sheet.
6. Find the characteristics of the specimen and write them on the worksheet;
7. Take some photos of the specimens you observe, photos that represent: habitus, stem surface, branching, leaf shape, special organs, and reproductive equipment.
8. Write the Latin name and ethnicity of each specimen listed, then confirm with IPNI and Cronquist classification (make it after the fieldwork)
9. Each group is required to submit a report in the form of a video uploaded on YouTube

Appendix 1: Observation Sheet

PLANT SYSTEMS PRACTICUM

Specimen :

Classification

Class :

Ordo :

Famili :

Genus :

Species :

Morphological characteristics:	
1.	
2.	
3.	
4, 5.	
Drawing :	Information: 1. 2. 3. 4. dst Description:

Appendix 2: Observation Sheet

Description:

References

Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. New York: Columbia University Press.

Cronquist, A. 1988. The Evolution and Classification of Flowering Plants. Second Edition. New York: Columbia University Press.

Dasuki, U.D. 1991. Sistematika Tumbuhan Tinggi, Jurusan Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Institut Teknologi Bandung, Bandung.

de Winter, W. P. and V. B. Amoroso. 2003. Plant Resources of South-East Asia Cryptogams: Fern and Fern Allies. Bogor: Prosea Foundation.

Gudiño, J. Matt von Konrat & Kimberly Mighell Produced by: Robin Foster, Juliana Philip, Laura Briscoe & Matt von Komrat Matt von Konrat and Environmental & Conservation Programs. No Year. The Field Museum Chicago, IL 60605, USA. Rapid Color Guide Comparison between Mosses, Liverworts and Hornworts by:

Hassemer, G., Prado, J. and Baldini, R.M., 2020. Diagnoses and descriptions in Plant Taxonomy: are we making proper use of them. Taxon, 69(1), pp.1-4.

Holttum, R. E. 1967. A Revised Flora of Malaya Volume II. Ferns of Malaya. Government Printing Office. Singapore.

Plant Identification: https://www.biologydiscussion.com/plant-taxonomy/plant-identification/an-overview-on-plant-identification/47635

Simpson, M.G., 2019. Plant systematics. Academic press.