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Building the herbarium specimens of some species of dicotyledonous plants for teaching at Tan Trao University

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Abstract
The article is founded upon theories related to plants, dicotyledonous plants, the herbarium specimens preservation, and the instructional demands of Tan Trao University's students. This forms the basis for constructing the herbarium specimens from the Dicotyledonae. Consequently, the herbarium specimens of 40 dried plant specimens belonging to the Dicotyledonae was established, encompassing 22 families, 18 orders, and 6 classes. Additionally, a sulfur powder preservation technique was introduced for the plant specimens, alongside analyze the applications of the herbarium specimens in teaching various topics related to taxonomy, encompassing theoretical lessons concerning the attributes and practical functions of plant species within different families and orders. Furthermore, delve into practical lessons that involve analyzing the characteristics of Angiosperm plants. Measures have been proposed to augment the number of plant specimens in the imminent future, while information pertaining to taxonomic specimens is archived in Excel files to facilitate students' access. These findings represent a pivotal stride towards enhancing teaching and learning efficacy, while offering support to students and educators in comprehending and mastering knowledge concerning dicotyledonous plants.

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1. Introduction

In the natural world, plants are of great significance to humans on earth. It is the foundation of biodiversity, agricultural diversity and the guarantee of sustainable human development. Therefore, the identification and conservation of plant species is an urgent matter. Simultaneously, this is the foundation for the transmission of the next generations as well as ensuring the development of the science of the industry.

In the study of plants, the process of collecting, preserving and managing specimens has been interested and used by botanists for a long time. The initial herbaria were established in Italy as a collection of dried plant samples sewn into paper. During the mid-16th century, John Falconer and William Turner, both Englishmen, were the first to document their herbaria. Subsequently, Line popularized the practice of arranging specimens on individual sheets of paper, which were then stacked for storage. By the early 19th century, plants were sewn or pasted onto flat paper sheets and bound into volumes. From these beginnings, herbaria swiftly proliferated around the world, storing millions of specimens within metal cabinets. Each herbarium has its own unique code, such as P for the Muséum National d'Histoire Naturelle in Paris (France), K for the herbarium at the Royal Botanic Gardens, Kew (UK), and HN for the herbarium at the Vietnam Institute of Ecology and Biological Resources, under the Vietnam Academy of Science and Technology in Hanoi.

In Vietnam, herbaria are established in various universities and plant research institutes, such as VNU University of Science and the Vietnam Museum of Nature under Thai Nguyen University of Education. Additionally, numerous research projects have been undertaken, including "Survey, cataloging, and construction of the herbarium specimens for woody plants in Ba Na - Nui Chua Nature Reserve" led by Dr.

Dinh Thi Phuong Anh (from Da Nang University) in 2005 [1], "Survey, evaluation, and restoration of the herbarium specimens at the Institute of Ecology and Biological Resources" by Dr. Le Xuan Canh, Institute of Ecology and Biological Resources.

Building on research findings worldwide and in Vietnam, in Tuyen Quang, the forest rangers of the Cham Chu Nature Reserve have undertaken the construction of the herbarium specimens. Furthermore, the establishment of plant specimens has also been explored, leading to the publication of findings such as herbal plant specimens in the Na Hang Nature Reserve studied by researcher Nguyen Thi Hai and colleagues within the project “Surveying and evaluating the current state of medicinal plant resources in several highland communes of Na Hang District, proposing conservation strategies and sustainable utilization for selected valuable and promising species”. Another herbarium specimens was established by researcher Nguyen Van Giap at the Cham Chu Nature Reserve. Notably, within the project “Research, evaluation of biological diversity in protected and special-use forests, developing management solutions, biodiversity conservation, and collecting specimens associated with ecotourism development in the Na Hang Nature Reserve," the provincial Forest Protection Department officials collected 520 plant specimens, including 342 leaf specimens, 125 bark specimens, 24 fruit specimens, 24 wood specimens, 3 flower specimens, 2 root specimens; along with 20 animal specimens and 150 documentary photographs.

The process of collecting and preserving specimens is of utmost importance as it aids in identifying new plant species and conducting plant inventories within specific regions or defined scopes. A herbarium is where the fundamental plant specimens are stored for research and learning purposes; it safeguards the value of all plant names, for if the standard specimen is lost, the name of that plant loses its significance. The current plant species, collected and preserved by scientists in herbaria, serve as an immensely vital source of information, indispensable for researchers and learners delving into the study of plants.

The Dicotyledonae is a large class of the Angiosperms, comprising around 120,000 species spanning approximately 330 families and 71 orders. This class encompasses numerous closely related plant species of significant importance to human life [2, 11, 12].

Currently, at the Biology Laboratory of Tan Trao University, there is a lack of herbarium specimens, especially for dicotyledonous plants, which is crucial for supporting students' learning. For theoretical lessons in plant classification, lecturers either prepare specimens themselves or request students to do so. In practical sessions, laboratory personnel usually prepare the specimens. When obtaining a plant specimen for study, all essential parts such as roots, stems, leaves, flowers, fruits, and seeds are necessary. However, obtaining all these parts is not always feasible due to the varying seasons throughout the year, particularly for flowers and fruits, which are influenced by different periods. The absence of dried specimens or having insufficient fresh specimens significantly affects students' motivation and the quality of lessons. Constructing a herbarium collection will empower educators to have a more proactive teaching approach, while students will engage more actively and enthusiastically in their studies, ultimately enhancing the effectiveness of the lessons.

In this article, I aim to build upon previous research outcomes to develop the herbarium specimens for some species of dicotyledonous plants. The results of this research will serve the purpose of teaching at Tan Trao University.

2. Contents

2.1. General aspects of plants and Dicotyledonous plants

2.1.1. Plant Kingdom

Plants are organisms capable of synthesizing nutrients from simple inorganic compounds and constructing complex molecules through the process of photosynthesis, which occurs in the chloroplasts of plant cells. Thus, plants are primarily autotrophic organisms. Photosynthesis, utilizing light energy, is facilitated by the pigment chlorophyll, present in all plant species (absent in animals), with fungi being an exception. Although lacking chlorophyll, fungi acquire nutrients from organic matter obtained from other organisms or dead tissue. Plants are also characterized by having cell walls composed of cellulose (absent in animals). Unlike animals, plants lack the ability for free movement, except for a few microscopic plant species with limited mobility. Another distinct feature of plants is their slow response to stimuli; reactions usually occur on a daily basis and only under sustained stimulation [11, 12].

Plants form a prominent group of organisms, encompassing familiar entities such as trees, flowering plants, grasses, ferns, and mosses. Approximately 350,000 plant species, identified as seed plants, mosses, ferns, and fern-like relatives, are estimated to exist. By the year 2004, around 287,655 species had been identified, including 258,650 flowering plants and 15,000 moss species [2, 6, 11, 12].

Aristotle classified organisms into plants, which generally do not exhibit movement, and animals. In Linnaeus' system, these categories evolved into the Vegetabilia kingdoom (later Plantae) and the Animalia kingdoom. Since then, it became evident that the plant kingdoom, as originally defined, encompassed several unrelated groups. As a result, fungi and certain algae were separated to form new kingdoms. Nonetheless, they are still considered as plants in various contexts. Indeed, any attempt to establish "plants" as a single taxon has faced challenges, as the concept of plants is defined in an approximate manner, unrelated to the presumed accurate concepts of species evolution on which modern taxonomy is based [2, 6].

2.1.2. Plant taxonomy

Currently, there are various concepts related to plant taxonomy. In our country, there have been instances where some authors considered the terms "classification," "taxonomia," and "systematicia" as synonymous, all falling under the umbrella of taxonomy. First and foremost, it's important to understand that plant taxonomy is a subset of Botany. According to De Candolle (1813), plant taxonomy is the overarching theory of classification, encompassing principles, methods, and rules of classification. The concept of plant taxonomy (as per the Dictionary of Botany, 1982) involves the science of describing and arranging the phylogenetic relationships of species and the relationships between species, genera, and families in accordance with the regulations of artificial and natural classification systems, as well as international rules for botanical nomenclature. Plant taxonomy also involves constructing and using plant handbooks, keys, classification procedures, sampling methods, recording, and preserving plant specimens.

The task of plant taxonomy is to classify and arrange plants based on their shared and distinct characteristics within a natural evolutionary framework [2, 6].

a) Historical Development

The history of the development of plant taxonomy holds significant importance. Just like plants themselves, it has evolved gradually from humble beginnings. The growth of this scientific discipline is intertwined with the advancement of human knowledge about plants. This development can be divided into three distinct stages:

Period of artificial taxonomy

During this period, the taxonomy of plant species was primarily based on subjective interpretations by authors. As a result, various methods of plant taxonomy emerged, and clear principles and methods of taxonomy were not yet established. Consequently, this stage did not truly develop into a concrete science. Prominent figures during this period include Theophrastus (371-286 BC), who was the first to propose a method of taxonomy and differentiate fundamental characteristics in plant structures. In his works "Historia Plantarum" and "De Causis Plantarum" he described around 500 plant species, mainly based on morphology. Pliny the Elder (79-24 BC) authored "Natural History," in which he described nearly 1000 plant species. Throughout the Middle Ages, scientific progress was hindered due to the dominance of the church, resulting in limited development of plant taxonomy.

In the Renaissance period (15th-16th century), plant taxonomy experienced a revival. The number of known plant species significantly increased, necessitating the construction of a classification system for use. During this period, three events played crucial roles in the development of plant taxonomy: the establishment of botanical gardens (16th century), the compilation of the "Encyclopedia of Plants," and the formation of herbaria. From the 16th to the 18th century, several classification systems emerged. Notable examples include the classification system by Cesalpino (1519-1603), which was highly regarded. He categorized plants based on the characteristics of fruits and seeds. Ray (1628-1705) was the first to classify plants based on seed leaves (cotyledons). According to him, plants could be divided into two major groups: "incomplete" (fungi, mosses, ferns, aquatic plants) and "complete" (monocots and dicots). Tournefort (1656-1708) classified plants based on flower characteristics, dividing flowering plants into those with petals and those without. Linnaeus (1707-1778) developed a classification system considered the pinnacle of artificial systems. He used reproductive organs as the basis for classification, particularly the number of stamens. His system was simple, understandable, and practical but also revealed certain shortcomings [6].

Period of natural taxonomy

After Linnaeus, plant taxonomy entered a period of constructing natural classification systems. In contrast to artificial classification systems, natural classification systems were built on the basis of natural relationships among plant species. Unlike the artificial classification system, the natural classification system is built upon the basis of natural plant relationships. The classification is not based solely on one or a few arbitrarily chosen characteristics; instead, it must rely on the entirety of their characteristics. This period began from the late 18th century to the early 19th century. The Jussieu family's classification systems organized plants in an ascending sequence, grouping families and emphasizing transitional forms, reflecting relationships between plant groups. De Candolle (1778-1841) divided cryptogams into vascular and non-vascular cryptogams, among other classifications. Notably, classification systems during this period still retained Linnaeus's concept that species were immutable [6].

Period of evolution

With the emergence of the evolutionary theories by Lamarck, Darwin, and their successors, the recognition of the essence of evolution led to the realization that, while classifying plants, it is necessary to group forms of plants together that share a common origin, rather than merely resembling each other in major characteristics, as was done in the period of natural classification. Up to now, there have been numerous different evolutionary systems such as those proposed by Bouch, Kursanov, Takhtajan, Engler, Metz. Therefore, modern taxonomy still holds the responsibility of addressing issues related to origins and evolutionary relationships [6].

b) Methods of plant taxonomy

Various methods of plant taxonomy are based on the following principles: plants with a common origin share similar characteristics. The closer plants are in relation, the more similar their characteristics are. Similarities can pertain to morphological, anatomical, physiological, biochemical, and embryological features, giving rise to various classification methods.

- Comparative morphological method: Grounded in morphological characteristics, particularly the morphology of reproductive organs, as this type of organ exhibits less variability than vegetative organs in response to changing environmental conditions. Individuals that are closely related share common morphological features. Despite its classic nature, this method continues to be extensively employed in contemporary studies.
- Comparative anatomy method: By the 19th century, due to the advancement of the microscope, plant anatomy had the opportunity to develop. Systematics employing this method have achieved accurate and objective results in plant classification. Comparative anatomical features enable the establishment of close relationships not only among the four major groups but also among smaller taxa, thereby allowing the formulation of taxonomic criteria for genera and species within families.
- Paleobotanical method: Relies on the examination of fossilized plant specimens found within geological strata, aiming to ascertain the relationships and origins of groups where intermediate stages no longer exist.
- Geographic method: Each genus and species of plants around the world has a distinct distribution range. By studying the distribution range of plants, researchers can infer their relationships.
- Biochemical method: Closely related plant species tend to accumulate similar biochemical compounds due to shared evolutionary processes.
- Individual development method: Based on the law of individual development: in the process of individual development, the body goes through the main stages (forms) that its ancestors went through. It is possible to trace the historical development of a plant to judge its

ancestral relationship.

- Immunological method: Immunity refers to an organism's non-reactivity to a particular disease. Immunity properties to a certain extent can be inherited across generations and become characteristic of a family or genus. Moreover, modern research has introduced new methods such as cell biology, pollen analysis, phytochemistry, etc. Notably, with the significant advancements in molecular biology, a new method called molecular taxonomy has emerged and developed. This method primarily relies on highly accurate techniques analyzing DNA, such as DNA fingerprinting and comparing nucleotide sequences. These techniques have led to the discovery of new species, resolution of classification uncertainties, comprehensive assessment of genetic diversity, classification relationships, and evolution of many plant species. However, a comprehensive classification often requires a combination of multiple methods to achieve accurate results.

c) International Code of Nomenclature for algae, fungi, and plants (ICN)

In the latter half of the 19th century, the study of plant taxonomy and the construction of phylogenetic systems gained momentum. Cooperation and exchange were necessary on a global scale. Plant taxonomy required a precise and straightforward nomenclature system recognized by botanists worldwide. This nomenclature system was not only related to the terms used to indicate the ranks of taxa but also to the names assigned to each taxon. From 1867 to the present, there have been 15 International Botanical Congresses, during which botanists discussed revisions and the establishment of a common code for botanical nomenclature and classification systems.

2.1.3. Taxon and taxonomic ranks

a) Taxon

A taxon is a group of real organisms, accepted as a taxon at any rank. For example, the order "Liliales" is a taxon at the order rank, the family "Liliaceae" is a taxon at the family rank, the genus "Lilium" is a taxon at the genus rank, and the species "Lilium longiflorum Thunb" is a taxon at the species rank. The fundamental taxon is the species. The concept of species is derived from observations of organisms in nature, highlighting the similarities and differences among individuals. There are various definitions of species, and Komarov's (1959) definition is considered relatively comprehensive: "A species is a set of individuals originating from a common ancestor, undergoing survival struggles and natural selection, isolated from other organisms. Simultaneously, a species is a specific stage in the general evolutionary process of organisms". Komarov emphasized genetic characteristics and the distribution of species: "Individuals within the same species can naturally mate to produce offspring capable of reproduction," and "each species has a distinct distribution range."

b) Taxonomic ranks

Taxonomic ranks are hierarchical levels containing taxon at that rank. For instance, a order rank has many members that are specific orders such as the Fabales, Rosales, etc. Groups of species sharing similar characteristics and a common ancestor are combined into larger units called genus. Following the same principle of common origin and shared characteristics, genera combine to form families, families form orders, orders form classes, and classes form divisions. In addition, sometimes people also use intermediate ranks such as: subspecies, varietas, forme, or sub-ranks such as suborders, subfamilies.

2.1.4. General characteristics of the Dicotyledonae

The Dicotyledonae (dicotyledon) comprises approximately 120,000 species, grouped into 325 families and 71 orders (Takhtajan 1980). The characteristic features of the dicotyledonae are presented in the comparative table below, which are commonly found in most representatives of the class. However, in some specific cases, not all of these features are fully expressed. For instance, the embryo of some dicotyledonous plant may have only one cotyledon (due to the reduction of the second cotyledon or fusion of the two cotyledons into one). Additionally, some individual representatives may have parallel leaf venation, or their stem might have a scattered arrangement of vascular bundles. Furthermore, certain dicotyledonae species have triple flowers (seen in some families like Nymphaeaceae, Ranunculaceae, and Piperaceae…). Therefore, in order to classify this or that plant into one of the two classes of Angiosperms, many properties must be combined.

The Dicotyledonae can be further divided into 7 subclasses:1/ Magnoliidae; 2/ Ranunculidae; 3/ Hamamelididae; 4/ Caryophyllidae; 5/ Dilleniidae; 6/ Rosidae; 7/ Asteridae.

2.2. Research methods

Based on the identified research subjects in this article, which are certain plant species belonging to the Dicotyledonae in Yen Son district, Tuyen Quang province, I employed the following methods to construct a specimen set of some dicotyledonous plant species for teaching purposes at Tan Trao University:

Theoretical Research Method

This method involves studying relevant literature and documents related to the topic. This includes studying the Plant Kingdom, the general characteristics of the Dicotyledonae, and plant taxonomy.

Plant specimen preparation method

The process of creating reference specimens involves two main steps: Preliminary processing outdoors and final completion of specimens indoors.

Step 1: Preliminary processing

After collecting the specimens, place them between layers of newspaper and gently flatten them according to their natural shape. If the specimens are too long, they can be folded, but care should be taken to avoid overlapping branches and leaves. Use 4-5 layers of paper between specimens to ensure sufficient moisture absorption, preventing smudging. For thicker parts (roots, fruits, etc.), use cotton or soft paper to prevent flattening or detachment.

In the case of folding branches, flip some leaves and flowers to ensure both sides are visible in the final specimen.

In case of folding branches, it is necessary to turn a few leaves and flowers upside down so that when making the specimen, there are enough 2 sides to observe.

For plants with compound leaves, it is necessary to press quickly (even before cutting samples) to avoid leaf fall and leaf shriveling after collection.

For very large leaves, exceeding the size of pressed paper, it is necessary to cut the top of the leaves, the edges of the leaves and the middle of the leaves. If it is a large compound, cut off one side, leaving the petiole, leaving the other side intact.

When you can arrange 4-5 samples, fold the wooden pair, tie it tightly to put it on the press table later.

Step 2: Specimen making

After preliminary processing, the specimens go through a drying process:

Press the specimens to create a stable shape.

Dry the specimens naturally under sunlight. If sunlight is not available, use quick drying methods to prevent mold growth. During sun-drying, replace the paper inside the press daily to facilitate quick drying and maintain natural colors. Use trellises or arrange stacks to expose the specimen pairs to sunlight. Rotate the presses every 1-2 hours for even drying.

If sunlight is insufficient, alternative methods such as charcoal, oil lamps, gas stoves, or electric stoves can be used. Modern facilities such as drying ovens, cabinets, and specialized drying rooms are available in laboratories, specimen collection facilities, and storage areas.

During the drying process, maintaining a moderate temperature (40-50°C) and regularly changing the paper are crucial to prevent loss of the plant's natural color.

2.3. Research Results

2.3.1. Results of building the herbarium specimens

After a process of collection, analysis, and classification, I successfully created a set of 40 dried plant specimens from the Dicotyledonae. These specimens belong to 22 families, 18 orders, and 6 subclasses. Each dried plant specimen has been categorized with common name, scientific name, family name, and order. The list of species components is presented in detail in Table 1.

Table 1: List of species composition in the herbarium specimens of Dicotyledonae

No. (1)	**Scientific name** (2)	**Common name** (3)
	I.magnoliidae	I. PHÂN LỚP NGỌC LAN
	1.1. Magnoliales	1.1 BỘ NGỌC LAN
	1.1.1. Magnoliaceae	1.1.1. Họ Ngọc lan
1	*Michellia alba*	Ngọc lan trắng
2	*Manglietia insignis*	Cây Mỡ
	1.1.2. Annonaceae	1.1.2. Họ Na
3	*Annona squamosa*	Cây Na
	1.2. Laurales	1.2. BỘ LONG NÃO
	1.2.1. Lauraceace	1.2.1. Họ Long não
4	*Cinnamomum camphora*	Long não
5	*Cinnamomum cassia*	Cây Quế
6	*Litsea cubeba*	Màng tang
	II. Ranunculidae	II. PHÂN LỚP MAO LƯƠNG
	2.1. Ranunculales	2.1. BỘ MAO LƯƠNG
	2.1.1. Menispermaceae	2.1.1. Họ Tiết dê
7	*Stephania glabra*	Dây bình vôi
	III. Hamamelididae	III. PHÂN LỚP SAU SAU
	3.1. Hamamelidales	3.1. BỘ SAU SAU
	3.1.1. Hamamelidaceae	3.1.1. Họ Sau sau
8	*Liquidambar formosana*	Sau sau
	3.2. Urtiales	3.2. BỘ GAI
	3.2.1. Moraceae	3.2.1. Họ Dâu tằm
9	*Broussonetia papyrifera*	Cây Dướng
	IV. Dilleniidea	IV. PHÂN LỚP SỔ
	4.1. Dillenliales	4.1. BỘ SỔ
	4.1.1. Dilleniaceae	4.1.1. Họ Sổ
10	*Tetracera scandens*	Cây chặc chìu
	4.2. Theales	4.2. BỘ CHÈ
	4.2.1. Clusiaceae	4.2.1. Họ Măng cụt
11	*Garcinia oblongifolia*	Cây Bứa
	4.3. Malvales	4.3. BỘ BÔNG
	4.3.1. Malvaceae	4.3.1. Họ Bông
12	*Hibiscus rosa-sinensis*	Dâm bụt
	4.4. Euphorbiales	4.4. BỘ THẦU DẦU
	4.4.1. Euphorbiaceae	4.4.1. Họ Thầu dầu
13	*Ricinus communis*	Thầu dầu tía
14	*Phyllanthus emblica*	Cây me rừng
15	*Sauropus androgynus*	Rau ngót
	4.5. Ebnales	4.5. BỘ THỊ
	4.5.1. Ebenaceae	4.5.1. Họ Thị
16	*Diospyros decandra*	Cây thị
17	*Diospyros kaki*	Cây hồng
	V. Rosidae	V. PHÂN LỚP HOA HỒNG
	5.1. Rosales	5.1. BỘ HOA HỒNG

	5.1.1. Rosaceae	5.1.1. Họ Hoa hồng
18	*Rubus fruticosus*	Mâm xôi
19	*Ziziphus mauritiana*	Táo ta
20	*Prunus salicina*	Mận tam hoa
21	*Prunus mume*	Cây Mơ
	5.2. Fabales	5.2. BỘ ĐẬU
	5.2.1. Fabaceae	5.2.1. Họ Đậu
22	*Leucaena leucocephala*	Keo giậu
23	*Mimosa pigra*	Mai dương
24	*Calliandra hematocephala*	Hùng kiều
25	*Saraca dives*	Vàng anh
26	*Bauhinia variegata*	Ban đỏ
	5.3. Myrtales	5.3. BỘ SIM
	5.3.1. Myrtaceae	5.3.1. Họ Sim
27	*Syzygium polyanthum*	Sắn thuyền
28	*Cleistocalyx nervosum*	Cây Vối
	5.4. Rutales	5.4. BỘ CAM
	5.4.1. Rutaceae	5.4.1. Họ Cam
29	*Clausena indica*	Quất rừng
	5.4.2. Anacadiaceae	5.4.2. Họ Xoài
30	*Mangifera indica*	Cây xoài
31	*Dracontomelon duperreanum*	Cây sấu
	5.4.3. Meliaceae	5.4.3. Họ Xoan
32	*Chukrasia tabularis*	Cây lát
	5.5. Sapindales	5.5. BỘ BỒ HÒN
	5.5.1. Sapindaceae	5.5.1. Họ Bồ hòn
33	*Dimocarpus longan*	Cây nhãn
34	*Litchi chinensis*	Cây vải
	5.6. Araliales	5.6. BỘ NHÂN SÂM
	5.6.1. Apiaceae	5.6.1. Họ Hoa tán
35	*Aralia armata*	Đơn châu chấu
	VI. Asteridae	VI. PHÂN LỚP CÚC
	6.1. Contortae	6.1. BỘ HOA VẶN
	6.1.1. Apocynaceae	6.1.1. Họ Trúc đào
36	*Holarrhena pubescens*	Thừng mức
37	*Nerium oleander*	Trúc đào
38	*Wrightia religiosa*	Mai chiếu thủy
	6.1.2. Rubiaceae	6.1.2. Họ Cà phê
39	*Oldenlandia capitellata*	Dạ cẩm
	6.2. Asterales	6.2. BỘ CÚC
	6.2.1. Asteraceae	6.2.1. Họ Cúc
40	*Blumea balsamifera*	Cây đài bi

Through this collection, I have successfully compiled a diverse range of dried plant specimens that represent the Dicotyledonae, showcasing the variety of families, orders, and subclasses within this class. This collection will serve as valuable teaching material for botanical education and research activities at Tan Trao University.

Observations on the species composition in the herbarium specimens of Dicotyledonae

Table 2: The species composition of plants within the subclass

No.	Subclass	Order	Family	Species
1	Magnoliidae	2	3	6
2	Ranunculidae	1	1	1
3	Hamamelididae	2	2	2
4	Dilleniidea	5	5	8
5	Rosidae	6	8	18
6	Asteridae	2	3	5
	Total	18	22	40

According to Table 2

- In terms of the number of orders, the Rosidae has the highest number of orders, accounting for 33.33%. Next is the Dilleniidea with 5 species, accounting for 27.78%. Following that, the Magnoliidae, Hamamelididae, and Asteridae each have 2 orders, each accounting for 11.11%. Lastly, the Ranunculidae has only 1 order, accounting for 5.56%.
- Regarding the number of families, the Rosidae also holds the highest number of families, with 8 families accounting for 36.36%. Next is the Dilleniidea with 5 families, accounting for 22.73%. The Magnoliidae and Asteridae both have 3 families, each accounting for 16.67%. The Hamamelididae has 2 families, accounting for 9.09%. The Ranunculidae has the fewest families, with 1 family accounting for 4.54%.
- When it comes to the number of species, the Rosidae still leads with the highest number of species, totaling 18 species and accounting for 45%. Following that, the Dilleniidea has 8 species, accounting for 20%. The Magnoliidae has 6 species, accounting for 15%. The Asteridae has 5 species, accounting for 12.5%. The Asteridae has 2 species, accounting for 5%. Lastly, the Ranunculidae has 1 species, accounting for 2.5%.

The information presented in Table 2 and the upcoming Table 3 provides an insightful analysis of the distribution and composition of species within the orders and subclasses of Dicotyledonae in the studied collection. This breakdown allows for a better understanding of the diversity and prevalence of different orders and species within this plant group.

Table 3: The species composition of plants within orders of the herbarium specimens of Dicotyledonae.

No.	Order	Family	Species
1	Magnoliales	2	3
2	Laurales	1	3
3	Ranunculales	1	1
4	Hamamelidales	1	1
5	Urtiales	1	1
6	Dillenliales	1	1
7	Theales	1	1
8	Malvales	1	1
9	Euphorbiales	1	3
10	Ebnales	1	2
11	Rosales	1	4
12	Fabales	1	5
13	Myrtales	1	2
14	Rutales	3	4
15	Sapindales	1	2
16	Araliales	1	1
17	Contortae	2	4
18	Asterales	1	1

Based on Table 3, we can observe the following

- In terms of the number of families, the Rutales has 3 families, accounting for 13.64%. Next are the Magnoliales and Contortae, both having 2 families each, making up 9.09%. All other orders have only 1 family, with a proportion of 4.54%.
- Concerning the number of species, the Fabales has the highest number with 5 species (12.5%). Following that, the Rosales, Rutales, and Contortae each have 4 species (10%); the Euphorbiales with 3 species (7.5%); the Ebnales, Myrtales, and Sapindales with 2 species (5%). The remaining orders each have only 1 species (1.25%).

Table 4: Species composition within families of the herbarium specimens of the Dicotyledonae

No.	Family		Species
1	Magnoliaceae	Họ Ngọc lan	2
2	Annonaceae	Họ Na	1
3	Lauraceace	Họ Long não	3
4	Menispermaceae	Họ Tiết dê	1
5	Hamamelidaceae	Họ Sau sau	1
6	Moraceae	Họ Dâu tằm	1
7	Dilleniaceae	Họ Sổ	1
8	Clusiaceae	Họ Măng cụt	1
9	Malvaceae	Họ Bông	1
10	Euphorbiaceae	Họ Thầu dầu	3
11	Ebenaceae	Họ Thị	2
12	Rosaceae	Họ Hoa hồng	4
13	Fabaceae	Họ Đậu	5
14	Myrtaceae	Họ Sim	2
15	Rutaceae	Họ Cam	1
16	Anacadiaceae	Họ Xoài	2
17	Meliaceae	Họ Xoan	1
18	Sapindaceae	Họ Bồ hòn	2
19	Apiaceae	Họ Hoa tán	1
20	Apocynaceae	Họ Trúc đào	3
21	Rubiaceae	Họ Cà phê	1
22	Asteraceae	Họ Cúc	1

Table 4 allows us to observe the following: among the mentioned families, the Fabaceae has the highest number of species with 5 species (12.5%). Next are the Rosaceae with 4 species (10%); the Lauraceace, Euphorbiaceae, and Apocynaceae, each with 3 species (7.5%). The Magnoliaceae, Ebenaceae, and Sapindaceae each have 2 species (5%). All remaining families have only 1 species (2.5%).

The number of plant specimens in this study is relatively small compared to the vast number of species in the Dicotyledonae. However, this number is still within the scope of a school-level scientific project.

2.3.2. Incorporating new steps in the herbarium specimens construction process

During the process of building the herbarium specimens, I employed the use of sulfur powder to dry the specimens and prevent mold, insects, and decay. This is a novel approach in the research, as existing literature on creating dried plant specimens mainly discusses the use of toxic substances like $HgCl_2$ or xianua, which are hazardous to the health of researchers and are not available in the laboratory of Tan Trao University. Another approach mentioned by some authors is soaking the specimens in 90^0 alcohol before pressing to prevent mold growth. However, experimentation revealed that if the air is excessively humid, this method doesn't effectively prevent mold formation.

Furthermore, the practice of affixing dried specimens onto mounting sheets using adhesive glue (502 glue) has shown to be more effective compared to previous studies. In traditional guidelines for creating herbarium specimens, authors often recommend attaching specimens to stiff mounting paper using thread. However, this method requires meticulous care and precision to avoid damaging the specimens, and it can sometimes compromise the aesthetic quality of the collection. By using adhesive glue (502 glue), the specimens are securely attached, ensuring both stability and aesthetic appeal.

2.4. Discussion

Due to limited research duration, the number of specimens in this article is relatively small compared to the biological diversity potential of Tuyen Quang province. Dang Huy Huynh and colleagues (1993) were the first to study the plant system in the Na Hang Nature Reserve and identified 244 species [7]. Cox (1994) recorded the presence of 353 species [7]. Later, Mike Hill and Neville Kemp (1996) identified and documented 607 species belonging to 123 higher vascular plant families in the Ban Bung subzone [7]. Mike Hill and Dan Hallam (1997) identified 918 species belonging to 135 higher vascular plant families in the Tat Ke subzone. In 2002, the Vietnam Plant Conservation Program between Vietnam and the United States conducted a survey on medicinal plants and biodiversity of certain the Orchidaceae and Gymnospermatophyta. This effort discovered and added numerous new species to the Na Hang Nature Reserve. The most recent study on plants is by Nguyen Nghia Thin (2006): "Plant Diversity in the Na Hang Nature Reserve, Tuyen Quang Province". According to this study, the plant system in Na Hang comprises 1,162 species belonging to 614 genera and 159 families across four divisions; among them, 709 species hold practical value. Within these findings, 42 species are listed in the Vietnam Red Data Book. Compared to the mentioned results, I hope that in the future, more specimen collections will be carried out in collaboration with students, researchers, and individuals sharing an interest in this matter [7, 8, 14].

Through guiding students in practical exercises within the Plant Taxonomy course, they will learn to create dried plant specimens and preserved plant specimens from various other divisions such as the Bryophyta, Polypodiopsida, Gymnospermatophyta, and the Monocotyledon... This will enable students to witness the diversity within the plant system and concurrently establish a database to facilitate their learning and teaching experiences in their future careers.

3. Conclusion and Recommendations

3.1. Conclusion

- The herbarium specimens was successfully built, including 40 specimens from the Dicotyledon, encompassing 22 families, 18 orders, and 6 subclasses. Each dried plant sample was accurately categorized with its common name, scientific name, family, and order.
- A new method of drying using sulfur powder was introduced to ensure long-term preservation of the plant specimens, addressing issues such as pests, molds, and decay.
- The applications of the herbarium specimens were analyzed within teaching contexts, particularly for theoretical lessons on classification, highlighting the characteristics and practical uses of different plant species in various families and orders. The set also proved useful for practical sessions involving the analysis of features of the Angiospermae. Furthermore, it facilitated comparisons of morphological traits among plant families.
- Strategies were proposed to increase the number of plant specimens in the future, including the organization of collection activities involving biology faculty members and students. Additionally, it was recommended to maintain an organized information database of classification specimens in Excel format to facilitate student reference.

3.2. Recommendations

- It is necessary to encourage the lecturers in the Subject of Biology and especially the students to make their own plant samples so that the specimen set is increasingly richer and more diverse.
- Establish appropriate mechanisms for the sustainable use and maintenance of the herbarium specimens over time.
- Advocate for increased attention and investment from the university's leadership to further expand plant species collection efforts. This expansion should not be limited to the Dicotyledon but should also include the Monocotyledon class, as well as extending into other fields such as the Bryophyta, Polypodiopsida, and Gymnospermatophyta. This approach will cater to the growing academic and research needs of students and align with the robust development of Tan Trao University.

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