Palyno-Anatomical Studies of Rosaceous Taxa from District Swat, Pakistan

By

Muhammad Abdullah

Department of Plant Sciences
Quaid-i-Azam University Islamabad, Pakistan
2023

Palyno-Anatomical Studies of Rosaceous Taxa from District Swat, Pakistan

A Thesis Submitted to the Quaid-i-Azam University in Partial Fulfillment of the Requirements for the Degree of Master of Philosophy (MPhil)

In

Botany/Plant Sciences (Plant Systematics and Biodiversity)

Department of Plant Sciences
Quaid-i-Azam University Islamabad, Pakistan
2023

DEDICATED

To

My Beloved Parents &
My Family

APPROVAL CERTIFICATE

This is certified that the dissertation entitled **"Palyno-Anatomical studies of Rosaceous Taxa from District Swat, Pakistan"** submitted by **Muhammad Abdullah** S/O **Habib Ur Rahim** Registration No. **02042111006** is accepted in its present form by the Department of Plant Sciences, Faculty of Biological Sciences, Quaid-i-Azam University, Islamabad as satisfying the dissertation requirement for the degree of **Master of Philosophy in Plant Sciences.**

Supervisor

Dr. Mushtaq Ahmad
Professor
Department of Plant Sciences
Quaid-i-Azam University, Islamabad

External Examiner

Dr. Kifayat Ullah Khan
Assistant Professor
Biosciences
COMSAT Institute of Information technology, Islamabad

Chairman

Dr. Mushtaq Ahmad
Professor
Department of Plant Sciences
Quaid-i-Azam University, Islamabad

Dated: 17 May 2023

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ACKNOWLEDGEMENT

I have no words to express my deepest sense of gratitude to the gracious, the greatest "Almighty Allah", the omnipotent, the omnipresent. The most merciful and most compassionate, whose innumerable blessings enabled me to complete this difficult task. I also pay all the tributes to the Holy Prophet Muhammad (PBUH), the most perfect and exalted among and of ever born on the surface of the earth for enlightening our conscience.

I gratefully acknowledge the support of Chairman, Department of Plant Sciences, ***Prof. Dr. Mushtaq Ahmad*** *for providing excellent spectral facilities during the entire course of my research work.*

I take pride in acknowledging the insightful guidance of my Supervisor ***Prof. Dr. Mushtaq Ahmad*** *Department of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan. His reliable comments, dynamic supervision, vast experience, sincere help, and erudition throughout the course of my research work, guided me in faltering steps. No words can adequately express my deep gratitude to my supervisor for all his guidance and kindness. I sincerely thank for all his trust and support to pursue my research work under his guidance. I also wish to express deepest and sincerest thanks to my co-supervisor* ***Dr. Muhammad Zafar (Associate Professor****) Department of Plant Sciences, Quaid-i-Azam University, Islamabad Pakistan, for his constant support, useful suggestions, valuable discussions, and reviewing the dissertation.*

Thanks, are also extended to ***Dr. Zahid Ullah (Assistant Professor)*** *University of Swat Pakistan, for his help in identification of species, and fruitful discussions on the taxonomic issues regarding Rosaceous taxa. I offer my profound thanks to* ***Dr. Muhammad Zafar*** *for provision of research facilities in the department of plant sciences and Herbarium respectively.*

*I have great pleasure in acknowledging my gratitude to my colleagues and fellow research scholars of Plant Systematics & Biodiversity lab, for their endless support and good wishes. I wish to express my deep sense of appreciation and gratitude to my lab fellows****; Tajalla Batool, Hadiqa Bibi, Naveed Abbas, Roshan Amjad, Ayman Zubaid, Salman Majeed, Sadia bibi, Wajiha, Nabila, Shaista Jabeen, Jamil Raza, Rozina, Maria Ameen, Shabir Ahmad, Muhammad Manzoor, Irfan Ullah,*** *and* ***Sardar Muhammad Ilyas*** *for their help and cooperation during various steps of my research. I also owe my special thanks to* ***Mr. Sufyan*** *and* ***Mr. Farooq*** *for their kind help during my research work.*

Muhammad Abdullah

ABSTRACT

This study was aimed to investigate stomatal and pollen diversity in Rosaceous taxa from district Swat, Pakistan, and the possible taxonomic potential of stomatal and pollen diversity in identification of plant species. Plant samples were gathered from District Swat-Pakistan, some of them were taken from temperate along with some species from alpine ecological locations. The study revealed micro-anatomical features of foliar epidermal and pollen morphology of 50 species in 19 genera belonging to family Rosaceae. For foliar epidermal anatomy lactic acid protocol was used to investigate both abaxial and adaxial surfaces while for pollen morphology acetic acid protocol was used under light microscope. Two types of trichomes were observed during microscopy, glandular trichome were mostly capitate while non-glandular trichome were mostly conical cylindrical. Both surfaces of the leaves exhibited differences in their leaf anatomical traits including type of stomata, epidermis, anticlinal wall, lobes, and diversity of trichomes. The epidermal cells shape reported as trigonal, tetragonal, pentagonal, hexagonal, irregular, wavy and polygonal. The largest epidermal cells were examined in *Duchesnea indica* (89.1 μm) on abaxial surface while on adaxial surface in *Sanguisorba minor* (78.8 μm) respectively. Seven distinct stomatal types were counted. Most Rosaceous taxa exhibit stephanocytic and paracytic stomata. The largest stomatal complex was recorded in *Duchesnea indica* (105.5 μm) and *Geum elatum* (100.8 μm), while smallest in *Malus pumila* (23.7 μm). Pollen grains of Rosaceous species were acetolyzed and observed under light microscope. Both qualitative and quantitative bioinformatic data were analyzed and measured through statistical software. Rosaceous taxa showed pollen variation in both qualitative and quantitative measurement including polar and equatorial measurment, length, and girth of pollen colpi and mesocolpium, exine thicken, pollen shape class and type of pollen. Based on pollen type only 3 types of pollen were observed in Rose family, tricolpate, tricolporate while a single tetracolpate is observed in *Cotoneaster nummularius.* Most of Rosaceous species showed prolate and sub-prolate pollen class. The largest polar diameter was observed in *Prunus armeniaca* (44.25 μm) while smallest were observed in *Spiraea canescens* (10.4 μm). The results of this investigation showed that micromorphological characteristics had taxonomic significance, that provide base line for correct identification of Rosaceous taxa using taxonomic keys.

Chapter # 01

Introduction

1.1 FAMILY ROSACEAE

Rosa is the type of genus from which the family gets its name, Rosaceae is generally represented by 90 genus and 3000 species make up the average-sized family of flowering plants known as the Rose family (Apg, 2009). 160 species are found in 27 genera and 4 subfamilies, according to (Anjum & Muhammad, 2014). According to (Kalkman, 1988) based on types of fruit forms and characteristic features in carpel, the diverse family Rosaceae is frequently divided into four separate subfamilies and approximately 20 tribes. That contains the following: (1) Maloideae, such as *Sorbus*, *Malus*, and *Pyrus*, which have inferior ovary and have fleshy pome type of fruits. (2) Prunoideae, such as *Prunus*, have drupe fruit (single-seeded stone fruit), which has a monocarpellary pistil that occasionally has 2–5 carpels. (3) Rosoideae family, which includes *Geum*, Rubus, *Potentilla*, *Fragaria*, and *Rosa*, has 10 or more carpels and primarily dry fruit. (4) Spiraeoideae, such as *Spiraea*, which are represented by follicle or capsule fruits. These subfamilies are sometimes treated like separate families.

1.2 DISTRIBUTION AND HABITAT

The Rose family has a sub cosmopolitan distribution with a higher species diversity in the temperate to alpine mountainous parts with special emphasis in the Northern Hemisphere. They cover the whole arctic and boreal hemispheres, reaching into North America, Asia, North Africa, up to the extreme temperate parts of the Southern Hemisphere. The herbaceous plants are a common component of peatlands, alpine meadows, open spaces, cold tundra, freshwater marshes, and the understory of temperate coniferous forests. Some tree species make up a minor portion of mature deciduous forests, which are generally composed of woody members that are pioneer species in the early phases of forest succession and lower-lying forest components (Hummer & Janick, 2009)

According to (Kolodziejek & Gabara, 2008), *Potentilla* species are most frequently found in the geographical zone of temperate and alpine mountainous regions of the Northern Hemisphere, *Duchsnea* in Africa, Europe, and north America, *Fragaria* in the subtropical and north temperate regions, and one species of *Duchsnea* is even found in south America. Genus *Rosa* plants are found throughout the Northern Hemisphere in Asia, Europe, North America, Western Asia, and Northeastern Africa.(Shujat ali , 2021). Typically, both wild and domesticated fruit-producing shrubs and trees belong to the genus *Prunus*, they are flourishing in the Northern Hemisphere's tropical, temperate, and occasionally in dry ecological zones. The *Rubus* genus is found throughout Europe as well as Northern, Central, and South Asia (Tomlik-Wyremblewska, 2000).

1.3 DIAGNOSTIC CHARACTERISTICS OF ROSACEAE

The Rose Family includes plants with a wider range of shapes and habits, including trees, shrubs, herbs, and occasionally climbers. Rhizomes are uncommon, and some species of the family may also have prickles, thorns, or profuse hairy indumentum (Judd et al., 1999). Some species of (*Fragaria* and *Rubus*) have stolons, pubescence can be glandular, non-glandular, and stellate, or the plants can occasionally be glabrous. Flowers are typically hypogamous, occasionally peri or epigamous, frequently fragrant, showy, epicalyx is rarely present, frequently bisexual, and rarely unisexual as observed in the genus *Sanguisorba*. Leaves can be both simple and palmately or pinnately compound type, often with petiole, stipulate, stipule, scaly, or adnate as in the genus (*Rosa*).

In fruit, the hypanthium frequently enlarges into fruits and can take on a variety of shapes, including cup-shaped, spherical, and conical. Typically having five sepals, in some exceptions sepals may be four. sepals are imbricate, valvate, occasionally persistent and frequently being joined below. Petals of the *Rosa* species, which are frequently 5 or more and can be numerous, imbricate to valvate aestivation and appear occur in a range of colours, that is from yellow, white, pink, purple to red. Stamens is frequently 10 to 15 or more, sometimes 10 or fewer, free, or rarely just basally joined, and adnate to nectar glands. Except in some circumstances, pollen grains are tricolporate to tricolpate. Tetracolpate can also be found in the genus (*Cotoneaster*). In rare situations, carpels are united to the hypanthium. Carpals might be single (*Prunus*) or multiple (*Rosa*), syncarpus, or apocarpus.

Depending on the genus, ovaries can be inferior, superior, or half-inferior and half-superior. For example, the ovary of the *Prunus* tree is superior, unilocular, and contains two ovules with position in terminal (Hummer & Janick, 2009). Fruits in the family are surprisingly diversified, ranging from achene, drupe, and pome to follicle, drupelets, or even dry capsules to specialized forms like pome, with largely fleshy or sporadically dry mesocarp, not dehiscing when mature. Cotyledons are oblong and occasionally pendulous, and the seeds are hard and membrane (*Rosa*), seeds with a range of colours, often black or brown, and plano-convex cotyledons (*Pyrus*). Fruit of the Rose family might be aggregation, etario of follicle (*Fragaria*), or etario of drupelets.

1.4 ECONOMIC IMPORTANCE

The Rosaceae family includes well-known and attractive species that are economically significant, mostly the fruit of Rose family is edible in temperate zone, and also used for ornamentations, but it also includes some timber harvests and medicinal or nutraceutical plants (Janick, 2005). The Rosaceae family's most prominent genus of edible fruit is (*Malus, Prunus, Pyrus, Duchesnia, Fragaria, Eriobotrya, Rubus*, and *Cydonia*). Various members of the Rose family are utilized as a decorative and medicinal purposes. *Eriobotrya japonica* seeds are added to alcoholic beverages, while the leaves are used for cough, sputum, and throat problems. A source of good border texture is *Potentilla nepalensis*, while the young leaves of *Potentilla supina* are suitable for eating. *Fragaria nubicola* is an edible fruit that is rich in amino acids, glucose, sucrose, citric acid, pectin, carotene, and vitamins B. *Pyrus pashia* is used to treat diarrhoea, *Prunus cerasus* fruit is tasty, and the leaves of the plant can be used to make green dye.

Most Rosa species are used primarily for ornamental purposes. Beautiful hybrid rose varieties are grown in gardens, parks, and other public spaces. Many species of the woody Rosaceae are raised in agroecosystems for their wood and fuel. In rural locations, many Rosaceae that produce fruit provide a source of food and nutrients. The local mountain residents in remote areas also sell some species to supplement their daily income. Rich germplasm is available from many wild species, which can be used to create new cultivars with wild relatives (Andreatta, 2008).

1.5 MICROMORPHOLOGY AS A VALUABLE TAXONOMIC TOOL

The environment in which plants develop also has an impact on their morphological characteristics, which are principally governed by genes in plants (Sattler & Rutishauser, 1997). At various taxonomic levels, these traits are persistent and frequently diagnostic to varying degrees. These physical features are widely used for the classification and diagnosis of species and serve as the basic framework and cornerstone of taxonomy. It has been discovered that, in addition to morphology, extra qualities and evidence must be taken into account because no taxonomic evidence is ever sufficient or completely dependable. A recent emphasis has been placed on multivariate (synthetic technique) for correlations between taxa that are more dependable and apparent.

The field of Systematics has greatly benefited from the development of microscopic methods. The ability to examine minute details under a light and an electron microscope has enabled taxonomists to take into considerations epidermal characteristics that is in the form of pollen grains, trichomes, stomata, silica bodies, papillae, prickles as well as cork cells, cell types, and nectaries etc. that is used to create novel taxonomic keys for easy identification and to developed a different taxonomic group for proper arrangement of taxa.

To clarify relationships between species and at a higher level, anatomical characteristics have been discovered to be particularly important (Metcalfe & Chalk, 1957). These characteristics aid in accurate species identification.

1.6 FOLIAR EPIDERMAL ANATOMY

Leaves are histologically and morphologically the most variable plant organ, encompasses a wide variety of characters of potential taxonomic value and significance. These characters are sometimes peculiar for species, genera or even families. The plant epidermis is a multipurpose tissue that is essential for maintaining water relationships, protecting against threats, and luring pollinators (Kiran et al., 2011). Stomata and its associated cells along with Pavement cells and trichomes are only a few examples of the several types of specialised cells that carry out this variety of tasks. Different levels of morphological specialisation are displayed by these distinct cells. In order to find epidermal traits that could be helpful in taxonomy, it is essential to try. (Hall & Melville, 1951; Jones, 1986) and (Adedeji, 2004) are a few of the well-researched publications on foliar epidermal anatomy.

1.7 LEAF EPIDERMAL MICRO-MORPHOLOGICAL CHARACTERS

1.7.1 Trichomes

The word trichome is derived from the Greek, meaning hair growth, and is scientifically applied to various kinds of epidermal outgrowths on different plant organs, with diverse structures and functions. They are hair-like structures on epidermal surfaces of leaves, stems, and floral organs. Trichomes are different from emergencies, as they arise from epidermal cells only, while emergences are endogenous structure arising from subepidermal cells (Werker, 2000). Trichomes possess considerable diversity, often taxa specific and can frequently identify species, genera, or families in taxonomic studies (Metcalfe & Chalk, 1950). Plants have developed several defense mechanisms against herbivores, insects, and climatic conditions, using physical and chemical defenses involving glandular and non-glandular trichomes. They also help to protect against pathogen attacks and provide resistance to plants against different stresses, such as drought, ultraviolet radiation, high temperatures, extreme colds, salinity etc.

Trichomes are found on almost all parts of the plants including stamens e.g (*Tradescantia*) and seeds (*Salix, Populus*). The size of rhizome varies from very minute few microns to extensively long which can be seen with naked eyes. Structurally trichomes are placed between papillae and epidermal emergences. Mostly trichome are often uniseriate, unicellular, or multicellular. The growth and development of trichomes are linked with plant growth and influenced by phytohormones such as cytokinin, jasmonic acid and salicylic acid.

1.7.2 Types of trichome

The two primary categories of trichomes are glandular and non-glandular trichomes (Sinha et al., 2001). Numerous types of bulbous tips, or glands, are present on glandular trichomes. These glands release a variety of chemicals, including mucilage, resins, terpenes, nectar, and water. They often release poisonous substances as a defense mechanism against herbivores and predators. Resins and essential oils that find extensive use in pharmaceutical, cosmetic, and agricultural industries are actually secreted by these glandular trichomes. Glandular trichomes may be uniseriate (with single layer of cell) and bi or multiseriate (with two or more vertical tires of cells). Several researchers, including (Bary, 1884) and (Cowan, 1950), have attempted to categorize the trichomes of angiosperms.

1.7.3 Unicellular glandular trichomes

These trichomes consist of single cell with globose, oval or oblong bulb like head. These can be branched or un-branched. The morphology of basal and apical cell is quite variable and further forming various types of unicellular glandular trichome.

1.7.4 Multicellular glandular trichomes

These trichomes consist of several cells, either uni or multiseriate, appears as an outgrowth of the epidermis with globose head consist of secretory cells involved in secretion of different metabolites.

1.7.5 Non-glandular trichomes

These trichomes are simple hairs, with no apical glands and are not involved in any type of secretion. They display considerable variation in form, shape and size. These trichomes have many further types primarily based on general appearance. They may be uni, bi or multicellular and consist of single, two or more vertical rows of cells. They may be simple straight, branched, stellate, peltate, club-shaped, T-shaped, Y-shaped, dendroid, cylindrical, triangular etc.

For the study of plant isoprenoid production, the glandular trichome is a superb model system. On immature stems and leaves, the presence of trichomes was frequently thought to be an adaptation to arid environments. The water diffusion boundary layer of the transpiring leaf surface has been proposed as a mechanism by which trichomes may influence transpiration. Consequently, an indumentum reduces air movement at the leaf surface and generates a zone of still air through which water vapour must diffuse when travelling from the interior of the leaf to the relatively dry air of the surrounding atmosphere (Woolley, 1964). Additionally, it has been said that some plants' trichomes have the capacity to draw moisture from the atmosphere (Galati, 1982; Lyshede, 1977).

The trichome when separate them from papillae bladder cells, tubercules, epidermal glands, etc., A certain size threshold is exceeded by trichomes, which are designated as having both a cell wall and a lumen.

1.7.6 Epidermal cell

The epidermal cells vary in structure in certain plant groups. These cells are those which are not associated along special structures like trichomes, stomata and venation etc. This variation in epidermal cells structure includes variation in shape, size, orientation, curvature of periclinal wall etc.

1.7.7 Seed surface patterns

The use of scanning electron microscope recently has revealed that the pattern of cellular arrangement and the distribution of other multicellular appendages on the seed coats thus differentiating between two species. For example, the classification of the two indian species of *Glinus* L., which produces appendaged seeds, is a prime illustration of how seed surface patterns are used in taxonomy. Under a light microscope, the seeds of two *Glinus* species that found in India, *G. oppositifolius* and *G. lotoides,* resemble one another and tubercle. SEM analyses, however, have shown that the two species' tubercle shapes are very distinct from one another.

1.7.8 Pollen grains

Scanning electron microscope and Light microscope has a huge impact on palynology as well and proven it to be very useful in taxonomy. Variation in number of pollens, position of pollen, sculpture, complexity of pollen grain aperture and its exine structure are used for classification of plants.

1.7.9 Stomata

The micro-morphological studies of stomata and the surrounding epidermal cells have shown increasing importance in taxonomy. Certain types of stomata are characteristic features of some families and sub families.

1.8 PURPOSE OF THE CURRENT STUDIES.

As the previously published account of the family Rosaceae of Pakistan is not sufficient (rather brief) to describe each of the taxa of Rosaceae micro-morphologically, so as a result the current updated information about the taxonomic position of Rosaceae has not been determined satisfactorily through the multiple parameters including, morphology, anatomy, and palynology so it was decided that a thorough investigation of Rosaceae would be needed and could yield further information for taxonomic and systematic research.

The Rosaceae family contains many potential genera, hence the goal of the current study was to deconstruct taxonomic issues and demonstrate the close relationships between genera and species utilizing palynological and micro-anatomical studies. This research also offers the conventional method of classifying Rosaceae based on morphology, anatomy, and palynology. Each of these parameters has diagnostic characteristics, and the combination of the various characters ultimately leads to the accurate identification of the species and genera and their placement in a particular taxonomic group. The current study's descriptions of the rose family are intended to highlight key characteristics of each taxon in order to gather as much information as possible about each taxon to aid in the identification of the rosaceous member.

There is much room for additional research on the pollen morphology and epidermal anatomy of the family Rosaceae from Pakistan in order to establish phylogenetic lines, and anatomical and pollen characters should be used in combination with other evidence derived from morphology, cytology, and geographical distribution. The current pollen and epidermal results of 50 species of 19 genera with limited geographic areas suggest that there is much scope for further research on these topics.

1.9 OBJECTIVES OF THE STUDIES

The current research is limited to enlisting and highlighting the value of numerous species found in District Swat. The study’s main goals are as follows.

- ❖ The present study provides a taxonomic revision in the investigation and interspecific variability in epidermal anatomical traits and micro-morphological features of pollen grains of family Rosaceae and to investigate their taxonomic potential.

- ❖ To collect available species of Rosaceous taxa from District Swat, for making a checklist, herbarium specimens records and field photographs, thus, to provides baseline for further study based on phylogenetics, morphometrics and molecular sequencing for correct identification of the species.

- ❖ This study provides novel data for new regions, allowing them to compare floral geographical diversity with District Swat region.

Chapter # 02

Materials and Methods

2.1 STUDY AREA OF (DISTRICT SWAT) THE NORTHERN PAKISTAN

Swat is a district in Pakistan that is located in Khyber Pakhtunkhwa province between 72° 08ˈ to 72° 50ˈ E longitudes and 34° 34ˈ to 35° 55ˈ N latitudes. The Swat district covers an area of 5337 Km^2 with a total human population of 2.3 million (Census Report, 2017). The district share boundaries with Gilgit-Baltistan and Chitral in the North, Buner and Shangla in the East and Southeast, and Dir in the West. Swat region is blessed with world's two highest mountain ranges, the Hindukush and the Himalaya, the district of Swat enjoys a special biogeographic location. The majestic mountains, enormous glaciers, magnificent rivers, and beautiful valleys that make up Pakistan's northern region are gifts from Mother Nature. According to research, mountains are home to one in three of all plant species globally (Namgail et al., 2012). The abrupt shift in vegetation cover, temperature, and soil throughout the altitudinal gradient is one of the ecosystems' astounding characteristics. These height gradients lead to diverse habitats, which in turn lead to a diversity of plant communities and species (Brown and Lomolino, 2000). The area is surrounded by high mountains, and has many sub valleys, with altitudes ranging from 600 m in south to 5800 m in the north, having two high peaks Falak Ser and Mankyal sar. The average altitude is 980 m (Mohiuddin, 2007) due to which the area is cooler and has a damper climate. Seven Tehsils, namely Babuzai, Khwaza Khela, Matta, Barikot, Charbagh, Bahrain, and Kabal make up the District. There are a specific number of Union councils in each Tehsil. In District Swat, there are sixty five Union councils, fifty six of which are rural and nine urban.

Due to its exceptional physical changes and geographic location, the district-Swat incorporates a broader array of climate variables. The region has four different seasons. Swat is a renowned tourism spot, attracting thousands of national and international tourists, being home to a variety of forest, rivers, glaciers, alpine meadows, waterfalls, lakes, beautiful valleys, and countless memorials of ancient Ghandhara civilization. The main tourist spots are Madyan, Behrain, Kalam, Malam Jabba, Gabbin Jabba, Jarogo, Miandam, Shahi Bagh and Mahodand. Swat is one of the nation's most well-liked tourist attractions because of these features (Khaliq and Fazal, 2018).

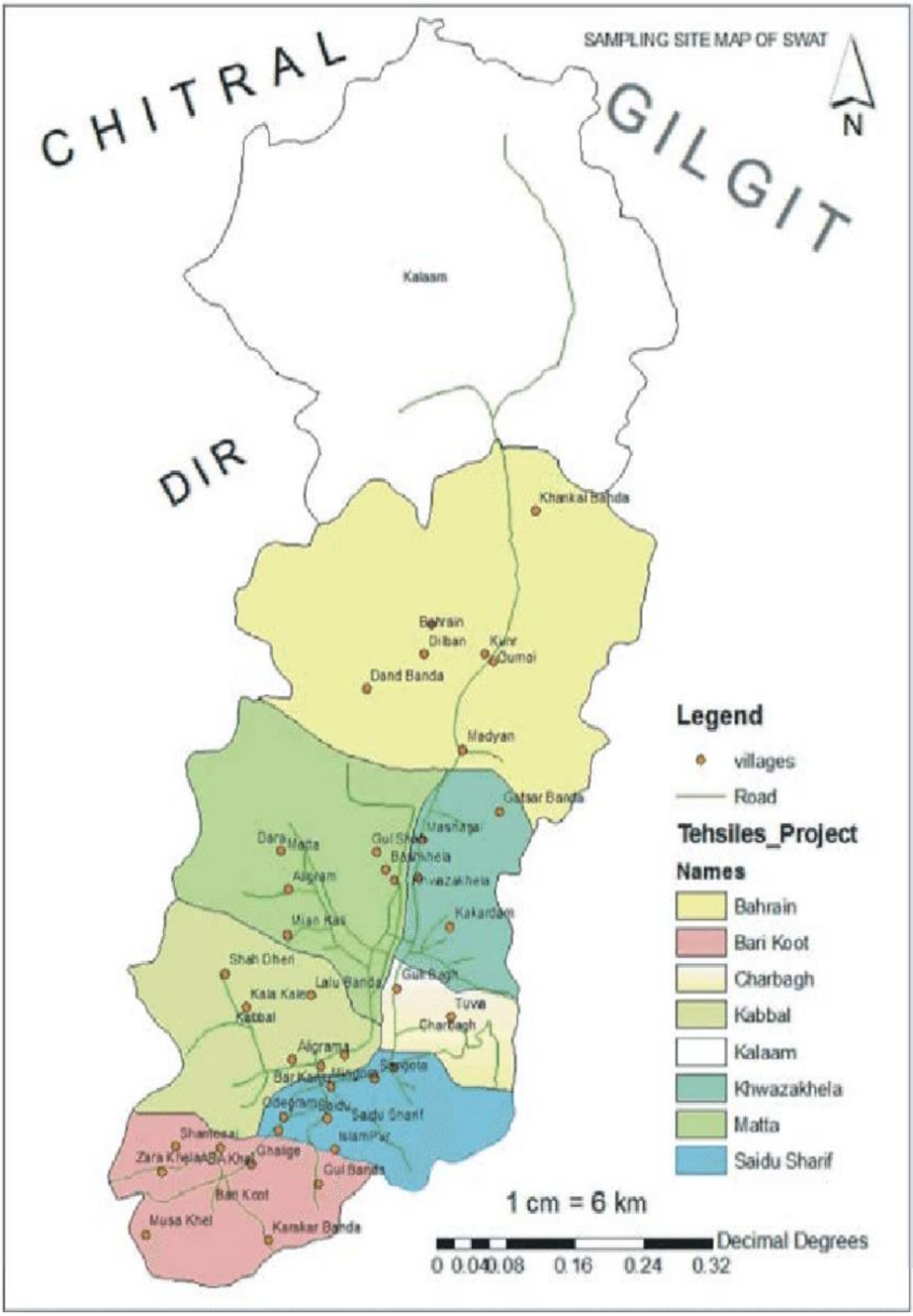


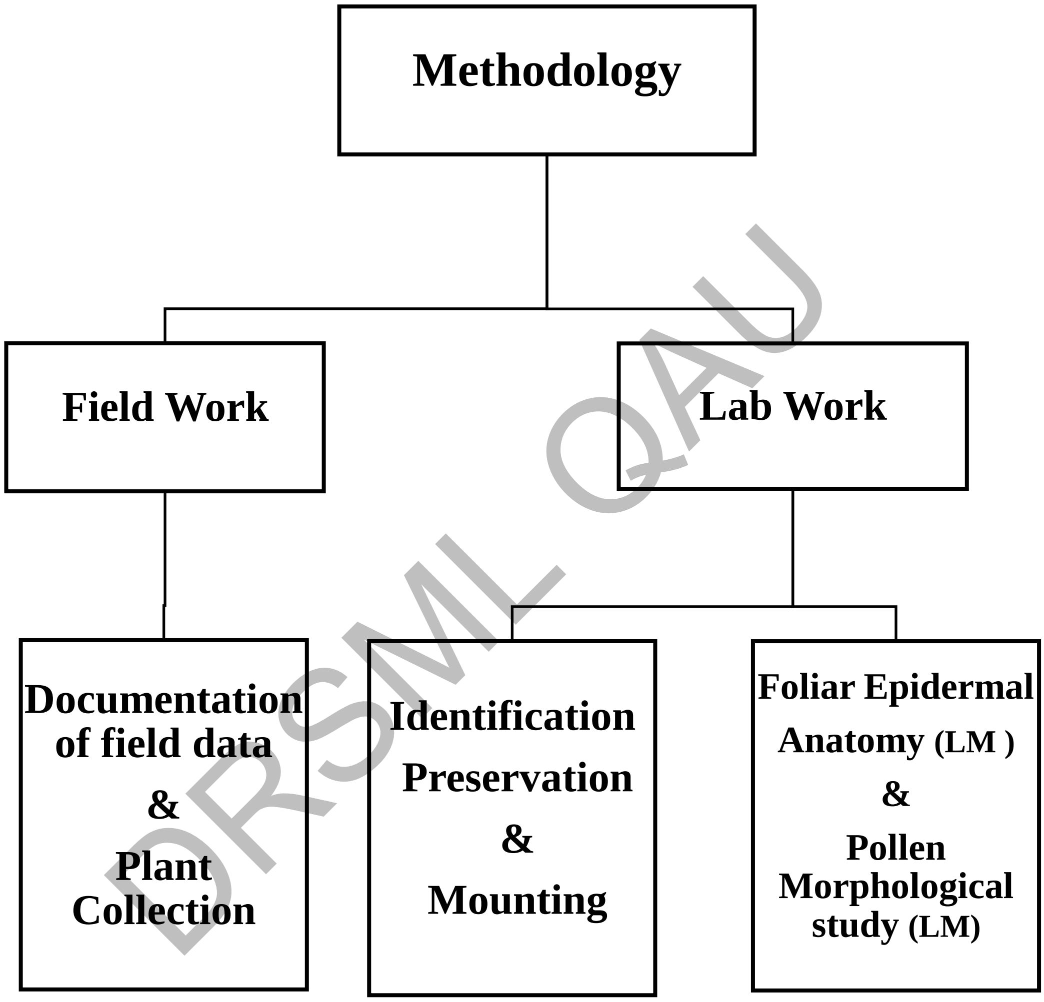
Fig 2.1: Map of the study area (District Swat) (*www. Scientific Diagram*, n.d.)

Fig.2.2: Collection site view of Miandam Valley, Swat

Fig 2.3: Panoramic view of Lalko Gabbin Jabba

Fig 2.4: Sparsely covered vegetation of the Genus *Pyrus* at Tehsil Kabal, Swat

Fig 2.5: Demographic view of *Pinus* at Mountainous area of Jarugu waterfall, Swat


Methodology
Field Work
Lab Work
Documentation of field data & Plant Collection
Identification Preservation & Mounting
Foliar Epidermal Anatomy (LM) & Pollen Morphological study (LM)

2.2 COLLECTION OF FIELD DATA

The current study was conducted from March to August of 2022, during the spring and summer. Both flat and mountainous geographical locality of the district Swat Pakistan were used to collect dicotyledonous flora of the Rosaceae family that was found in both temperate and Alpine regions. Field visits were scheduled to the district of Swat's temperate and alpine regions (Utror, Ghabral, Gabbin Jab, Malam Jab, Jarughu, Kalam, Bahrain, Marghazar, Madyan, Janshai Meadows, Miandam Alpines, Shahibagh Alpine, and above Mahodand).

2.3 IDENTIFICATION OF TAXA

Each plant was documented as shown in (figures 2.10-57) and field notes were prepared as shown in (Table 2.1) that included information about each plant's habit, habitat, height, associated plants, geographic coordinates, and the time it was collected. At the same time, blotting paper and a presser were used to press the collected plants. Plant specimens were pressed in a way to be easily analyzed morphologically using the accepted procedures. The identification of plants was carried out by the help of expert taxonomists at Quaid-i-Azam University Islamabad and at Swat University of Pakistan's in Department of Biodiversity Plant Sciences, using published floras of Pakistan, China, and online databases, while nomenclature was used in accordance with (www.ThePlant.list.org) and other recognized standards (www.ipni.org). The collected sample of plants were placed in newspapers, which is then changed from time to time Until the plants is dried having no moisture. Field notes of the collected samples were prepared having all the sufficient information's of the collected plants that include local and botanical name of the collected samples, geographical coordinates and locality, date of collection, and herbarium voucher number on herbarium sheets of each sample of the plants were written at the time of collection.

The collected plants after identification were pasted on herbarium sheets after which they were saved in Pakistan's Department of Plant Science Quaid-i-Azam University Islamabad's herbarium (ISL) as shown in plate 2.1.

Fig 2.6: Dense vegetation of *Spiraea Canescens* at Marghazar Valley

Fig 2.7: Source area of *Rubus* species from Ghudha Valley, Swat

Fig 2.8: Preservations of dried plant specimens

Fig 2.9: Labeling and mounting of specimens on herbarium sheets.

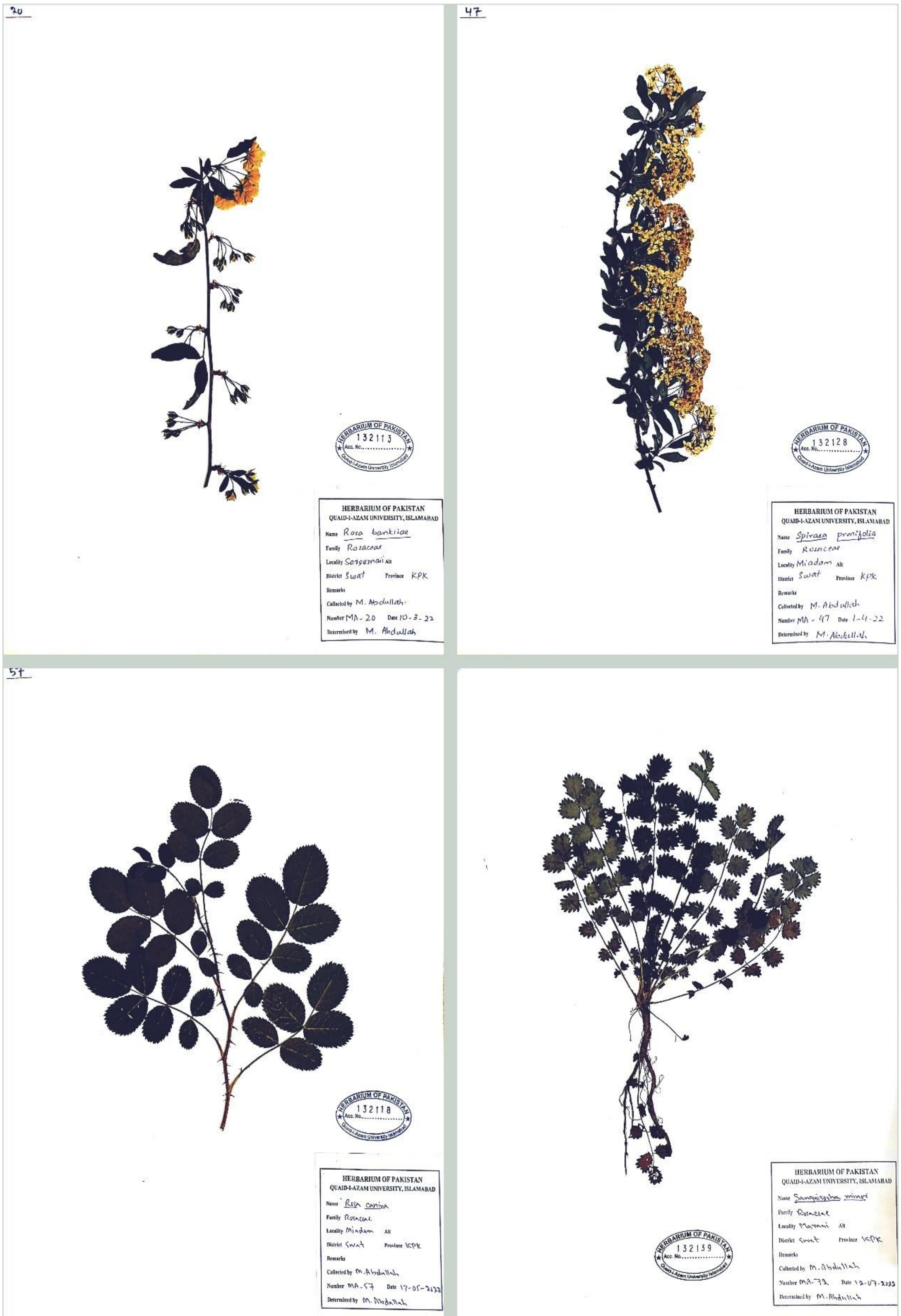


Plate 2.1: Mounting of plants on herbarium sheets

Table 2.1. Detail table on current collected species of family Rosaceae.

Sr.No	Species	Common Name	Habit	Status	Locality	District	Coordinates	Collector Name	Date of collection	Accession No.
1	***Pyrus pashia* Buch.-Ham. ex D.Don**	Himalayan pear	Tree	Wild	Ghoda	Swat	34°58’31.78”N 72° 13’42.97”E	Abdullah Saddam	16/02/2022	ISL-132097
2	***Pyrus calleryana* Decne.**	Callery pear	Tree	Wild	Kuza Samai	Swat	34°55’03.34”N 72° 13’20.97”E	Abdullah Arif Shah	27/03/2022	ISL-132098
3	***Pyrus communis* L.**	Common pear	Tree	Cultivated	Manai	Swat	34°58’21.23”N 72° 12’38.67”E	Abdullah Oman	21/03/2022	ISL-132099
4	***Pyrus bretschneideri* Rehder**	Yali pear	Tree	Wild	Fazal Banda	Swat	35°04’10.31”N 72° 16’25.00”E	Abdullah Rizwan	23/03/2022	ISL-132100
5	***Pyrus pyrifolia* (Burm.f.) Nakai**	Asian pear	Tree	Cultivated	Fazal Banda	Swat	35°04’11.92”N 72° 16’21.98”E	Abdullah Kashif	20/03/2022	ISL-132101
6	***Prunus persica* (L.)Batsch**	Peach	Tree	Cultivated	Odigram	Swat	34°45’15.30”N 72° 17’27.50”E	Abdullah Saddam	16/02/2022	ISL-132102
7	***Prunus domestica* L.**	European plum	Tree	Cultivated	Odigram	Swat	34°44’58.90”N 72° 17’10.74”E	Abdullah Kashif	19/02/2022	ISL-132103
8	***Prunus armeniaca* L.**	Apricot	Tree	Cultivated	Drush khela	Swat	35°00’09.57”N 72° 26’44.27”E	Adnan Abdullah	13/02/2022	ISL-132104
9	***Prunus dulcis* (Mill.) D.A.Webb**	Almond	Tree	Cultivated	Shah Deraii	Swat	34°53’01.34”N 72° 14’04.16”E	Abdullah Babar	20/03/2022	ISL-132105
10	***Prunus cerasus* L.**	Sour cherry	Tree	Wild	Jarogho	Swat	34°06’02.42”N 72° 12’56.14”E	Abdullah Babar	22/03/2022	ISL-132106
11	***Prunus avium* (L.) L.**	Wild cherry	Tree	Cultivated	Mankyal	Swat	35°20’52.22”N 72° 36’32.33”E	Abdullah Babar	26/03/2022	ISL-132107
12	***Potentilla supina* L.**	Bushy Cinquefoil	Herb	Wild	Odigram	Swat	34°45’04.90”N 72° 16’56.93”E	Abdullah Babar	24/03/2022	ISL-132108
13	***Potentilla recta* L.**	Sulphur Cinquefoil	Herb	Wild	Chinar bagh	Swat	34°42’25.71”N 72° 27’31.71”E	Abdullah Rizwan	27/05/2022	ISL-132109
14	***Potentilla reptans* L.**	Creeping Cinquefoil	Herb	Wild	Kalam	Swat	35°26’43.38”N 72° 35’58.01”E	Abdullah Inam	28/05/2022	ISL-132110

15	***Potentilla nepalensis* Hook.**	Nepal Cinquefoil	Herb	Wild	Gabbin Jabba	Swat	35°09’16.18”N 72° 22’32.57”E	Abdullah	12/07/2022	ISL-132111
16	***Potentilla atrosanguinea* G.Lodd. ex D.Don**	Himalayan Cinquefoil	Herb	Wild	Janshai meadows	Swat	35°32'44.92"N 72°35'22.12"E	Abdullah Kashif	18/07/2022	ISL-133367
17	***Potentilla crantzii* (Crantz) Beck ex Fritsch**	Alpine Cinquefoil	Herb	Wild	Janshai meadows	Swat	35°32'43.92"N 72°35'21.39"E	Abdullah Kashif	18/07/2022	ISL-133368
18	***Rosa indica* L.**	Cyme rose	Shrub	Cultivated	Barikot	Swat	34°40’04.24”N 72° 12’21.05”E	Abdullah	16/02/2022	ISL-132112
19	***Rosa banksiae* R.Br.**	Banks’ rose	Shrub	Cultivated	Sarsainai	Swat	34°48’57.34”N 72° 16’36.05”E	Abdullah	10/03/2022	ISL-132113
20	***Rosa chinensis* Jacq.**	China rose	Shrub	Cultivated	Kabal	Swat	34°47’30.32”N 72° 16’42.88”E	Abdullah	20/03/2022	ISL-132114
21	***Rosa × damascena* Herrm.**	Damask rose	Shrub	Wild	Charbagh	Swat	34°50’32.98”N 72° 31’58.46”E	Abdullah	29/03/2022	ISL-132115
22	***Rosa laevigata* Michx.**	Cherokee rose	Shrub	Cultivated	Shagai	Swat	34°44’08.89”N 72° 20’40.43”E	Abdullah	30/03/2022	ISL-132116
23	***Rosa brunonii* Lindl.**	Himalayan musk rose	Shrub	Wild	Marghzar	Swat	34°40’04.88”N 72° 20’36.42”E	Abdullah	02/05/2022	ISL-132117
24	***Rosa canina* L.**	Dog rose	Shrub	Wild	Miandam	Swat	35°03’13.90”N 72° 33’54.05”E	Abdullah	13/05/2022	ISL-132118
25	***Rosa pendulina* L.**	Alpine rose	Shrub	Wild	Ghabral	Swat	35°31'29.72"N 72°24'37.41"E	Abdullah Kashif	18/07/2022	ISL-133371
26	***Rosa webbiana* Wall. ex Royle**	Wild rose	Shrub	Wild	Maho dandh	Swat	35°42'37.19"N 72°39'29.44"E	Abdullah Adnan	19/07/2022	ISL-133374
27	***Rubus macilentus* Jacquem. ex Cambess.**	Lean raspberry	Shrub	Wild	Jarogho	Swat	35°06’06.11”N 72° 12’48.63”E	Abdullah Saddam	29/03/2022	ISL-132120
28	***Rubus vestitus* Weihe**	European blackberry	Shrub	Wild	Odigram	Swat	34°45’02.80”N 72° 17’17.21”E	Abdullah Saddam	26/03/2022	ISL-132121
29	***Rubus ellipticus* Sm.**	Yellow Himalayan Raspberry	Shrub	Wild	Jambil	Swat	34°41’29.68”N 72° 28’29.11”E	Abdullah Inam	17/03/2022	ISL-132119

30	***Rubus niveus* Thunb.**	Mysore raspberry	Shrub	Wild	Jambil	Swat	34°40’37.90”N 72° 28’51.25”E	Abdullah Rizwan	07/05/2022	ISL-132122
31	***Rubus occidentalis* L.**	Black raspberry	Shrub	Wild	Miandam	Swat	35°03’13.90”N 72° 33’54.05”E	Abdullah Adnan	11/06/2022	ISL-132123
32	***Fragaria nubicola* (Lindl. ex.Hook.f.) Lacaita**	Himalayan strawberry	Herb	Cultivated	Takhtaband	Swat	34°46’10.37”N 72° 18’39.02”E	Abdullah Saddam	03/04/2022	ISL-132124
33	***Fragaria vesca* L.**	Wild strawberry	Herb	Wild	Madyan	Swat	34°40’04.24”N 72° 12’21.05”E	Abdullah Sajid khan	01/04/2022	ISL-132125
34	***Geum urbanum* L.**	Wood avens	Herb	Wild	Bahrain	Swat	35°12’06.42”N 72° 32’48.70”E	Abdullah Oman khan	13/05/2022	ISL-132126
35	***Geum elatum* var. humile (Royle) Franch.**	High avens	Herb	Wild	Bara Samaii	Swat	34°55’56.13”N 72° 13’25.88”E	Abdullah Oman khan	12/07/2022	ISL-132127
36	***Spiraea prunifolia* Siebold & Zucc.**	Bridalwreath spirea	Shrub	Wild	Barham patti	Swat	35°04’11.07”N 72° 29’56.45”E	Abdullah Oman khan	01/04/2022	ISL-132128
37	***Spiraea canescens* D.Don**	Grey stem spiraea	Shrub	Wild	Behar	Swat	34°54’46.65”N 72° 31’41.24”E	Abdullah Oman khan	02/05/2022	ISL-132129
38	***Cotoneaster nummularius* Fisch. & C.A.Mey.**	Nummular	Shrub	Wild	Guligram	Swat	34°43’28.29”N 72° 19’57.88”E	Abdullah Babar khan	03/04/2022	ISL-132130
39	***Cotoneaster affinis* Lindl.**	Purpleberry cotoneaster	Tree	Wild	Sanghr	Swat	34°41’22.80”N 72° 28’24.62”E	Abdullah Adnan	14/04/2022	ISL-132131
40	***Crataegus songarica* K. Koch**	Asian hawthorn	Tree	Wild	Fazal Banda	Swat	35°03’56.24”N 72° 16’04.98”E	Abdullah Oman khan	29/03/2022	ISL-132132
41	***Cydonia oblonga* Mill.**	Quince	Tree	Wild	Qamber	Swat	34°46’19.43”N 72° 19’53.86”E	Abdullah Babar khan	16/02/2022	ISL-132133

42	***Duchesnea indica* (Jacks.) Focke**	Mock strawberry	Herb	Wild	Chail	Swat	35°08’27.41”N 72° 34’30.78”E	Abdullah	18/02/2022	ISL-132134
43	***Eriobotrya japonica* (Thunb.) Lindl.**	Loquat	Tree	Cultivated	Bara Bandai	Swat	34°49’18.11”N 72° 24’02.41”E	Abdullah	02/02/2022	ISL-132135
44	***Malus pumila* Mill.**	Paradise apple	Tree	Cultivated	Kanjo	Swat	34°49’17.12”N 72° 20’54.15”E	Abdullah	26/03/2022	ISL-132136
45	***Sorbaria tomentosa* (Lindl.) Rehder**	Kashmir false spirea	Tree	Wild	Miandam	Swat	35°03’08.48”N 72° 33’57.52”E	Abdullah	13/05/2022	ISL-132137
46	***Sibbaldia procumbens* L.**	Creeping sibbaldia	Herb	Wild	Gabbin Jabba	Swat	35° 09’46.21”N 72° 22’36.08”E	Abdullah	12/07/2022	ISL-132138
47	***Sibbaldia cuneata* Hornem. ex Kuntze**	Five finger cinquefoil	Herb	Wild	Janshai meadows	Swat	35°33'4.97"N 72°35'21.11"E	Abdullah Kashif	17/07/2022	ISL-133372
48	***Sanguisorba minor* Scop.**	Salad burnet	Herb	Wild	Marnai	Swat	34°58'22.08"N 72°12'47.07"E	Abdullah Oman	12/07/2022	ISL-132139
49	***Filipendula ulmaria* (L.) Maxim.**	Meadows sweet	shrub	Wild	Ghoda	Swat	34°58'17.03"N 72°12'34.66"E	Abdullah Oman	18/07/2022	ISL-133370
50	***Acomastylis elata* (Wall. ex G.Don) F.Bolle**	High Avens	Herb	Wild	Janshai meadows	Swat	35°33'1.39"N 72°35'21.67"E	Abdullah Kashif	17/07/2022	ISL-133373

2.4 SOURCE OF CURRENT STUDY MATERIALS

The current study members of the family Rosaceae for taxonomic study were collected with successive field trips from different geographical locality of District Swat Khyber Pakhtunkhwa the northern areas of Pakistan. In some Rosaceous taxa more than one specimen of the same plant was gathered from different phyto-geographical zones of the studied areas. The most investigated areas of district swat include, Barikot, Shamozai, Kabal, Bara bandai, Kuza bandai, Madyan, Cheel, Mankiyal, Charbagh, Fazal banda, Jarughu abshar, Utror, Ghabral, Gabbin Jab, Malam Jab, Kalam, Bahrain, Marghazar, Janshai Meadows, Miandam Alpines, Shahibagh Alpine, and above Mahodand were used for investigations of the current Rosaceous taxa. The Rosaceous taxa were collected with full structure form having root, shoot, leaves, and flowers. The photographs of each Rosaceous taxa along with habit and habitat were taken by using Sony camera (Model DSC-W800).

A total of 50 Rosaceous taxa belonging to 19 genera that include Pyrus, Prunus, Rosa, Potentilla, Rubus, Fragaria, Geum, Spiraea, Cotoneaster, Crataegus, Cydonia, Duchesnea, Eriobotrya, Malus, Sorbaria, Sibbaldia, Sanguisorba, Filipendula and Acomastylis of family Rosaceae were studied in present research work. 19 different genera were investigated for micro-anatomical study while for palynological study 17 genera out of 19 were used to investigate the diversity in pollen morphology under light microscope. Herbarium sample of palynological and micro-anatomical specimens were submitted in laboratory of plant systematic department Quaid-i-Azam University Islamabad Pakistan for future records.

2.5 CHEMICALS USED IN PRESENT RESEARCH STUDY

The names of the companies that produced the various chemicals employed in the current investigation are listed below. 4 grammes of five crystal mercuric chloride (BDH) and 900 milliliters of 99.8% pure ethanol (Schalaru company) were used to poison the plant specimens to preserve them. 65% Nitric acid of (Sigma Aldrich Company) and 90.08% of lactic acid of (Daejung Kosadaq limited Company) were utilized for studies on the anatomy of the leaf epidermis. Glycerin jelly was used on pollen to reduce transparency and to make them visible and transparent nail paint was employed to create permanent slides.

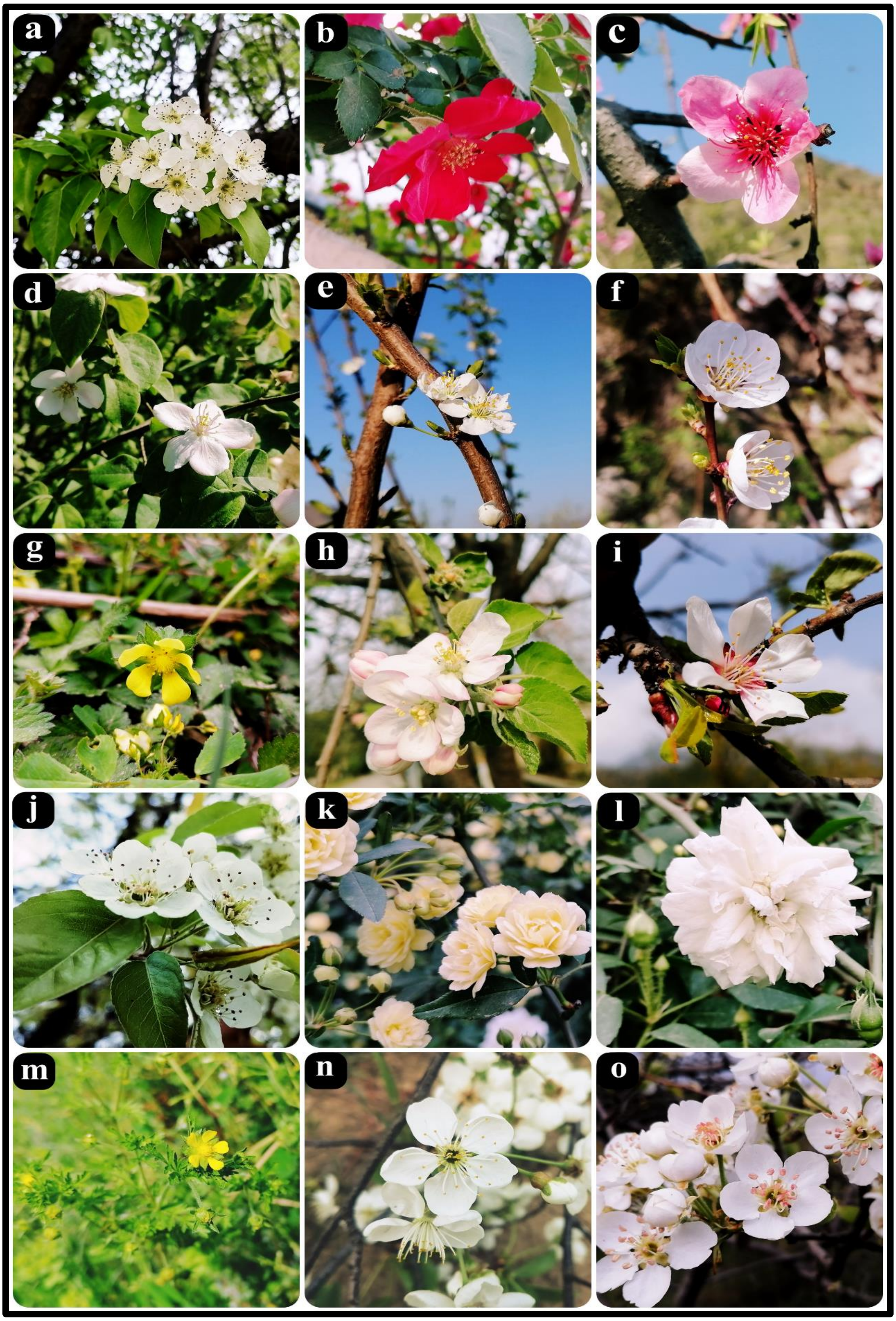


Plate 2.2 Field photographs of Rosaceous taxa **(a)** *P. pashia* **(b)** *R. indica* **(c)** *P. persica* **(d)** *C. oblonga* **(e)** *P. domestica* **(f)** *P. armeniaca* **(g)** *D. indica* **(h)** *M. pumila* **(i)** *P. dulcis* **(j)** *P. calleryana* **(k)** *R. banksiae* **(l)** *R. chinensis* **(m)** *P. supina* **(n)** *P. cerasus* **(o)** *P. communis.*

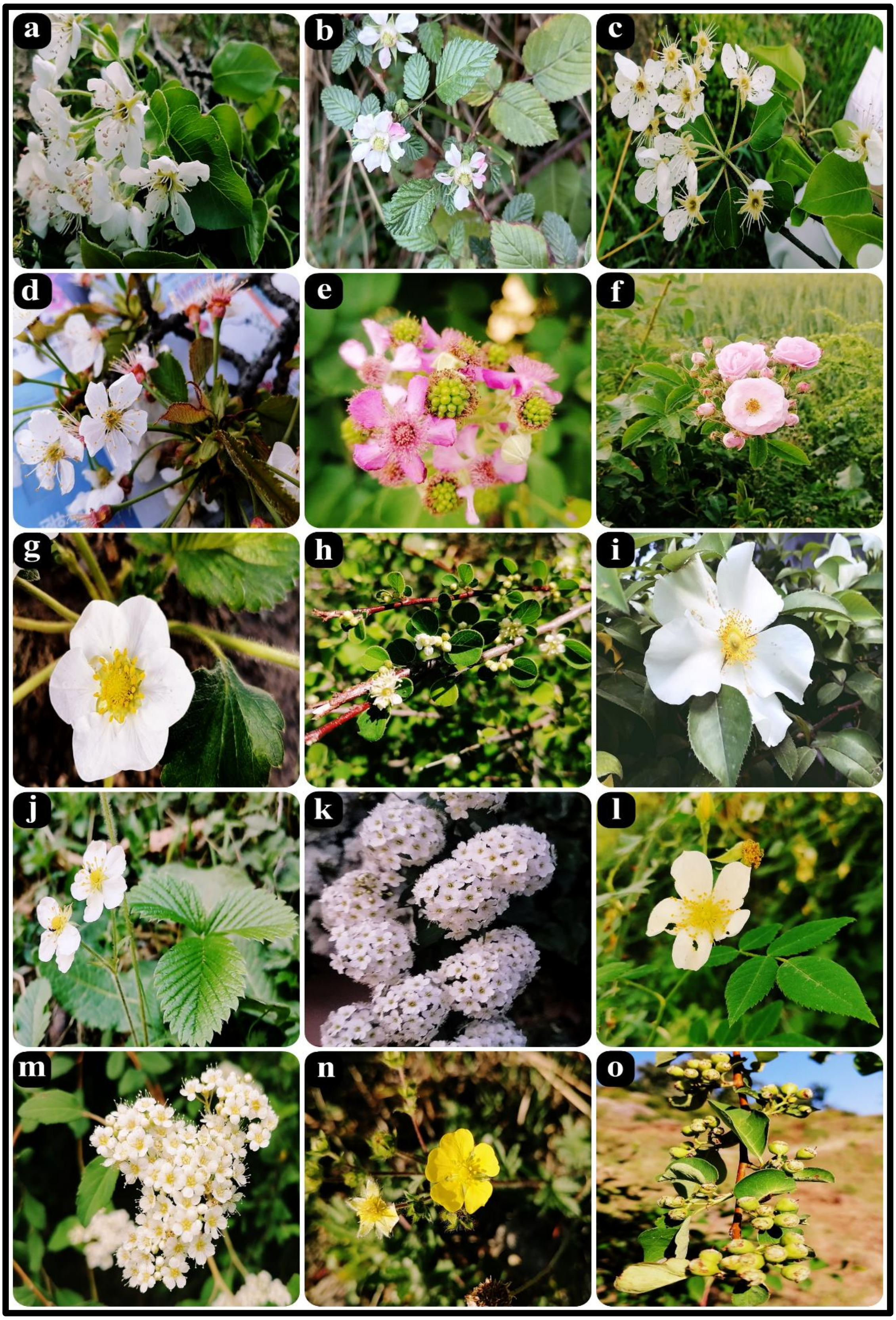


Plate 2.3 Field photographs of Rosaceous taxa **(a)** *P. bretschneideri* **(b)** *R. macilentus* **(c)** *P. pyrifolia* **(d)** *P. avium* **(e)** *R. vestitus* **(f)** *R. damascena* **(g)** *F. nubicola* **(h)** *C. nummularius* **(i)** *R. laevigata* **(j)** *F. vesca* **(k)** *S. prunifolia* **(l)** *R. brunonii* **(m)** *S. canescens* **(n)** *P. recta* **(o)** *C. affinis.*

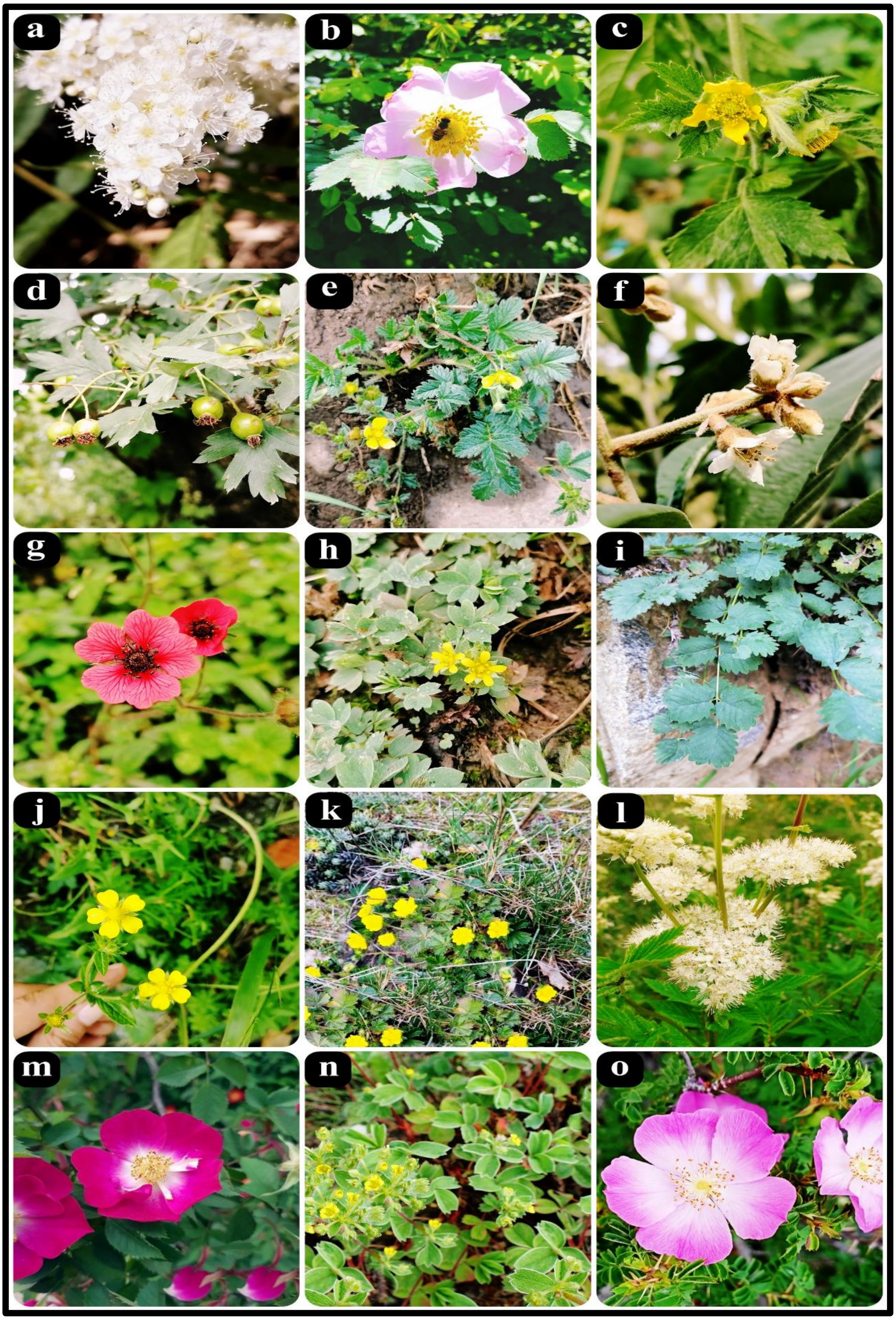


Plate 2.4 Field photographs of Rosaceous taxa **(a)** *S. tomentosa* **(b)** *R. canina* **(c)** *G. urbanum* **(d)** *C. songarica* **(e)** *P. reptans* **(f)** *E. japonica* **(g)** *P. nepalensis* **(h)** *S. procumbens* **(i)** *S. minor* **(j)** *G. elatum* **(k)** *P. crantzii* **(l)** *F. ulmaria* **(m)** *R. pendulina* **(n)** *S. cuneata* **(o)** *R. webbiana.*

2.6 PHOTOGRAPHS OF ROSACEOUS TAXA

The photographs of each Rosaceous taxa were taken by using Sony camera (Model DSC-W800). Some photographs that were captured for the current Rosaceous taxa collected from district Swat are given below.

2.7 TAXONOMIC STUDY OF THE FAMILY ROSACEAE

The current taxonomic study of the family Rosaceae is mainly based on two aspects.

1) Foliar epidermal Anatomy &
2) Pollen morphology

2.7.1 Protocol used for foliar epidermal anatomy.

The current research work is mainly based on Light Microscope (LM) which was used to investigate the foliar epidermal anatomy. The samples were tagged specifically and processed by using mixture of both lactic acid and nitric acid protocol. 9-10 mature leaves from each plant specimen were taken for the purpose of foliar epidermal slides preparations. The current research work followed (Clarke, 1960) method with a bit modifications.

2.7.1.1 Lactic acid protocol

For epidermal anatomical analysis the leaves that were sampled were divided into little pieces and put in a test tube already coded after which Lactic acid was added to the point of the test tube where the leaves were dipped in it. The tubes were then heated by using a spirit lamp and after boiling the samples, the leaves became transparent. The lactic acid boiled leaf sampled was then transferred to a Patri dish having cold water. A sharp blade and a camel brush were used to peel up the epidermal layer to separate both abaxial and adaxial layer of the epidermis. A section of abaxial and adaxial were then transferred to a slide and almost 2 drops of cooled lactic acid were added to leaf sample taken on slide. A slide cover was then put on the peel up of sample. Thus at least 2-5 abaxial and adaxial slides were prepared for each sampled species. To make a permanent slide a transparent nail polish was used.

This was the way through which both the abaxial and adaxial epidermal slides of the sample were prepared. The prepared slides were then observed with the help of

DM-1000 resolution light microscope along with Japan meiji 5000 camera photographs of the epidermal sections of the sample were taken. Both stomatal and trichomes shapes were observed and at least 10 measurements were taken for each character by using ocular meter. Qualitative and quantitative bioinformatics data were entered into Excel spreadsheets where mean and average were calculated.

2.7.1.2 Statistical assessment

2.7.1.2.1 Stomatal index (SI).

Following formula determines index of stomata,

$$S.I = \frac{S}{E + S} \times 100$$

Where (E) denotes number of cells present in a defined area and (S) denotes number of stomata present in a specific unit area (Stace, 1965).

2.7.1.2.2 Trichome index (TI).

Following formula determines index of trichome,

$$T.I = \frac{T}{E + T} \times 100$$

Where (E) denotes the cells epidermal number per unit of area and (T) denotes the number of trichomes per unit of area (Stace, 1965).

2.7.1.2.3 Cluster analysis.

A cluster analysis was conducted to elaborate the links among the assessed taxa using the Multivariate Statistical tool in the Past software.

2.7.1.2.4 A statistical tool Principal Component Analysis (PCA).

Using the statistical Past software, Principal Component Analysis (PCA) was performed (Harman 1976). By employing different metrics variable for the PCA, include the species, length and width of epidermal cell, subsidiary cell, stomata, stomatal pore, guard cell, trichome, trichome index and stomatal index of both abaxial and adaxial surfaces.

2.7.2 Protocol used for pollen morphology.

In most cases fresh materials (flowers) were used for collections of anthers to study palynological characters however in certain cases herbarium specimens were also used to collect anthers. The sampling was done from 47 species of Family Rosaceae representing 17 genera from both temperate and alpine geographical regions.

The current palynological study of Rosaceous flora mainly followed the technique of Wodehouse (1935). Using binocular stereomicroscope anthers were extracted from the flowers with the help of needles and forceps. After extractions the anthers were then put on slides. To crack the anthers wall, a few drops of chilled glacial acetic acid were added to the anthers. The anthers were then crushed softly by the help of glass rod with a flattened end. After crushing the extra debris and the anthers materials were removed by the help of needles. The slides were then treated with painting glycerin gel to remove transparency. After being successfully studied for Light Microscopy, the slides were varnished to make them permanent.

This was the method used in this study for pollen preparations. Pollens of Rosaceous taxa were observed in Nikon HFX-DX (Japan) microscope with magnification of 10x and 40x with 100x (oil immersion, 1.5) objectives. Measurements of the current study pollen were based on 10-30 well unbroken pollens per species. The quantitative observations of pollen were taken by LEICE-DM-1000 microscope while photographs of the pollen were taken by Meiji infinity DK. 5000 camera. Pollen size, polar and equatorial diameter, Mesocolpium, Exine thickness, pollen pore width and length etc. were the characters which were observed in the current study under light microscope. 1966 classifications of Erdtman were used for shape classes based on P/E ratio Fig 2.10. Qualitative data were arranged in Excel spreadsheet and statistical analysis including mean and standard error were calculated.

2.7.2.1 Sterility & fertility of Rosaceous Pollen

Determinations of fertile and sterile Rosaceous pollens were calculated by the following formulas.

$$F = F \div F + S \times 100$$

$$S = S \div F + S \times 100$$

Where, F represent fertile pollen and S represents sterile pollen.

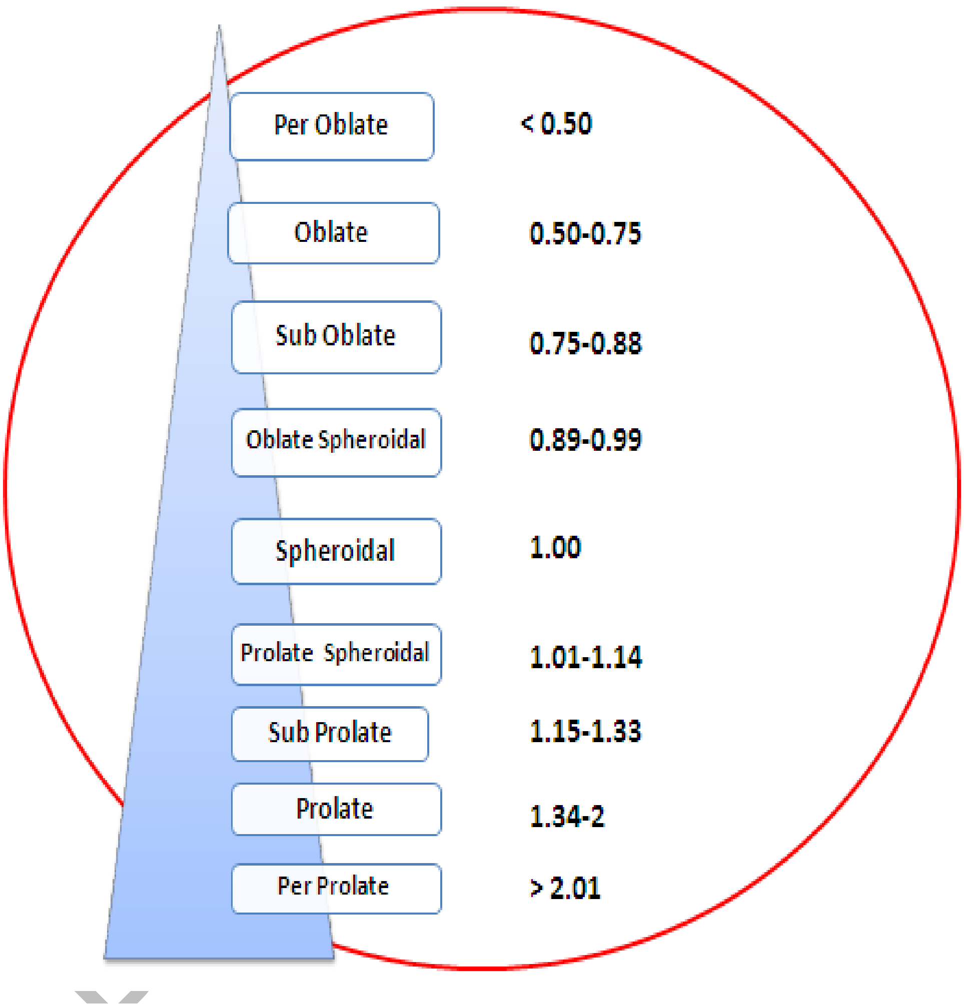


Fig. 2.10: Pollen shape classes after (Erdtman, 1966).

Fig 2.11: Preparation of pollen slides

Fig 2.12: Observations of pollen data under light microscope

Chapter # 03

Results and Discussion

3.1 ANATOMICAL DESCRIPTION

(1) *Pyrus pashia* Buch. Ham. ex D.Don

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were tetragonal to hexagonal in shape up to 4 lobes with deeply undulate anticlinal wall. Average cells length of the epidermal was (34.1±4.64) µm and width was (18.9±2.21) µm.

Abaxial surface:

Stomata were Stephanocytic, common, with raised in appearance. The stomatal complex average length was (53.6±2.72) µm and width was (30.5±0.87) µm. Appearance of the epidermal cells were irregular shpe up to 7 lobes with roughly straight of the anticlinal wall. Epidermal cells Average length was (38.2±3.88) µm and width was (20.8±1.62) µm.

Trichome:

Trichome were not observed both abaxial along with adaxial surface.

(2) *Pyrus calleryana* Decne.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were tetragonal in shape up to 4 lobes with undulate anticlinal walls pattern. Average epidermal cells length was (16.1±0.80) µm and width was (16.9±0.57) µm.

Abaxial surface

Stomata were Stephanocytic, common, with raised and sunken in appearance. The average length of stomatal complex was (41.8±4.84) µm and width was (46.7±1.78) µm. Epidermal cells were appeared irregular shape up to 3 lobes and anticlinal wall on abaxial surface was slightly straight. The average length of the epidermal cells was (21.2±3.59) µm and width was (15.9±1.35) µm.

Trichome:

Non-glandular trichomes were conical elongated, rare, unicellular, uniseriate, and present on costal side. Average measurement with respect to length of non-glandular trichome was (858.2±34.6) µm and width measurement was (16.1±1.25) µm.

(3) *Pyrus communis* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were trigonal to pentagonal up to 5 lobes with roughly undulate anticlinal walls pattern. Average length of the epidermal cells was (48.1±4.94) µm and width on adaxial surface was (20.6±3.44) µm.

Abaxial surface:

Stomata were Stephanocytic, common, with slightly raised in appearance. The average length of stomatal complex was (74.5±2.02) µm and width was (99.6±2.39) µm. Shape of the epidermal cells were trigonal up to 5 lobes with slightly curved anticlinal wall. Average epidermal cells length was (26.6±2.96) µm and width was (32.9±4.60) µm.

Trichome:

Trichome were not observed on both adaxial and abaxial surface.

(4) *Pyrus bretschneideri* Rehder

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were trigonal to pentagonal up to 3 lobes with undulate anticlinal walls pattern. Average epidermal cells length was (18.8±2.69) µm and width was (18.7±1.64) µm.

Abaxial surface:

Stomata were Anomocytic, abundant, with slightly sunken in appearance. Average stomatal complex computed length was (43.6±1.91) µm and computed width was (35.3±2.15) µm. Shape of the epidermal cells were tetragonal up to 3 lobes with smoothly curved anticlinal walls pattern. Average epidermal cells length was (11.0±0.72) µm and width was (19.5±2.48) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal and intercoastal in position. The average length of non-glandular trichome was (966.4±32.2) µm and width was (17.8±0.34) µm.

(5) *Pyrus pyrifolia* (Burm.f.) Nakai

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were trigonal in apperance up to 4 lobes with straight in appearance the anticlinal wall. Average epidermal cells length was (40.6±3.11) µm and width was (35.7±2.98) µm.

Abaxial surface:

Stomata were Anomocytic, common, with sunken in appearance. The average length of stomatal complex was (43.4±0.30) µm and width was (24.3±0.30) µm. Polygonal appearance of the epidermal cells up to 3 lobes with marginally curved anticlinal walls pattern. Average epidermal cells length was (28.8±2.38) µm and width was (18.0±1.08) µm.

Trichome:

No Trichome were observed on both adaxial as well as on abaxial surface.

(6) *Prunus persica* (L.)Batsch

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were pentagonal up to 2 lobes with roughly undulate anticlinal wall pattern. Average epidermal cells length was (34.1±4.33) µm and width was (17.8±0.76) µm.

Abaxial surface:

Stomata were Anomocytic, abundant, with slightly sunken in appearance. The average length of stomatal complex was (60.2±4.44) µm and width was (54.5±3.61) µm. Epidermal cells physical appereance were polygonal up to 3 lobes as well as straight in morphology in anticlinal wall pattern. Average elongation of the epidermal cells was (20.2±1.29) µm along with width (14.8±0.95) µm.

Trichome:

No trichomes were observed on both surfaces.

(7) *Prunus domestica* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. morphology of the epidermal cells was polygonal up to 2 lobes as well as straight appearance of the anticlinal wall. Average elongation of the epidermal cells was (32.4±4.43) µm and width was (34.4±5.29) µm.

Abaxial surface:

Stomata were Anomocytic, abundant, with raised in appearance. The average length of stomatal complex was (50.6±1.25µm and width was (50.2±0.69) µm. Shape of the epidermal cells were tetragonal up to 7 lobes with simple wavy anticlinal walls pattern. Average epidermal cells length on abaxial surface was (29.7±2.16) µm and width was (19.0±1.15) µm.

Trichome:

Non-glandular trichomes were cylindrical, common, unicellular, uniseriate, and present only on coastal region. The average length of non-glandular trichome was (351.0±76.2) µm and width was (24.6±1.79) µm.

(8) *Prunus armeniaca* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Tetragonal to polygonal shape epidermal cells up to 2 lobes as well as straight appearance of the anticlinal wall. lengthwise average epidermal cells was (38.1±6.26) µm and width (36.8±3.33) µm.

Abaxial surface:

Stomata were Anomocytic, abundant, with sunken in appearance. The average length of stomatal complex was (48.1±0.87) µm and width was (34.5±0.41) µm. Physically epidermal cells were trigonal to pentagonal up to 6 lobes as well as straight shape anticlinal wall. Average length of the epidermal cells was (27.4±4.29) µm and width was (22.2±2.78) µm.

Trichome:

Non-glandular trichomes were conical, rare, unicellular, uniseriate, and present only on coastal region. The average length of non-glandular trichome was (339.3±19.0) µm and width was (22.1±0.62) µm.

(9) *Prunus dulcis* (Mill.) D.A.Webb

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Morphologically epidermal cells were polygonal up to 5 lobes as well as straight in anticlinal wall appearnce. Average length of the epidermal cells was (36.7±5.73) µm and width was (31.3±1.73) µm.

Abaxial surface:

Stomata were Tetracytic, common, with very raised in appearance. The average length of stomatal complex was (65.2±0.35) µm and width was (61.5±0.74) µm. Shape of the epidermal cells were trigonal to tetragonal up to 3 lobes with wavy anticlinal wall pattern on abaxial. Average epidermal cells length was (36.3±3.88) µm and width was (24.4±3.28) µm.

Trichome:

Trichome were not observed on both adaxial and abaxial surface.

(10) *Prunus cerasus* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. morphology of the epidermal cells were wavy up to 9 lobes with undulate anticlinal wall. Average elongation of the epidermal cells on adaxial surface was (32.5±2.97) µm and width was (56.1±2.13) µm.

Abaxial surface:

Stomata were Tetracytic, abundant, with raised in appearance. The average elongation of stomatal complex was (70.0±1.46) µm and width was (67.8±1.91) µm. Shape of the epidermal cells were wavy up to 9 lobes with sinuate anticlinal wall morphology. Average length of the epidermal cells was (30.7±1.73) µm and width was (45.0±4.86) µm.

Trichome:

Non-glandular trichomes were cylindrical, very rare, unicellular, uniseriate, and present only on coastal region. The average length of non-glandular trichome was (484.3±37.3) µm and width was (28.3±0.72) µm.

(11) *Prunus avium* (L.) L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Irregular epidermal cells shape up to 4 lobes with undulate morphology of the anticlinal wall. Average elongation of the epidermal cells was (58.3±2.84) µm and width was (30.7±4.25) µm.

Abaxial surface:

Stomata were Stephanocytic, abundant, with very raised in appearance. The average length of stomatal complex was (36.5±0.80) µm and width was (44.6±1.28) µm. Epidermal cells morphology were irregular up to 4 lobes with sinuate anticlinal wall. Average length of the epidermal cells was (32.2±1.11) µm and width was (24.0±1.57) µm.

Trichome:

Non-glandular trichomes were conical and cylindrical, rare, unicellular, uniseriate, and present only on coastal region. The average length of non-glandular trichome was (771.7±11.9) µm and width was (23.2±0.83) µm.

(12) *Potentilla supina* L.

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Laterocytic, rare, with slightly sunken in appearance. The average length of stomatal complex was (81.9±8.79) µm and width was (72.9±4.15) µm. Shape of the epidermal cells were trigonal to tetragonal up to 3 lobes with slightly curved anticlinal wall. Average length of the epidermal cells was (45.3±4.69) µm and width was (26.1±1.70) µm.

Abaxial surface:

Stomata were Laterocytic, abundant, with slightly raised in appearance. The average length of stomatal complex was (85.2±4.46) µm and width was (73.1±5.38) µm. Epidermal cells were morphologicaly irregular up to 7 lobes with slightly curved anticlinal wall. Average length of the epidermal cells was (45.8±4.86) µm and width was (24.6±1.70) µm.

Trichome:

Non-glandular trichomes were conical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (233.8±34.7) µm and width was (10.0±0.22) µm. Glandular trichomes were elongated capitate. The average length of glandular trichome was (65.7±0.78) µm and width was (24.1±0.23) µm.

(13) *Potentilla recta* L.

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Laterocytic, very rare, with sunken in appearance. The average length of stomatal complex was (68.3±2.81) µm and width was (78.6±1.56) µm. Shape of the epidermal cells were irregular up to 4 lobes with deeply undulate anticlinal wall pattern. Average adaxial length of the epidermal cells was (45.7±1.55) µm and width was (35.8±0.88) µm.

Abaxial surface:

Stomata were Laterocytic, abundant, with very raised in appearance. The average length of stomatal complex was (56.0±6.94) µm and width was (61.9±3.65) µm. The Epidermal cells morphology were irregular up to 5 lobes with undulate appearance of the anticlinal wall. Average length of the epidermal cells was (33.0±1.71) µm and width was (26.3±0.62) µm.

Trichome:

Non-glandular trichomes were conical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (656.0±46.2) µm as well as width was (19.3±0.86) µm. Glandular trichomes were elongated capitate. Average elongation of glandular trichome was (49.6±1.3) µm along with width (25.8±1.1) µm.

(14) *Potentilla reptans* L.

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Laterocytic, rare, with slightly raised in appearance. The average length of stomatal complex was (83.2±7.46) μm and width was (84.5±8.05) μm. The epidermal cells morphology were polygonal up to 2 lobes as well as straight in anticlinal wall. Average length of the epidermal cells was (36.7±5.31) μm and width was (28.8±2.13) μm.

Abaxial surface:

Stomata were Laterocytic, abundant, with slightly sunken in appearance. The average length of stomatal complex was (77.9±7.81) μm and width was (66.3±9.40) μm. Morphologically epidermal cells were tetragonal up to 4 lobes as well as straight in anticlinal wall. Average length of the epidermal cells was (40.7±4.29) μm and width was (27.7±2.17) μm.

Trichome:

Non-glandular trichomes were conical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (779.8±15.9) μm and width was (21.1±2.78) μm. Glandular trichomes were elongated capitate. Average elongation of glandular trichome was (46.5±1.96) μm and width was (25.0±0.17) μm.

(15) *Potentilla nepalensis* Hook.

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Stephanocytic, common, with raised in appearance. The average length of stomatal complex was (80.5±5.28) μm and width was (66.6±4.32) μm. Morphology of the epidermal cells were irregular up to 6 lobes with slightly curved in anticlinal wall. Average length of the epidermal cells was (40.6±4.24) μm and (32.3±2.61) μm.

Abaxial surface:

Stomata were Laterocytic, common, with very raised in appearance. The average length of stomatal complex was (68.5±4.19) μm and width was (57.6±1.84) μm. morphology of the epidermal cells were polygonal up to 5 lobes with slightly curved in anticlinal walls. The average epidermal cells length was (38.2±1.30) μm and width was (29.3±1.31) μm.

Trichome:

Non-glandular trichomes were conical, rare, unicellular, uniseriate, coastal and intercoastal in position. The average length of non-glandular trichome was (551.4±42.8) μm and width was (15.9±0.63) μm. Glandular trichomes were elongated capitate. The average length of glandular trichome was (64.2±3.72) μm and width was (23.3±1.59) μm.

(16) *Potentilla atrosanguinea* G.Lodd.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were pentagonal up to 3 lobes with deeply undulate anticlinal walls pattern. Average epidermal cells length was (54.2±1.84) μm and width was (24.3±3.29) μm.

Abaxial surface:

Stomata were Laterocytic, rare, with raised in appearance. The average length of stomatal complex was (68.1±0.95) μm and width was (83.3±0.94) μm. Morphology of the epidermal cells were polygonal up to 5 lobes with slightly curved in anticlinal walls appearance. The average epidermal cells length was (42.1±3.39) μm and width was (31.8±4.75) μm.

Trichome:

Non-glandular trichomes were conical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (522.7±61.3) μm and width was (15.2±1.31) μm. Glandular trichomes were elongated capitate. The average length of glandular trichome was (62.4±2.12) μm and width was (22.4±1.01) μm.

(17) *Potentilla crantzii* (Crantz) Beck ex Fritsch

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Staurocytic, rare, with slightly raised in appearance. The average length of stomatal complex was (92.5±4.40) µm and width was (89.6±3.13) µm. Morphology of the epidermal cells were trigonal to tetragonal up to 3 lobes with roughly straight in anticlinal wall. Average elongation of the epidermal cells was (50.4±6.11) µm and along with width (25.1±3.03) µm.

Abaxial surface:

Stomata were Laterocytic, abundant, with sunken in appearance. The average length of stomatal complex was (82.8±71.8) µm and width was (71.8±3.39) µm. Morphology of the epidermal cells were irregular up to 6 lobes with undulate in anticlinal wall morphology. Average length of the epidermal cells was (40.7±3.60) µm and width was (23.8±2.76) µm.

Trichome:

Non-glandular trichomes were conical, abundant, unicellular, uniseriate, coastal and intercoastal in position. The average length of non-glandular trichome was (467.1 ±1.26) µm and width was (34.3±6.77) µm.

(18) *Rosa indica* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not revealed on adaxial surface. Morphologically epidermal cells were irregular in shape up to 3 lobes with straight in anticlinal wall. Average length of the epidermal cells was (51.6±3.51) µm and width was (26.7±2.57) µm.

Abaxial surface:

Stomata were Paracytic, common, with raised in appearance. The average length of stomatal complex was (56.4±2.73) µm and width was (55.9±5.13) µm. Shape of the epidermal cells were trigonal to tetragonal up to 4 lobes with wavy anticlinal walls pattern. The epidermal cells average length was (45.5±4.17) µm and width was (28.2±1.93) µm.

Trichome:

Non-glandular trichomes were cylindrical, very rare, unicellular, uniseriate, coastal and intercoastal in position. The average length of non-glandular trichome was (319.8±69.0) µm and width was (13.6±1.04) µm.

(19) *Rosa banksiae* R.Br.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were polygonal up to 5 lobes with wavy anticlinal walls pattern. Average epidermal cells length on adaxial surface was (42.0±5.56) µm and width was (22.6±3.97) µm.

Abaxial surface:

Stomata were Actinocytic, common, with sunken in appearance. The average length of stomatal complex was (44.0±5.29) µm and width was (42.9±1.54) µm. Shape of the epidermal cells were polygonal up to 5 lobes with undulate anticlinal wall pattern. Abaxial average length of the epidermal cells was (32.7±3.26) µm and width was (19.3±2.15) µm.

Trichome:

Non-glandular trichomes were cylindrical, very rare, unicellular, uniseriate, and only on coastal position. The average length of non-glandular trichome was (488.1±23.5) µm and width was (10.0±0.17) µm.

(20) *Rosa chinensis* Jacq.

(Leaves are hypostomatic)

Adaxial surface:

No Stomata were appeared on adaxial surface. Epidermal cells were morphologicaly irregular up to 4 lobes with wavy in anticlinal wall. Average epidermal cells elongation was (26.1±2.25) µm and width was (19.7±2.69) µm.

Abaxial surface:

Stomata were Tetracytic, abundant, with slightly sunken in appearance. The average length of stomatal complex was (49.3±3.03) µm and width was (43.4±2.46) µm. Shape of the epidermal cells were wavy up to 6 lobes with undulate anticlinal walls pattern. Average epidermal cells length was (23.2±2.52) µm and width was (15.0±1.17) µm.

Trichome:

Non-glandular trichomes were cylindrical, very rare, unicellular, uniseriate, and only on coastal position. The average length of non-glandular trichome was (431.3±4.74) µm and width was (9.95±0.21) µm.

(21) *Rosa* × *damascena* Herrm.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were tetragonal in shape up to 2 lobes with undulate in anticlinal wall morpholgy. Average elongatio of epidermal cells was (36.7±3.52) µm and width was (21.9±2.04) µm.

Abaxial surface:

Stomata were Stephanocytic, common, with slightly raised in appearance. The average length of stomatal complex was (69.3±6.68) µm and width was (45.7±1.53) µm. Epidermal cells were morphologicaly wavy up to 5 lobes as well as straight in anticlinal wall. Elongation of epidermal cells was (31.1±3.21) µm and width was (20.0±1.79) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate coastal, intercostal, and marginal in position. The average length of non-glandular trichome was (212.5±46.4) µm and width was (9.70±1.52) µm.

(22) *Rosa laevigata* Michx.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. morphology of the epidermal cells was polygonal up to 5 lobes with wavy in anticlinal wall. Average epidermal cells elongation was (21.8±2.27) µm and width was (18.7±1.16) µm.

Abaxial surface:

Stomata were Paracytic, common, with slightly sunken in appearance. The average length of stomatal complex was (46.4±2.47) µm and width was (37.9±3.38) µm. morphology of the epidermal cells were irregular up to 2 lobes with Smoothly curved in anticlinal wall. Average elongation of the epidermal cells was (24.4±3.27) µm and width was (18.2±1.30) µm.

Trichome:

Trichome were not present on both abaxial and adaxial surface.

(23) *Rosa brunonii* Lindl.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were trigonal to tetragonal Shape up to 3 lobes with undulate in anticlinal wall. Average epidermal cells elongation was (39.9±1.35) µm and width was (19.5±1.32) µm.

Abaxial surface:

Stomata were Paracytic, abundant, with very raised in appearance. The average length of stomatal complex was (68.3±0.93) µm and width was (54.6±0.95) µm. Shape of the epidermal cells were wavy up to 7 lobes with sinuate in anticlinal wall. Average elongation of the epidermal cells was (35.0±1.96) µm and width was (22.2±1.28) µm.

Trichome:

Non-glandular trichomes were cylindrical, rare, unicellular, uniseriate, and only on coastal position. The average length of non-glandular trichome was (293.1±35.3) µm and width was (7.50±0.17) µm.

(24) *Rosa canina* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were tetragonal shape up to 2 lobes with straight in anticlinal walls. Average length of the epidermal cells was (45.6±0.86) µm and width was (29.3±3.00) µm.

Abaxial surface:

Stomata were Paracytic, common, with very raised in appearance. Average elongation of stomatal complex was (72.3±1.76) µm along with width (54.3±2.32) µm. Shape of the epidermal cells were wavy up to 9 lobes with sinuate in anticlinal wall. Epidermal cells average elongation was (43.7±1.77) µm and width was (24.5±0.87) µm.

Trichome:

Non-glandular trichomes were cylindrical, common, unicellular, uniseriate, coastal and intercoastal in position. The average length of non-glandular trichome was (384.1±83.0) µm and width was (9.80±0.33) µm.

(25) *Rosa pendulina* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were wavy up to 6 lobes with sinuate in anticlinal wall appearance. Epidermal cells average elongation was (59.4±7.38) µm and width was (36.4±3.63) µm.

Abaxial surface:

Stomata were Paracytic, rare, with slightly raised in appearance. The average length of stomatal complex was (94.4±3.32) µm and width was (80.0±4.73) µm. Shape of the epidermal cells were wavy up to 9 lobes with sinuate in anticlinal wall. Epidermal cells average elongation was (52.7±4.62) µm and width was (26.1±1.40) µm.

Trichome:

Trichome were not observed on both adaxial and abaxial surface.

(26) *Rosa webbiana* Wall. ex Royle

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were trigonal to tetragonal in shape up to 2 lobes with sinuate in anticlinal wall. Epidermal cells average elongation was (40.1±4.74) µm and width was (24.9±2.27) µm.

Abaxial surface:

Stomata were Paracytic, abandant, with sunken in appearance. The average elongation of stomatal complex was (81.1±1.61) µm and width was (66.1±1.50) µm. Shape of the epidermal cells were polygonal up to 6 lobes with wavy anticlinal walls pattern. The average epidermal cells length was (38.5±1.34) µm and width was (28.5±1.50) µm.

Trichome:

Non-glandular trichomes were cylindrical, rare, unicellular, uniseriate, and only on coastal position. The average length of non-glandular trichome was (369.8±41.3) µm and width was (10.2±0.26) µm.

(27) *Rubus macilentus* Jacquem. ex Cambess.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were pentagonal up to 4 lobes with roughly curved in anticlinal wall. Epidermal cells average elongation was (34.9±3.88) µm and width was (41.7±6.51) µm.

Abaxial surface:

Stomata were Stephanocytic, abandant, with very raised in appearance. The average elongation of stomatal complex was (55.0±2.60) µm and width was (55.9±1.42) µm. Shape of the epidermal cells were irregular up to 3 lobes with undulate anticlinal walls pattern. The average epidermal cells length was (36.2±1.51) µm and width was (43.3±3.74) µm.

Trichome:

Non-glandular trichomes were cylindrical, very rare, unicellular, uniseriate, and only on coastal position. The average length of non-glandular trichome was (172.0±5.52) µm and width was (10.3±0.25) µm. Glandular trichome were elongated capitate. The average length of glandular trichome was (60.1±12.9) µm and width was (59.6±0.79) µm.

(28) *Rubus vestitus* Weihe

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were wavy up to 7 lobes with sinuate in anticlinal wall. Average length of the epidermal cells was (41.8±4.62) µm and width was (26.9±3.75) µm.

Abaxial surface:

Stomata were Stephanocytic, common, with raised in appearance. The average length of stomatal complex was (71.4±4.07) µm and width was (49.7±2.37) µm. Shape of the epidermal cells were wavy up to 6 lobes with sinuate in anticlinal wall. Epidermal cells average elongation was (35.4±3.12) µm and width was (29.2±2.42) µm.

Trichome:

Non-glandular trichomes were stellate and cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (551.6±1.01) µm and width was (16.0±1.87) µm.

(29) *Fragaria nubicola* (Lindl. ex.Hook.f.) Lacaita

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were hexagonal in shape up to 3 lobes with roughly curved in anticlinal wall. Epidermal cells average elongation was (68.4±5.59) µm and width was (63.9±3.04) µm.

Abaxial surface:

Stomata were Actinocytic, abundant, with sunken in appearance. The average length of stomatal complex was (92.6±2.89) µm and width was (71.4±2.09) µm. Shape of the epidermal cells were hexagonal up to 3 lobes with roughly curved in anticlinal wall. Average epidermal cells elongation was (38.1±2.07) µm and width was (25.1±1.64) µm.

Trichome:

Non-glandular trichomes were cylindrical, common, unicellular, uniseriate, coastal and intercoastal in position. Glandular trichome were Dumble capitate. The average length of non-glandular trichome was (606.1±1.02) µm and width was (10.0±1.76) µm. Glandular trichome was Dumble capitate. The average length of glandular trichome was (49.0±0.65) µm and width was (10.3±1.42) µm.

(30) *Fragaria vesca* L.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were trigonal to tetragonal in shape up to 3 lobes with undulate in anticlinal wall. Average epidermal cells elongation was (32.8±3.91) µm and width was (21.7±3.94) µm.

Abaxial surface:

Stomata were Laterocytic, abundant, with sunken in appearance. The average length of stomatal complex was (59.7±0.96) µm and width was (63.7±0.57) µm. Shape of the epidermal cells were wavy up to 6 lobes with wavy in anticlinal wall. Average epidermal cells elongation was (20.3±1.50) µm and width was (14.6±0.78) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. Glandular trichome were Dumble capitate. The average length of non-glandular trichome was (626.1±1.10) µm and width was (12.2±0.32) µm. Glandular trichome was Dumble capitate. The average length of glandular trichome was (37.0±3.14) µm and width was (10.1±0.26) µm.

(31) *Geum urbanum* L.

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Tetracytic, rare, with raised in appearance. The average length of stomatal complex was (67.4±2.93) µm and width was (60.6±1.51) µm. Shape of the epidermal cells were polygonal to tetragonal up to 6 lobes with curved in anticlinal wall pattern. Average epidermal cells elongation was (35.9±4.65) µm and width was (29.9±6.38) µm.

Abaxial surface:

Stomata were Tetracytic, abundant, with slightly sunken in appearance. The average length of stomatal complex was (72.1±5.19) µm and width was (68.4±11.4) µm. morphology of the epidermal cells were polygonal up to 7 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (42.4±6.43) µm and width was (24.0±2.86) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (631.4±1.16) µm and width was (26.5±1.59) µm. Glandular trichome were elongated capitate and slender acute. The average length of glandular trichome was (101.7±10.3) µm and width was (28.1±0.87) µm.

(32) *Geum elatum var. humile* (Royle) Franch.

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Stephanocytic, rare, with sunken in appearance. The average length of stomatal complex was (79.7±4.75) µm and width was (67.9±4.32) µm. Shape of the epidermal cells were polygonal to tetragonal up to 3 lobes with curved in anticlinal wall. Average epidermal cells elongation was (56.0±3.99) µm and width was (52.5±3.32) µm.

Abaxial surface:

Stomata were Tetracytic, common, with sunken in appearance. The average length of stomatal complex was (100.8±8.31) µm and width was (80.5±6.17) µm. Shape of the epidermal cells were wavy up to 8 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (63.8±4.06) µm and width was (32.4±1.16) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (234.8±43.2) µm and width was (10.8±0.51) µm. Glandular trichome were elongated capitate. The average length of glandular trichome was (54.3±25.6) µm and width was (14.1±1.17) µm.

(33) *Spiraea prunifolia* Siebold & Zucc.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were trigonal to tetragonal shape up to 5 lobes with curved in anticlinal wall. Average epidermal cells elongation was (26.9±3.06) µm and width was (22.4±2.84) µm.

Abaxial surface:

Stomata were Paracytic, abundant, with raised in appearance. The average length of stomatal complex was (35.2±5.86) µm and width was (41.1±1.50) µm. Shape of the epidermal cells were trigonal to tetragonal up to 5 lobes with curved in anticlinal wall. Average epidermal cells elongation was (15.7±0.88) µm and width was (22.8±0.94) µm.

Trichome:

Trichome were not observed on both adaxial and abaxial surface.

(34) *Spiraea canescens* D.Don

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were tetragonal in shape up to 3 lobes with curved in anticlinal wall. Average epidermal cells elongation was (24.3±1.25) µm and width was (16.1±1.72) µm.

Abaxial surface:

Stomata were Actinocytic, common, with sunken in appearance. The average elongation of stomatal complex was (56.7±1.59) µm and with width (44.5±0.87) µm. Shape of the epidermal cells were tetragonal up to 2 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (16.7±0.41) µm and width was (14.4±0.46) µm.

Trichome:

Trichome were not observed on both adaxial and abaxial surface.

(35) *Cotoneaster nummularius* Fisch. & C.A.Mey.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Epidermal cells were trigonal to tetragonal in shape up to 3 lobes with wavy in anticlinal wall. Average epidermal cells elongation was (24.8±3.73) µm and width was (32.5±2.42) µm.

Abaxial surface:

Stomata were Paracytic, abundant, with sunken in appearance. The average length of stomatal complex was (37.4±4.49) µm and width was (38.3±5.99) µm. morphology of the epidermal cells were irregular up to 3 lobes with wavy in anticlinal wall. Average epidermal cells elongation was (12.8±1.04) µm and width was (17.9±2.05) µm.

Trichome:

Non-glandular trichomes were cylindrical, common, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (484.8±39.0) µm and width was (18.7±1.63) µm.

(36) *Cotoneaster affinis* Lindl.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. morphology of epidermal cells was pentagonal up to 2 lobes as well as straight in anticlinal wall. Average epidermal cells elongation was (31.9±7.74) µm and width was (27.2±3.85) µm.

Abaxial surface:

Stomata were Actinocytic, common, with slightly sunken in appearance. The average length of stomatal complex was (49.2±4.89) µm and width was (41.8±3.80) µm. Shape of the epidermal cells were irregular up to 3 lobes with wavy anticlinal walls pattern. The average epidermal cells length was (24.2±3.88) µm and width was (10.5±0.90) µm.

Trichome:

Non-glandular trichomes were conical, rare, unicellular, uniseriate, and only present on coastal region. The average length of non-glandular trichome was (276.0±4.17) µm and width was (14.8±0.26) µm.

(37) *Crataegus songarica* K. Koch

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were pentagonal up to 4 lobes with undulate anticlinal walls pattern. The average epidermal cells length was (48.6±1.81) µm and width was (23.3±1.38) µm.

Abaxial surface:

Stomata were Paracytic, common, with very raised in appearance. The average length of stomatal complex was (89.3±3.56) µm and width was (91.4±5.87) µm. Shape of the epidermal cells were wavy up to 5 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (34.6±1.53) µm and width was (66.5±38.6) µm.

Trichome:

Non-glandular trichomes were conical, rare, unicellular, uniseriate, and only present in coastal region. The average length of non-glandular trichome was (464.0±49.8) µm and width was (30.2±1.14) µm.

(38) *Cydonia oblonga* Mill.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were wavy up to 5 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (37.8±4.30) µm and width was (17.8±1.97) µm.

Abaxial surface:

Stomata were Paracytic, abundant, with raised in appearance. The average length of stomatal complex was (40.5±3.06) µm and width was (32.8±2.03) µm. Shape of the epidermal cells were wavy up to 5 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (47.9±1.07) µm and width was (19.4±1.30) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (1176.4±82.1) µm and width was (19.4±1.78) µm.

(39) *Duchesnea indica* (Jacks.) Focke

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Paracytic, very rare, with slightly sunken in appearance. The average length of stomatal complex was (105.5±8.49) µm and width was (101.3±5.99) µm. morphology of epidermal cells were polygonal up to 7 lobes with undulate in anticlinal wall. Average epidermal cells was (63.1±5.18) µm and width was (37.8±3.11) µm.

Abaxial surface:

Stomata were Paracytic, abundant, with slightly raised in appearance. The average length of stomatal complex was (89.7±2.07) µm and width was (76.0±6.32) µm. Shape of the epidermal cells were wavy up to 8 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (89.1±3.38) µm and width was (43.2±5.13) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. Glandular trichome were capitate. The average elongation of non-glandular trichome was (968.4±1.32) µm and width was (19.2±0.41) µm. The average elongation of glandular trichome was (74.4±2.34) µm and width was (29.3±0.97) µm.

(40) *Eriobotrya japonica* (Thunb.) Lindl.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. morphology of the epidermal cells was mostly polygonal up to 4 lobes with curved in anticlinal wall. Average epidermal cells elongation was (25.9±3.09) µm and width was (20.3±2.48) µm.

Abaxial surface:

Stomata were Staurocytic, abundant, with slightly sunken in appearance. The average length of stomatal complex was (33.5±0.64) µm and width was (40.7±1.81) µm. Morphology of the epidermal cells were alomost polygonal up to 3 lobes with undulate in anticlinal wall. Average elongation of the epidermal cells was (19.8±2.15) µm and width was (17.2±2.31) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal position. The average length of non-glandular trichome was (776.1±1.66) µm and width was (22.0±1.96) µm.

(41) *Malus pumila* Mill.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were polygonal up to 3 lobes with curved anticlinal walls pattern. The average epidermal cells length was (18.6±0.32) µm and width was (9.95±0.21) µm.

Abaxial surface:

Stomata were Paracytic, abundant, with slightly raised in appearance. The average length of stomatal complex was (23.7±0.28) µm and width was (18.1±0.25) µm. Shape of the epidermal cells were wavy up to 5 lobes with sinuate in anticlinal wall. Average elongation of epidermal cells was (13.0±0.14) µm and width was (10.7±0.35) µm.

Trichome:

Non-glandular trichomes were cylindrical, rare, unicellular, uniseriate, and only present in coastal region. The average length of non-glandular trichome was (867.4±54.7) µm and width was (17.0±0.79) µm.

(42) *Sorbaria tomentosa* (Lindl.) Rehder

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were pentagonal up to 3 lobes with curved anticlinal walls pattern. The average epidermal cells length was (29.6±3.53) µm and width was (23.9±2.52) µm.

Abaxial surface:

Stomata were Anomocytic, abundant, with raised in appearance. The average elongation of stomatal complex was (41.8±1.45) µm and along with width (35.3±1.39) µm. Shape of the epidermal cells were pentagonal up to 3 lobes with curved anticlinal walls pattern. The average epidermal cells length was (15.5±1.82) µm and width was (10.1±0.89) µm.

Trichome:

Non-glandular trichomes were conical, very rare, unicellular, uniseriate, and only present on coastal region. The average length of non-glandular trichome was (594.4±1.06) µm and width was (11.3±1.12) µm.

(43) *Sibbaldia procumbens* L.

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Stephanocytic, common, with slightly sunken in appearance. The average length of stomatal complex was (51.6±10.2) µm and width was (55.3±1.92) µm. Morphology of the epidermal cells were polygonal up to 3 lobes with straight in anticlinal wall. Average elongation of epidermal cells was (29.2±3.23) µm and width was (22.4±1.32) µm.

Abaxial surface:

Stomata were Stephanocytic, common, with slightly raised in appearance. The average length of stomatal complex was (47.3±3.34) µm and width was (40.0±1.44) µm. Shape of the epidermal cells were wavy up to 4 lobes with undulate anticlinal wall pattern. Average length of the epidermal cells was (25.3±1.92) µm and width was (18.3±1.46) µm.

Trichome:

Non-glandular trichomes were broad conical, common, unicellular, uniseriate, coastal and intercoastal in position. The average length of non-glandular trichome was (1132.6±9.80) µm and width was (26.1±0.60) µm.

(44) *Sibbaldia cuneata* Hornem. ex Kuntze

(Leaves are Amphistomatic)

Adaxial surface:

Stomata were Staurocytic, rare, with sunken in appearance. The average length of stomatal complex was (62.6±3.04) µm and width was (52.6±3.22) µm. Morphology of the epidermal cells were mostly polygonal up to 2 lobes with curved in anticlinal wall. Average elongation of epidermal cells was (19.3±1.17) µm and width was (16.5±1.34) µm.

Abaxial surface:

Stomata were Stephanocytic, common, with sunken in appearance. The average length of stomatal complex was (62.0±3.17) µm and width was (53.6±3.08) µm. Shape of the epidermal cells were polygonal up to 3 lobes with undulate anticlinal walls pattern. The average epidermal cells length was (22.1±1.95) µm and width was (16.7±1.27) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. Glandular trichome were short capitate. The average length of non-glandular trichome was (829.0±1.23) µm and width was (35.2±4.28) µm. Glandular trichome was short capitate. The average length of glandular trichome was (40.3±0.23) µm and width was (13.2±0.01) µm.

(45) *Sanguisorba minor* Scop.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were wavy up to 4 lobes with undulate in anticlinal wall. Average elongation of the epidermal cells was (78.8±8.29) µm and width was (39.4±1.76) µm.

Abaxial surface:

Stomata were Paracytic, abundant, with raised in appearance. The average length of stomatal complex was (96.4±3.61) µm and width was (94.4±1.90) µm. Shape of the epidermal cells were wavy up to 7 lobes with sinuate in anticlinal wall. Average epidermal cells elongation was (45.2±5.11) µm and width was (28.8±4.19) µm.

Trichome:

Non-glandular trichomes were cylindrical, very rare, unicellular, uniseriate, and only present on coastal region. The average length of non-glandular trichome was (637.8±11.4) µm and width was (27.0±0.53) µm.

(46) *Filipendula ulmaria* (L.) Maxim.

(Leaves are hypostomatic)

Adaxial surface:

Stomata were not observed on adaxial surface. Shape of the epidermal cells were trigonal to pentagonal up to 3 lobes with wavy anticlinal walls pattern. The average epidermal cells length was (30.5±3.92) µm and width was (16.4±1.21) µm.

Abaxial surface:

Stomata were Stephanocytic, common, with slightly sunken in appearance. The average length of stomatal complex was (69.4±0.87) µm and width was (53.2±3.60) µm. Shape of the epidermal cells were hexagonal up to 3 lobes with undulate in anticlinal wall. Average elongation of the epidermal cells was (30.7±2.08) µm and width was (21.6±3.23) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal, intercoastal and marginal in position. The average length of non-glandular trichome was (1155.6±46.4) µm and width was (7.5±0.17) µm.

(47) *Acomastylis elata* (Wall. ex G.Don) F.Bolle

(Leaves are amphistomatic)

Adaxial surface:

Stomata were Stephanocytic, rare, with sunken in appearance. The average length of stomatal complex was (80.3±4.56) µm and width was (63.6±4.09) µm. Shape of the epidermal cells were polygonal up to 2 lobes with curved anticlinal walls pattern. The average epidermal cells length was (54.5±3.54) µm and width was (34.5±1.27) µm.

Abaxial surface:

Stomata were Stephanocytic, abundant, with slightly sunken in appearance. The average length of stomatal complex was (77.9±3.33) µm and width was (68.5±1.76) µm. morphology of the epidermal cells were polygonal up to 4 lobes with undulate in anticlinal wall. Average epidermal cells elongation was (52.6±3.63) µm and width was (34.4±1.35) µm.

Trichome:

Non-glandular trichomes were cylindrical, abundant, unicellular, uniseriate, coastal and intercoastal in position. Glandular trichome were elongated capitate. The average length of non-glandular trichome was (401.7±62.4) µm and width was (19.5±1.30) µm. Glandular trichome was elongated capitate. The average length of glandular trichome was (80.0±0.7) µm and width was (27.5±0.31) µm.

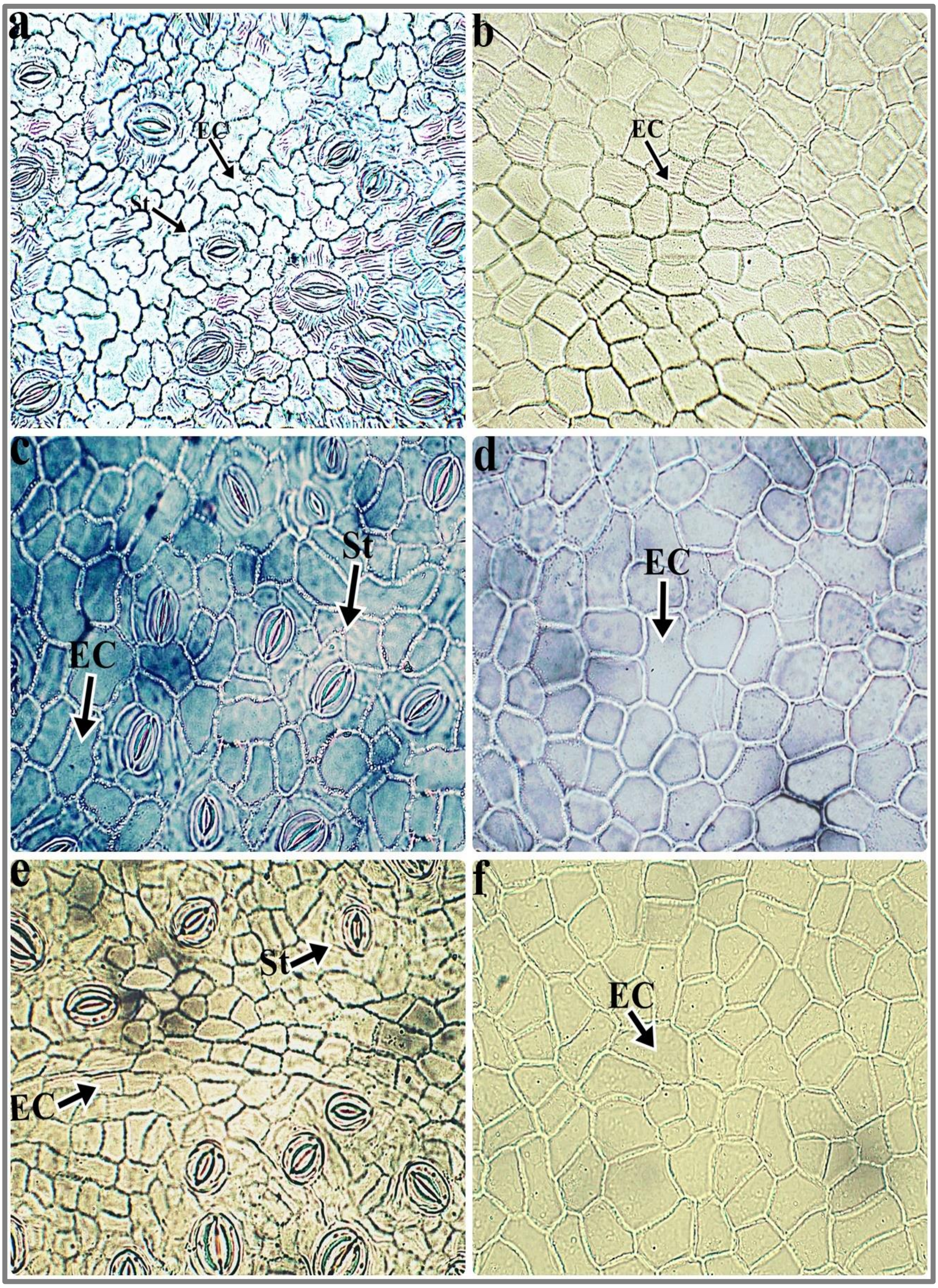


Plate 3.1: Foliar anatomical micrgraphs of (1) *Pyrus pashia*, a) abaxial surface, b) adaxial surface. (2) *Rosa indica,* c) abaxial surface, d) adaxial surface. (3) *Prunus persica,* e) abaxial surface, f) adaxial surface.

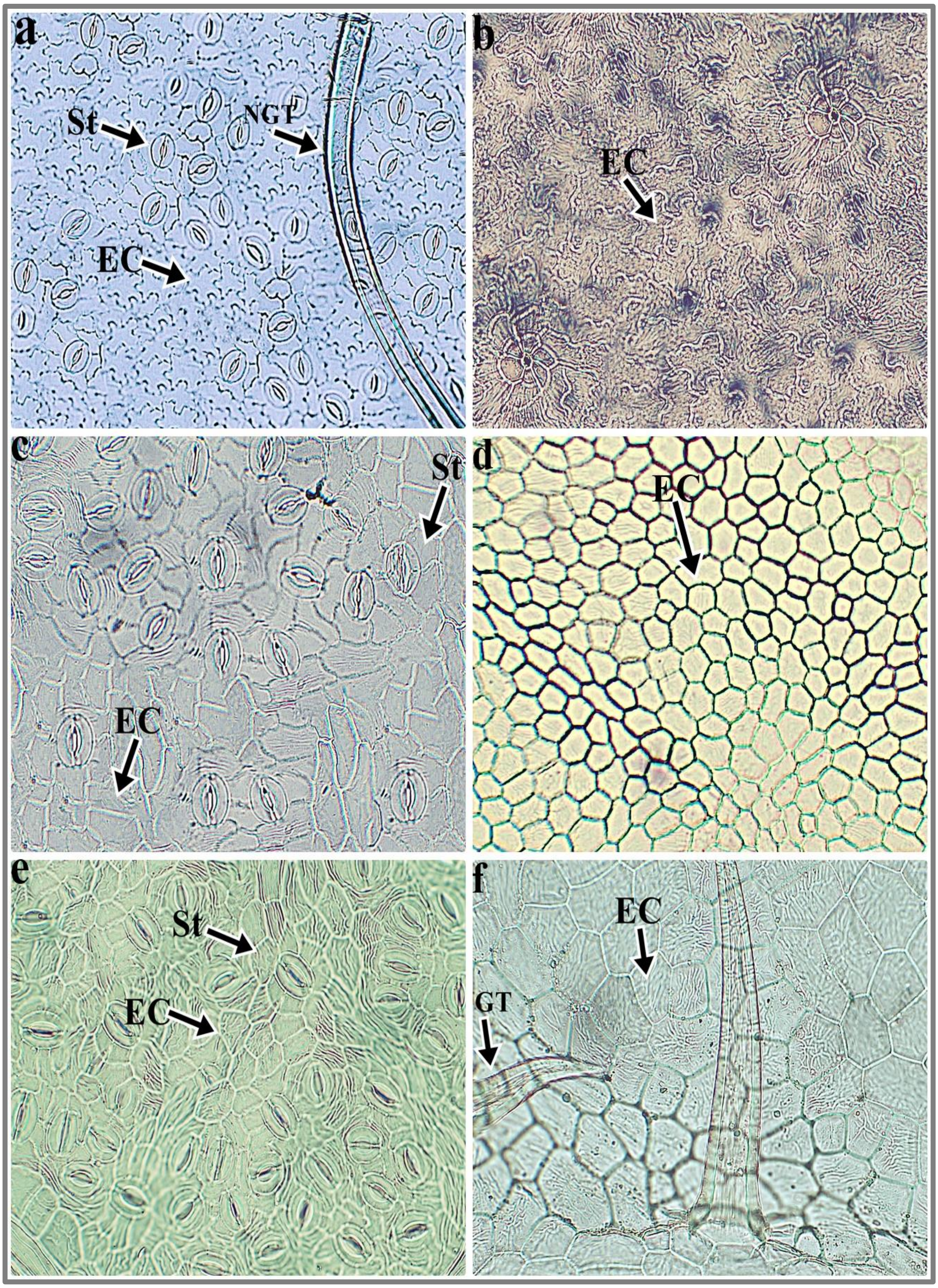


Plate 3.2: Foliar anatomical micrgraphs of (1) *Cydonia oblonga*, a) abaxial surface, b) adaxial surface. (2) *Prunus domestica*, c) abaxial surface, d) adaxial surface. (3) *Prunus armeniaca*, e) abaxial surface, f) adaxial surface.

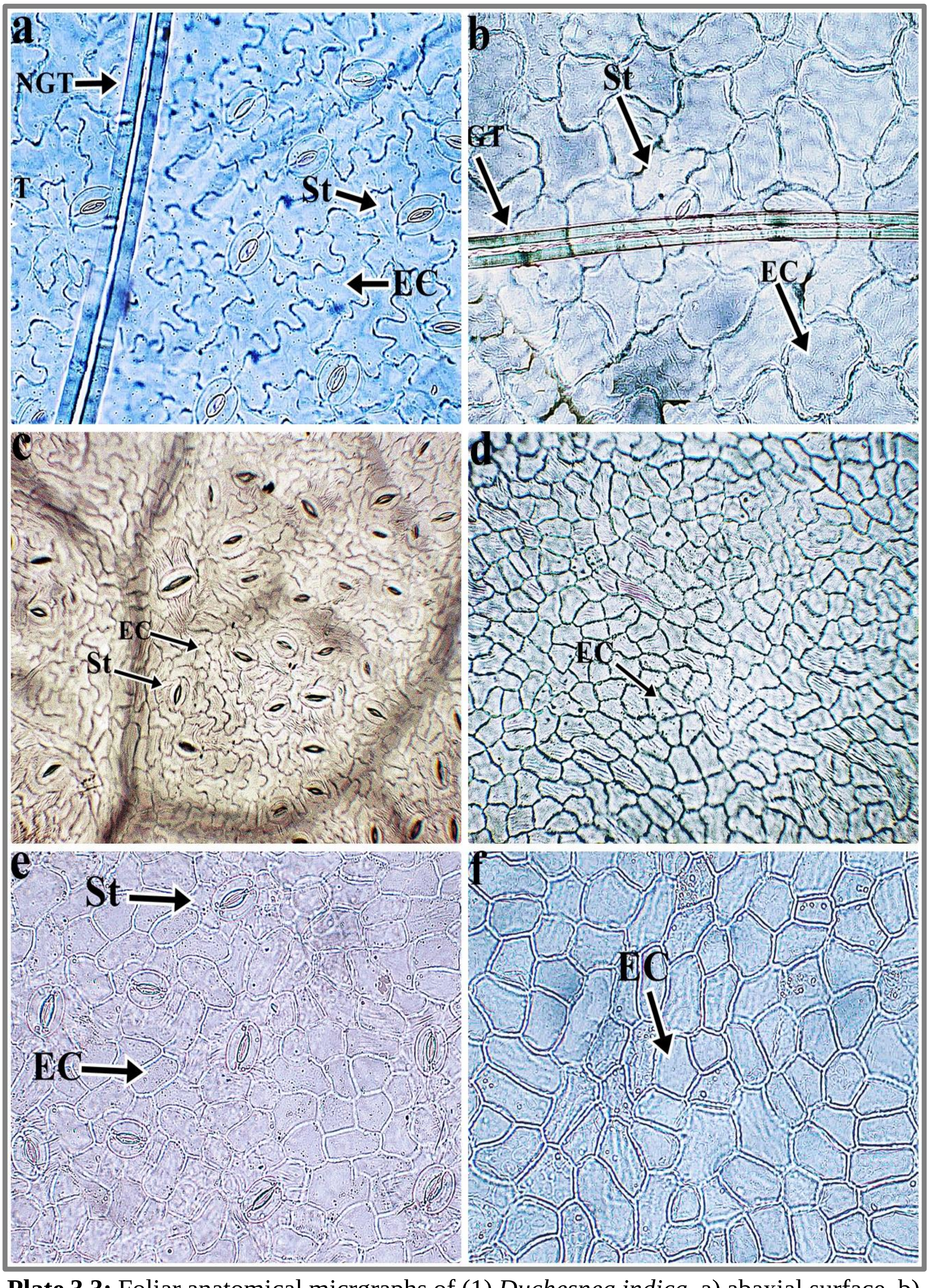


Plate 3.3: Foliar anatomical micrgraphs of (1) *Duchesnea indica*, a) abaxial surface, b) adaxial surface. (2) *Malus pumila,* c) abaxial surface, d) adaxial surface. (3) *Prunus dulcis,* e) abaxial surface, f) adaxial surface.

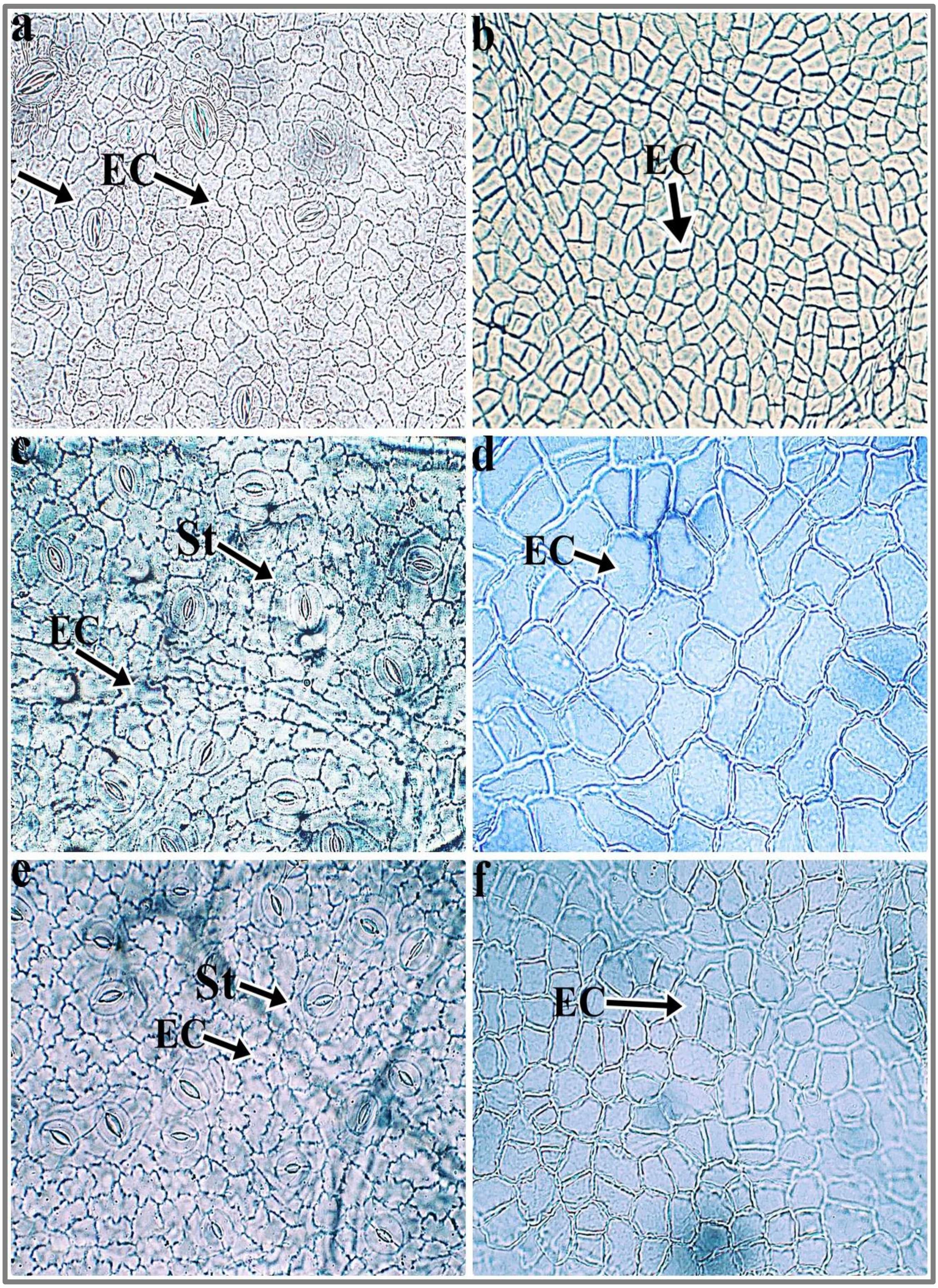


Plate 3.4: Foliar anatomical micrgraphs of (1) *Pyrus calleryana,* a) abaxial surface, b) adaxial surface. (2) *Rosa banksiae,* c) abaxial surface, d) adaxial surface. (3) *Rosa chinensis,* e) abaxial surface, f) adaxial surface.

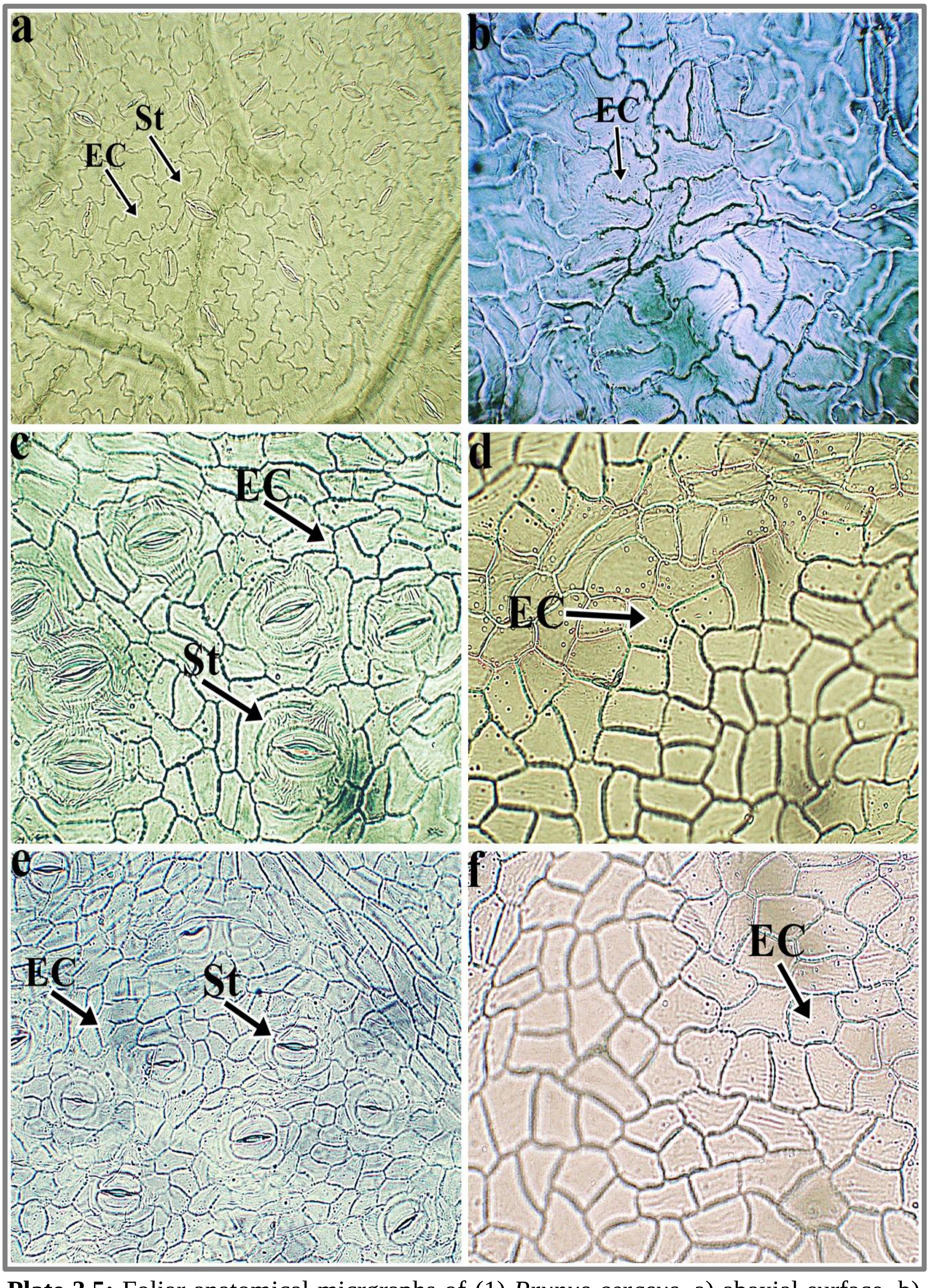


Plate 3.5: Foliar anatomical micrgraphs of (1) *Prunus cerasus*, a) abaxial surface, b) adaxial surface. (2) *Pyrus communis,* c) abaxial surface, d) adaxial surface. (3) *Pyrus bretschneideri,* e) abaxial surface, f) adaxial surface.

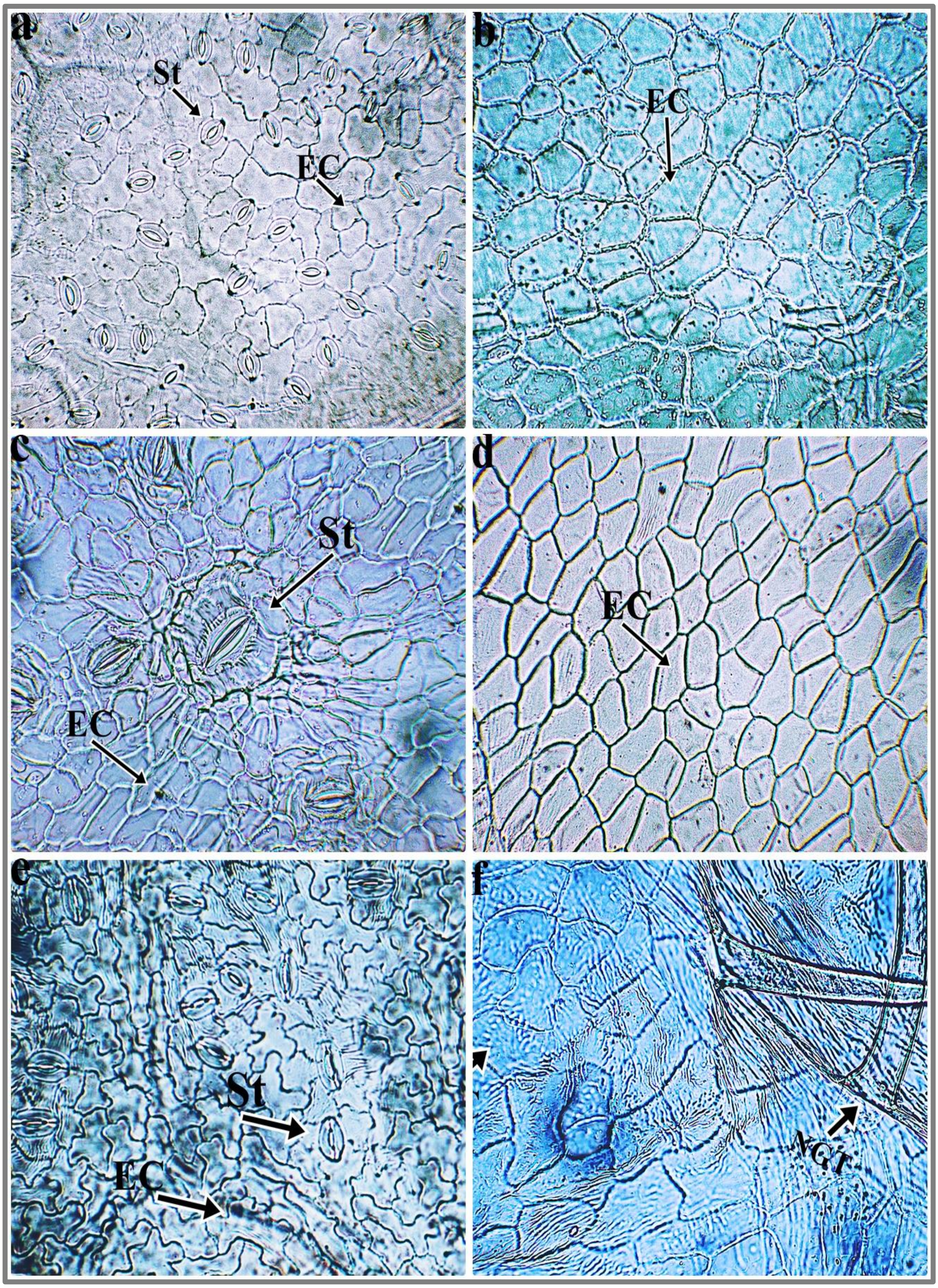


Plate 3.6: Foliar anatomical micrgraphs of (1) *Rubus macilentus*, a) abaxial surface, b) adaxial surface. (2) *Pyrus pyrifolia*, c) abaxial surface, d) adaxial surface. (3) *Prunus avium*, e) abaxial surface, f) adaxial surface.

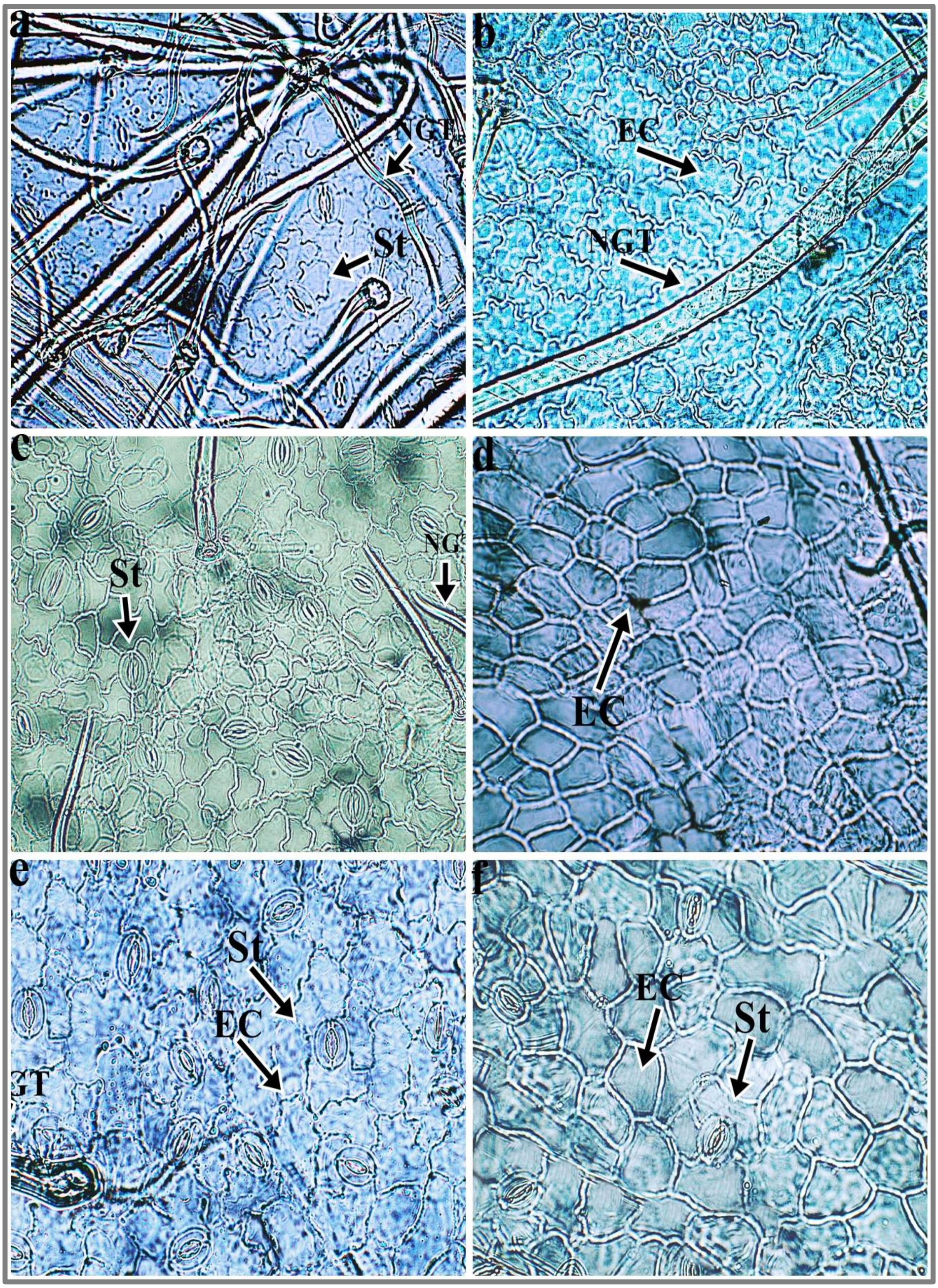


Plate 3.7: Foliar anatomical micrgraphs of (1) *Rubus vestitus*, a) abaxial surface, b) adaxial surface. (2) *Rosa × damascena*, c) abaxial surface, d) adaxial surface. (3) *Potentilla supina*, e) abaxial surface, f) adaxial surface.

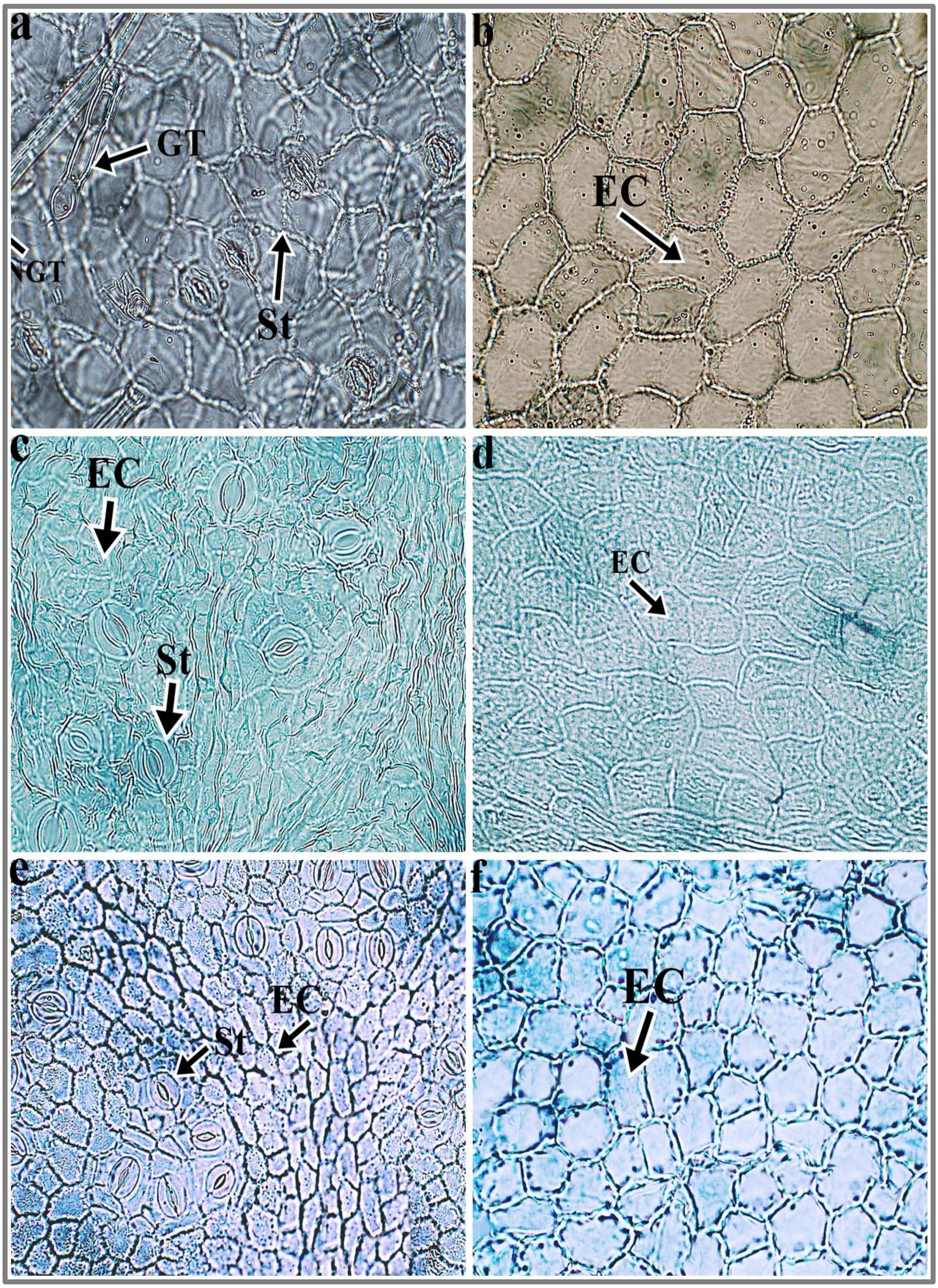


Plate 3.8: Foliar anatomical micrgraphs of (1) *Fragaria nubicola,* a) abaxial surface, b) adaxial surface. (2) *Cotoneaster nummularius,* c) abaxial surface, d) adaxial surface. (3) *Rosa laevigata,* e) abaxial surface, f) adaxial surface.

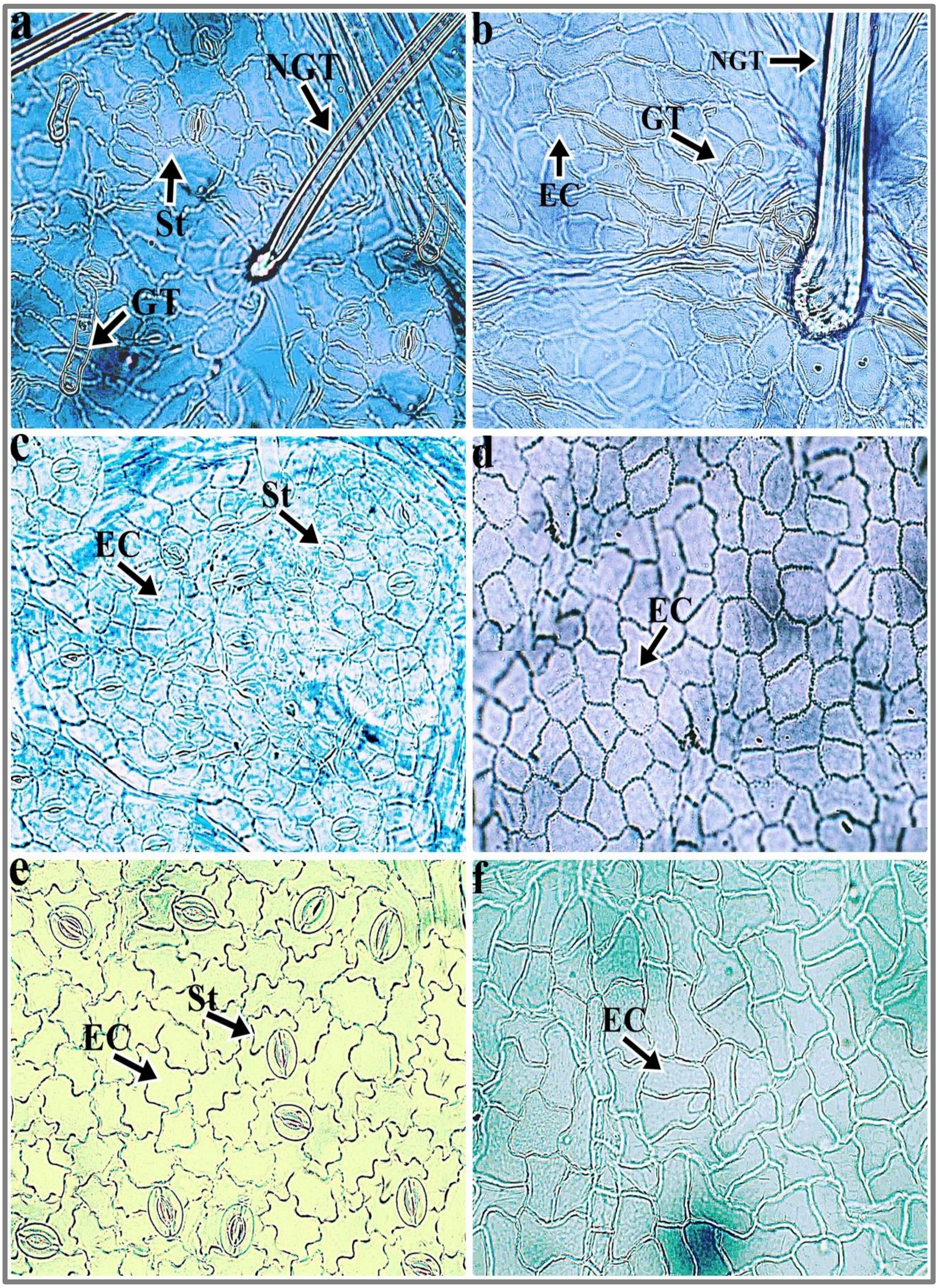


Plate 3.9: Foliar anatomical micrgraphs of (1) *Fragaria vesca,* a) abaxial surface, b) adaxial surface. (2) *Spiraea prunifolia,* c) abaxial surface, d) adaxial surface. (3) *Rosa brunonii,* e) abaxial surface, f) adaxial surface.

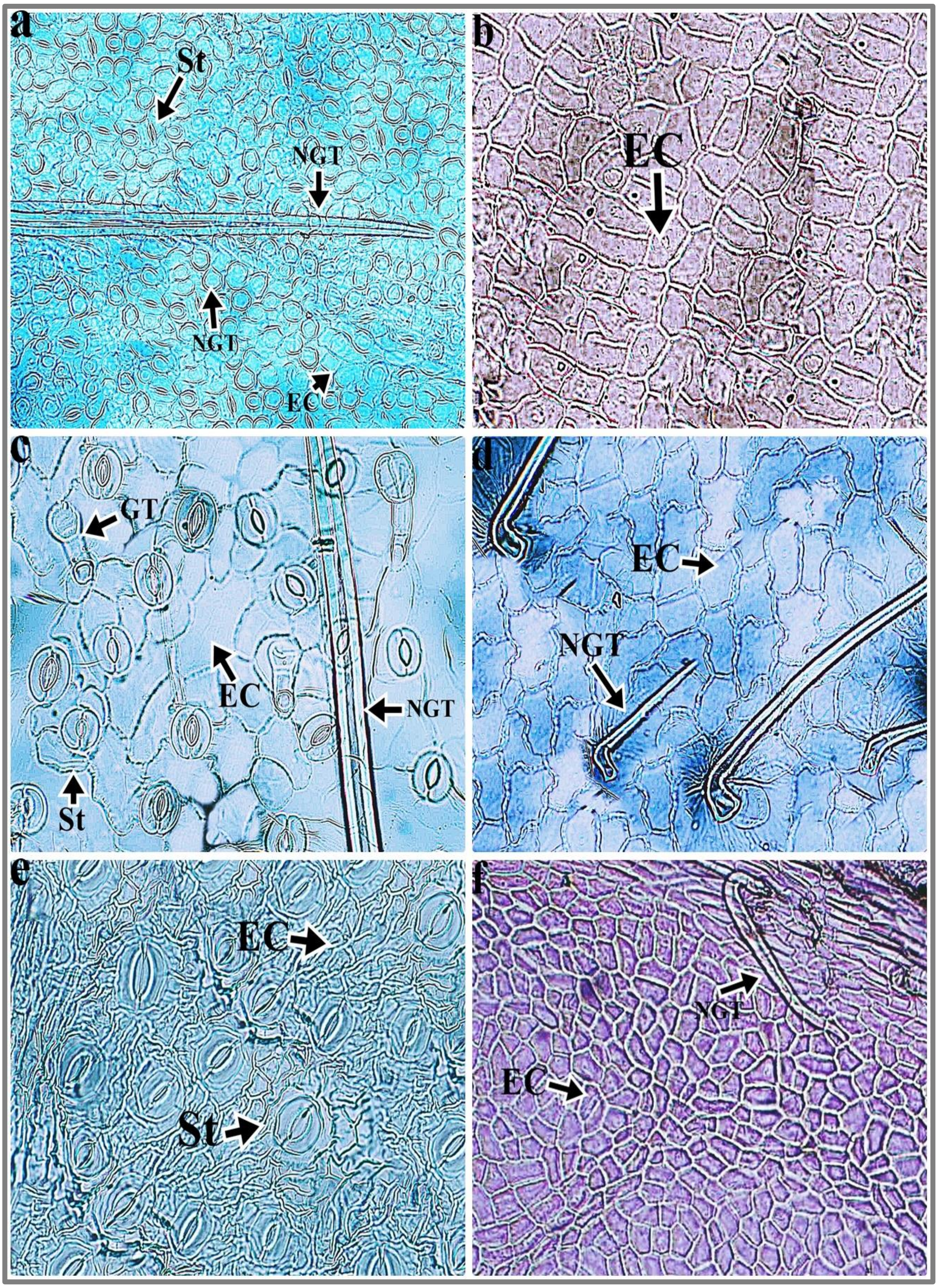


Plate 3.10: Foliar anatomical micrgraphs of (1) *Spiraea canescens,* a) abaxial surface, b) adaxial surface. (2) *Potentilla recta,* c) abaxial surface, d) adaxial surface. (3) *Cotoneaster affinis,* e) abaxial surface, f) adaxial surface.

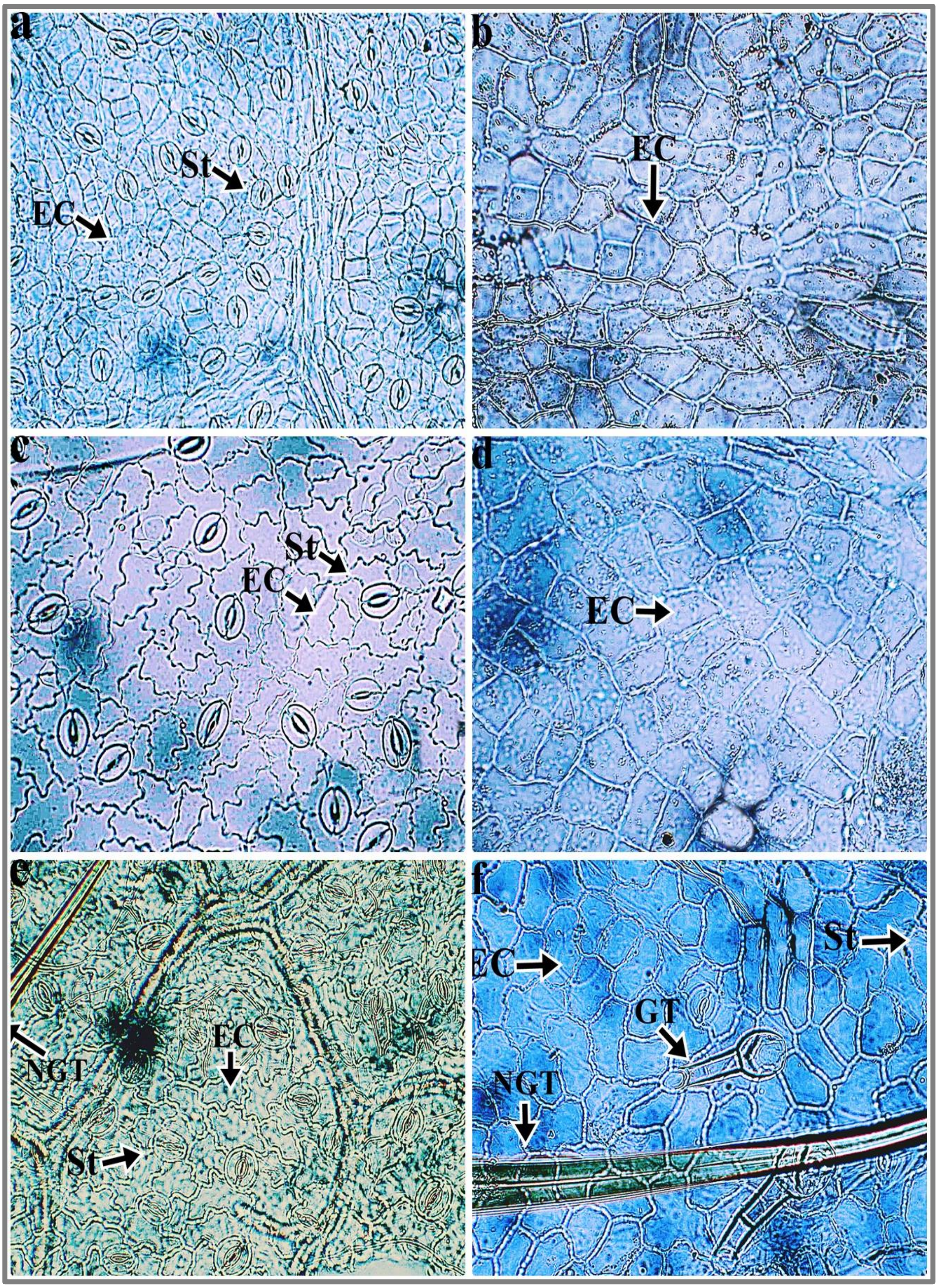


Plate 3.11: Foliar anatomical micrgraphs of (1) *Sorbaria tomentosa*, a) abaxial surface, b) adaxial surface. (2) *Rosa canina*, c) abaxial surface, d) adaxial surface. (3) *Geum urbanum,* e) abaxial surface, f) adaxial surface.

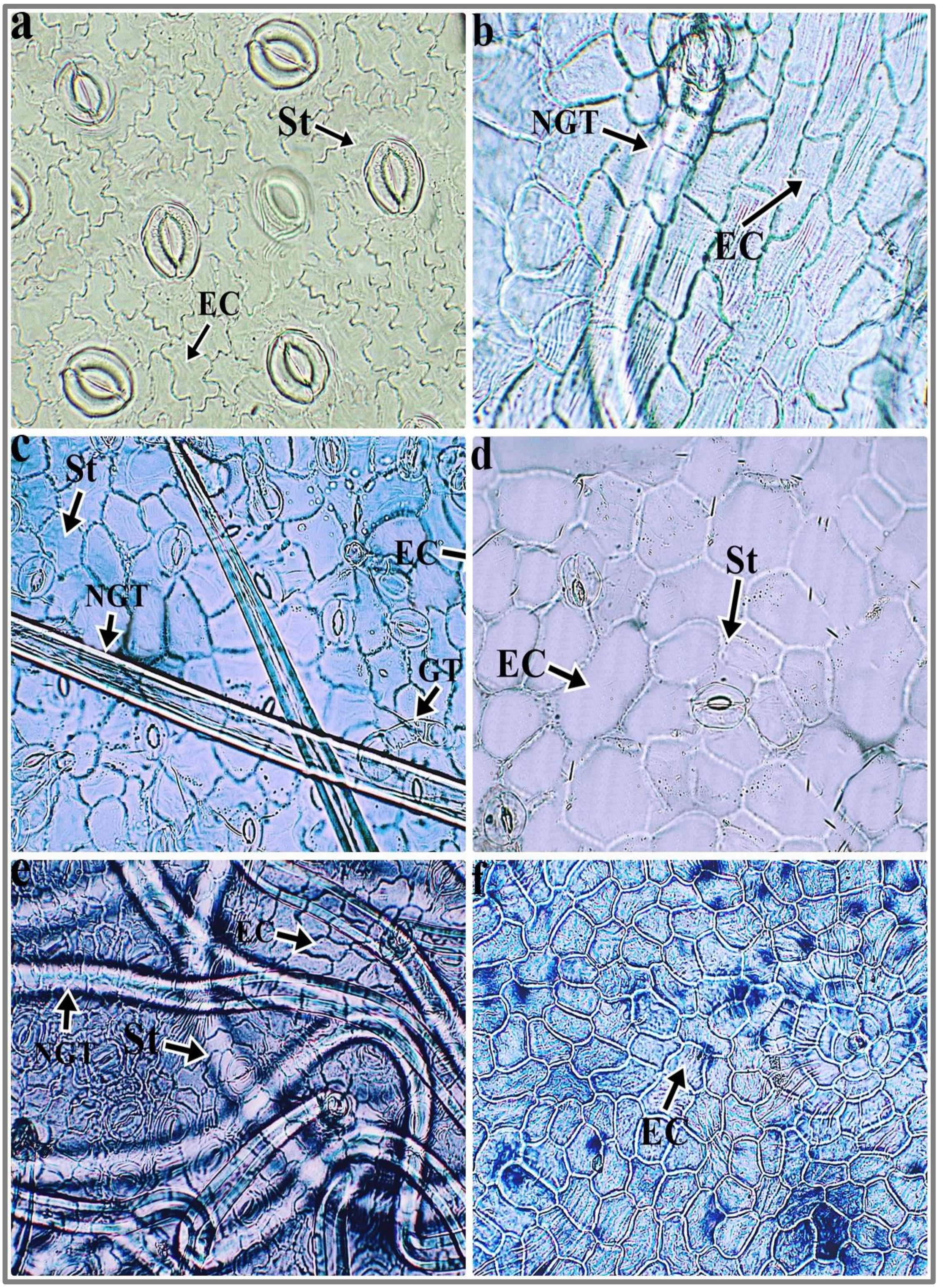


Plate 3.12: Foliar anatomical micrgraphs of (1) *Crataegus songarica,* a) abaxial surface, b) adaxial surface. (2) *Potentilla reptans,* c) abaxial surface, d) adaxial surface. (3) *Eriobotrya japonica,* e) abaxial surface, f) adaxial surface.

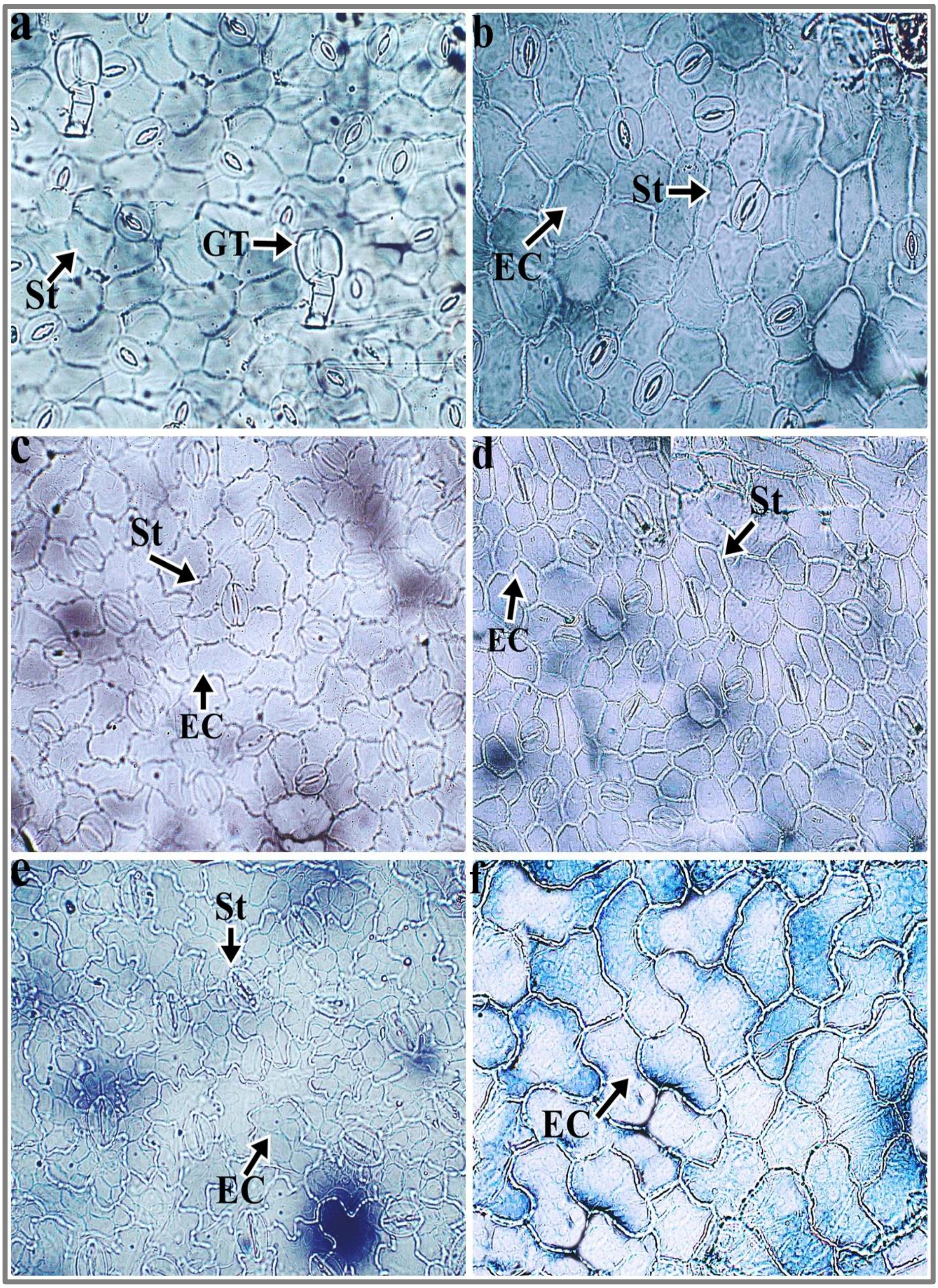


Plate 3.13: Foliar anatomical micrgraphs of (1) *Potentilla nepalensis,* a) abaxial surface, b) adaxial surface. (2) *Sibbaldia procumbens,* c) abaxial surface, d) adaxial surface. (3) *Sanguisorba minor,* e) abaxial surface, f) adaxial surface.

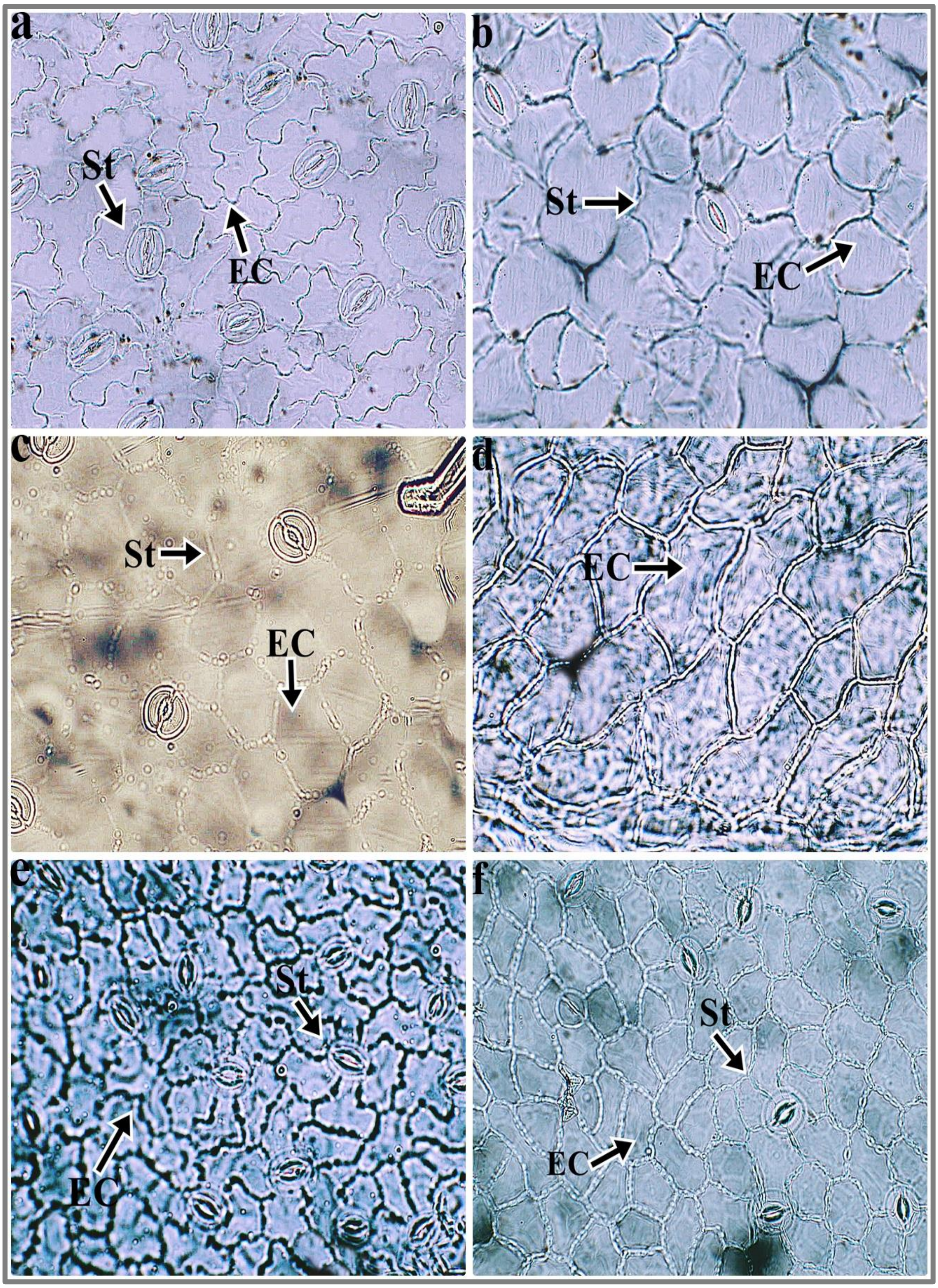


Plate 3.14: Foliar anatomical micrgraphs of (1) *Geum elatum*, a) abaxial surface, b) adaxial surface. (2) *Potentilla atrosanguinea*, c) abaxial surface, d) adaxial surface. (3) *Potentilla crantzii*, e) abaxial surface, f) adaxial surface.

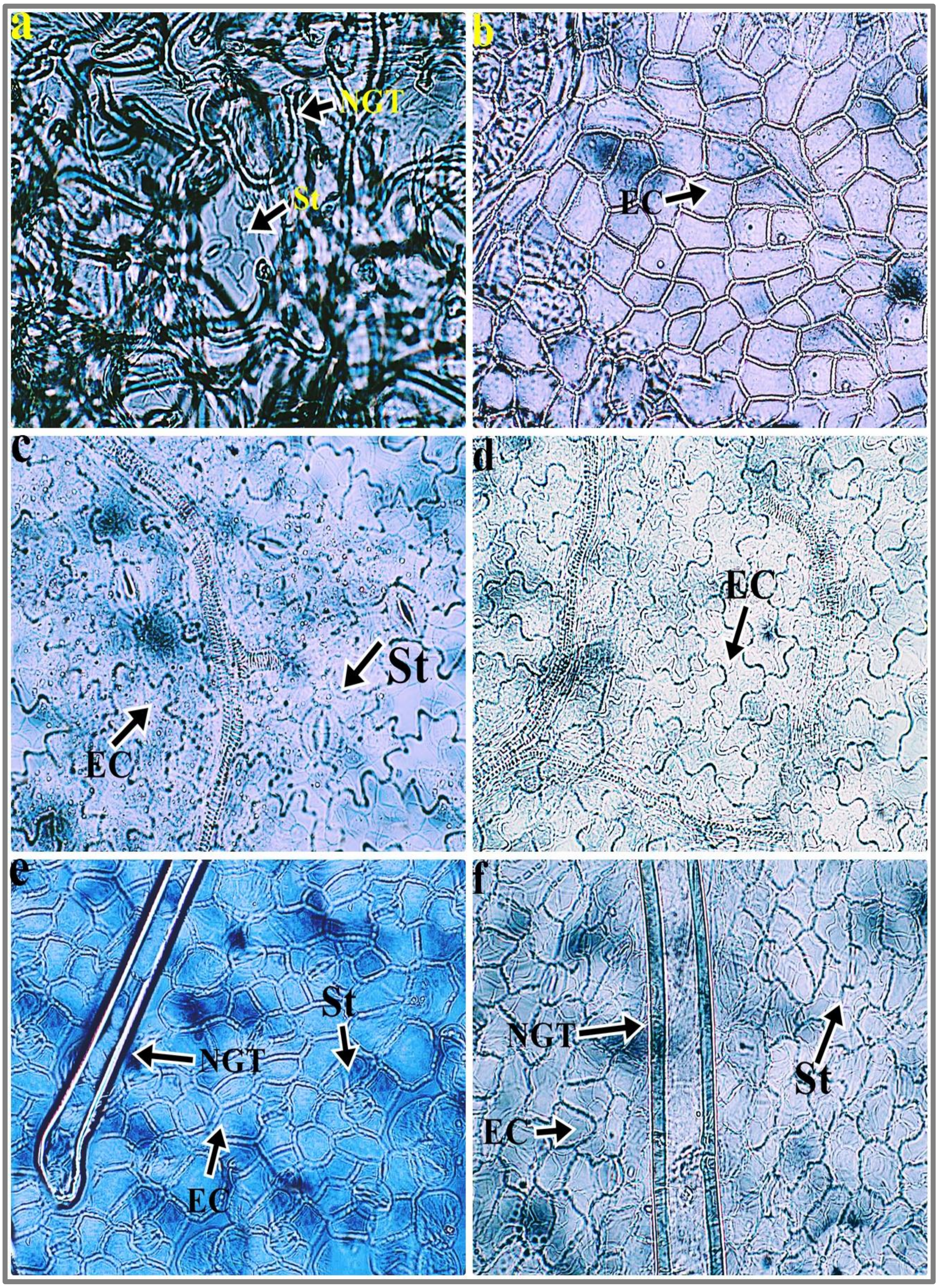


Plate 3.15: Foliar anatomical micrgraphs of (1) *Filipendula ulmaria,* a) abaxial surface, b) adaxial surface. (2) *Rosa pendulina,* c) abaxial surface, d) adaxial surface. (3) *Sibbaldia cuneata,* e) abaxial surface, f) adaxial surface.

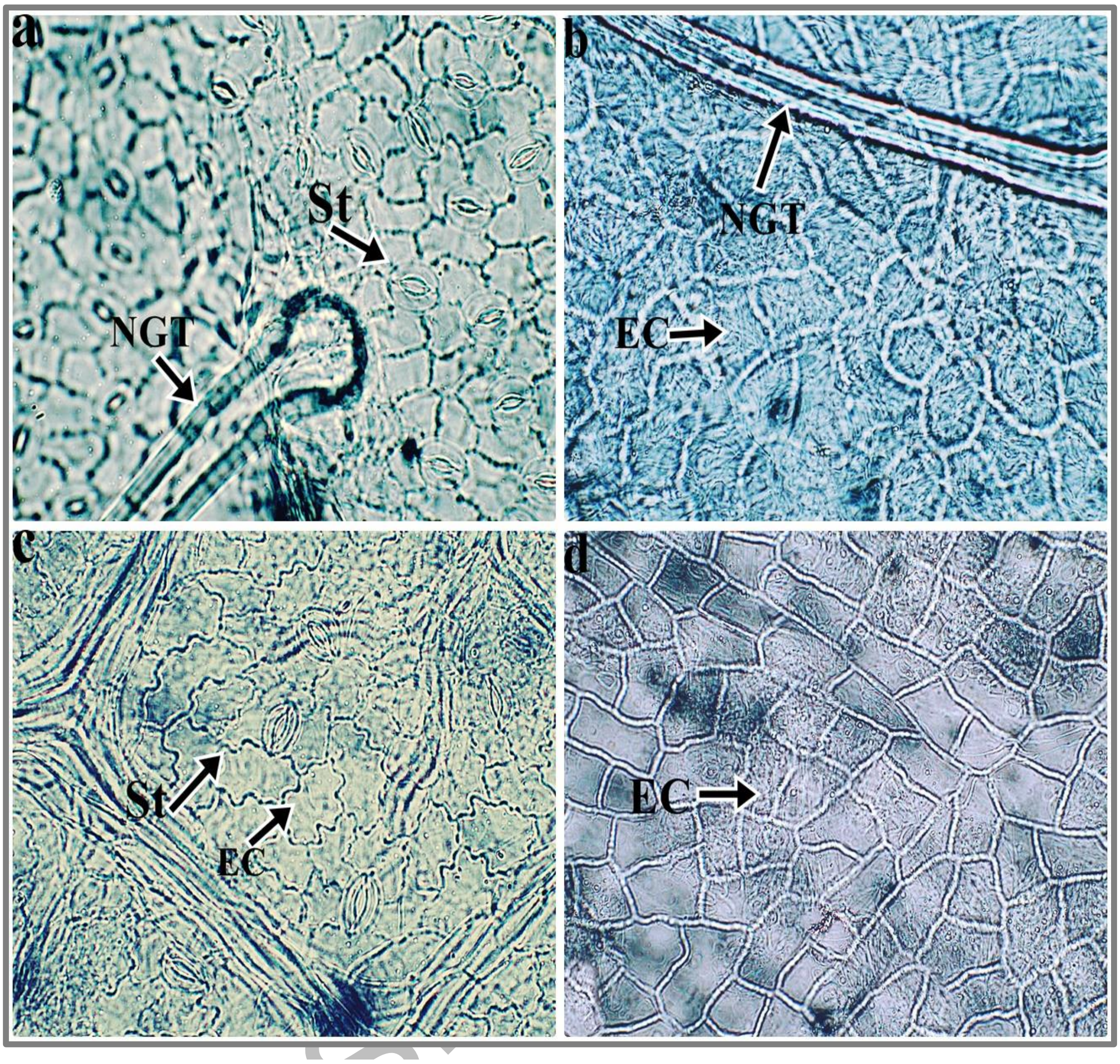


Plate 3.16: Foliar anatomical micrgraphs of (1) *Acomastylis elata*, a) abaxial surface, b) adaxial surface. (2) *Rosa webbiana*, c) abaxial surface, d) adaxial surface.

3.2 FOLIAR ANATOMICAL FINDINGS

47 species of the Rose family's foliar epidermal anatomy were investigated using a light microscope. In the current study our findings were to observe variation in foliar epidermal micro-morphology. The micro-morphological characteristics of the foliar epidermis displayed remarkable variety in both the qualitative and quantitative dimensions as shown in (Table 3.2-3.6). Utilizing the qualitative traits of these taxa, taxonomic dichotomous keys have been built for rapid species recognition and demarcation as shown in (plate 1-16) illustrated light micrographs of the taxa were created.

3.2.1 Foliar epidermal micro-morphology

The leaf epidermal anatomical features of the Rose family showed a great degree of variation on both the adaxial and abaxial surfaces, as shown in the current study in (plate 1-16). The different shapes of epidermal cells (trigonal, tetragonal, pentagonal, hexagonal, polygonal, irregular, and wavy) have been found in the current investigation of Rosaceous leaf micro-morphology as shown in (Table 3.2). Additionally, variations in Rosaceous epidermal cells anticlinal wall pattern on both abaxial and adaxial surface were also observed, which include (undulate, straight, curved, wavy, sinuate, deeply undulate, roughly straight, slightly curved, roughly undulate, smoothly curved, slightly straight). The epidermal cells' number of lobes, which ranges from 4 to 9, varies on both surfaces. *Prunus persica* has the least number of lobes, followed by *Prunus domestica*, *Prunus armeniaca*, *Potentilla reptans*, *Rosa damascene*, *Rosa laevigata*, *Rosa canina*, *Rosa webbiana*, *Spiraea canescens*, *Cotoneaster affinis*, *Sibbaldia cuneata*, and *Acomastylis elata*, which has two (2) lobes per cell, whereas extreme number of lobes were seen in *Prunus cerasus and Rosa pendulina* has 9 lobes per cell. The major epidermal cells on abaxial side were observed in *Duchesnea indica* (89.1±3.38 µm) and width is (43.2±5.13 µm), while smallest epidermal cell on abaxial surface was observed in *Pyrus bretschneideri* (11.0±0.72 µm) and width is (19.5±2.48 µm) as shown in Figure 3.1**.** Similarly maximum length of the epidermal cell on adaxial surface was observed in *Sanguisorba minor* (78.8±8.29 µm) and its width is (39.4±1.76 µm), while minimum length of the epidermal cell on adaxial surface was observed in *Pyrus calleryana* (16.1±0.80 µm) and its width is (16.9±0.57 µm) as illustrated in Figure 3.2**.**

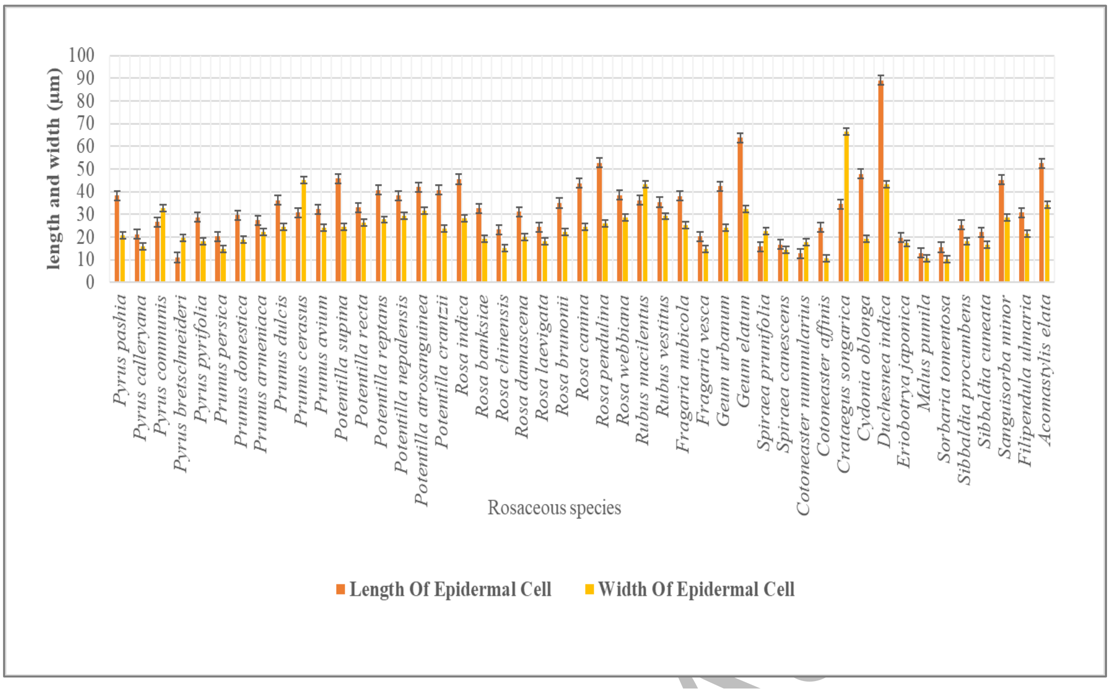


Fig 3.1: Graphical representation shows length and width of Epidermal cells on abaxial surface**.**

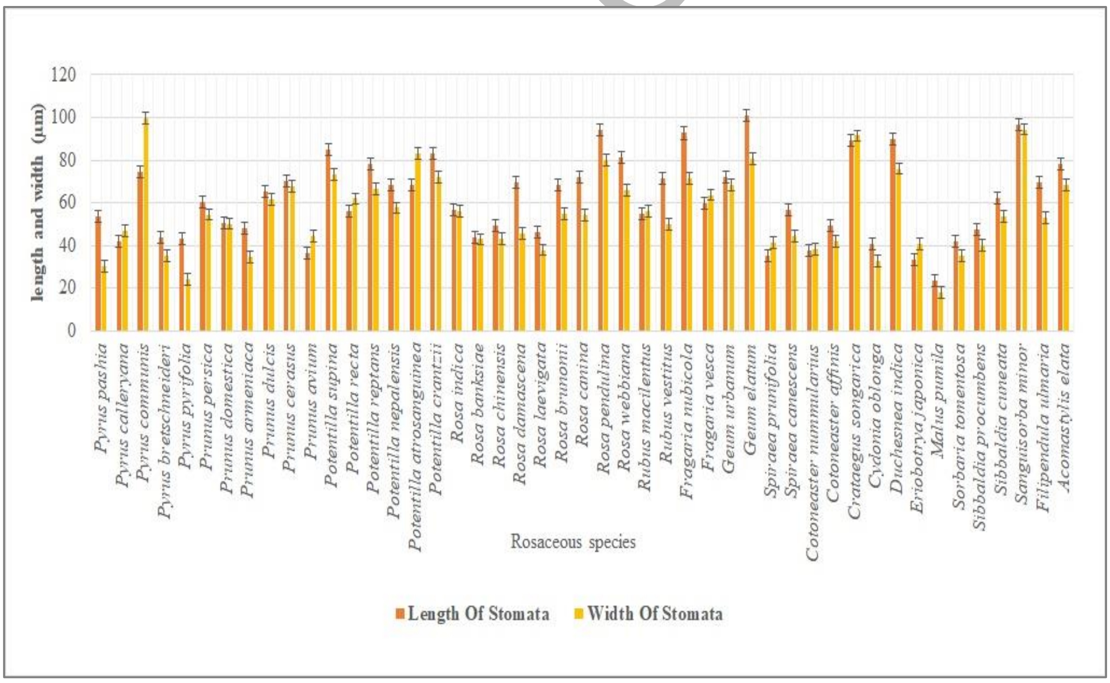


Fig 3.2: Graphical representation of length and width of epidermal cell on adaxial surface**.**

3.2.2 Micro-morphology of stomatal complex

In the present finding on abaxial surface of all 47 Rosaceous taxa stomatal complex were observed with a numerous variation, 15 species have Stephanocytic type of stomata, 14 species have Paracytic stomata, 10 species have Laterocytic stomata, 6 species have Anomocytic stomata, 5 have species have Tetracytic stomata, 4 species have Actinocytic stomata while only 3 species have Staurocytic type of stomata. Similarly, on adaxial surface only 11 species out of 47 stomatal complexes were observed that include (*Potentilla supina, Potentilla recta, Potentilla reptans, Potentilla nepalensis, Potentilla crantzii, Geum urbanum, Geum elatum, Duchesnea indica, Sibbaldia procumbens, Sibbaldia cuneata* and *Acomastylis elata).*

Different lengthwise quantitative stomatal complex variation has been observed in all studied Rosaceous taxa. Maximum lengthwise stomatal complex on adaxial surface was seen in *Duchesnea indica* (105.5±8.49 µm) and its width is (101.3±5.99 µm), while minimum lengthwise stomatal complex on adaxial surface was noted in *Sibbaldia procumbens* (51.6±10.2 µm) and width is (55.3±1.92 µm) as shown in Figure 3.3. Similarly maximum lengthwise stomatal complex on abaxial surface was observed in *Geum elatum* (100.8±8.31 µm) and its width is (80.5±6.17 µm), while minimum lengthwise stomatal complex on abaxial surface was noted in *Malus pumila* (23.7±0.28 µm) and its width is (18.1±0.25 µm) as examined in Figure 3.4**.** Significant quantitative variations in Subsidiary cells were also observed in all Rosaceous studied taxa. Maximum lengthwise subsidiary cell on abaxial surface was noted in *Duchesnea indica* (66.1±9.63 µm), while minimum length wise subsidiary cell on abaxial surface was observed in *Pyrus bretschneideri* (10.2±0.69 µm) as described in Figure 3.5. Similarly maximum lengthwise subsidiary cell on adaxial surface was noted in *Geum elatum* (53.0±5.71 µm), while minimum lengthwise subsidiary cell on adaxial surface was seen in *Acomastylis elata* 24.8±2.29 µm) as illustrated in Figure 3.6**.**

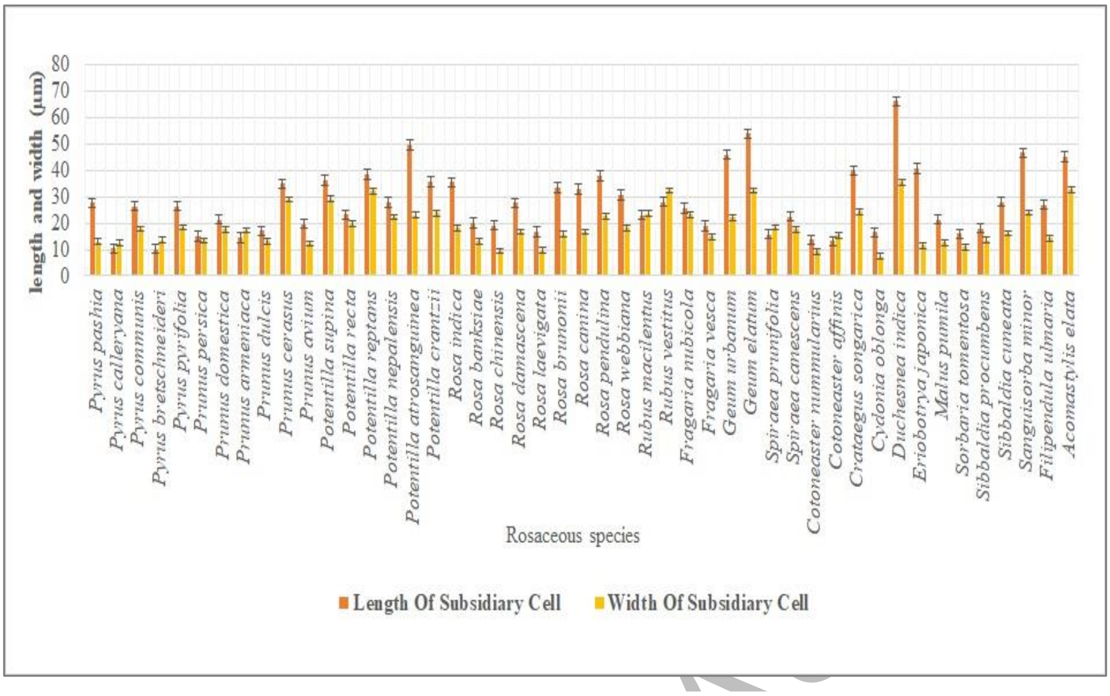


Fig 3.3: Graphical representation of length and width of Stomatal complex on adaxial surface**.**

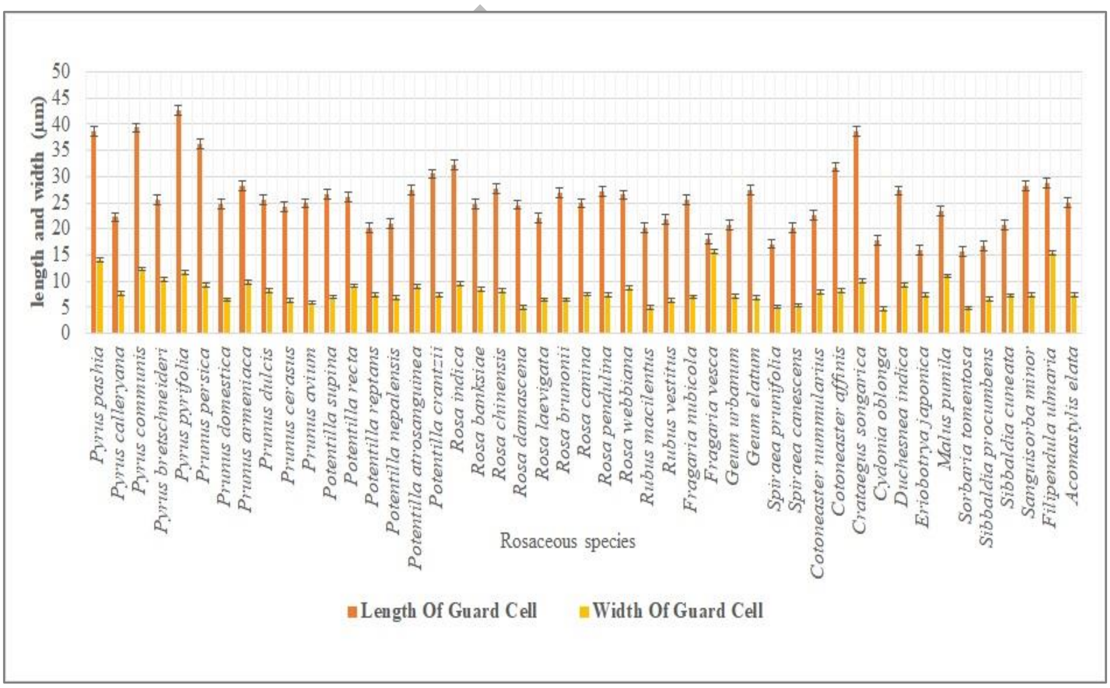


Fig 3.4: Graphical representation of length and width of Stomatal complex on abaxial surface**.**

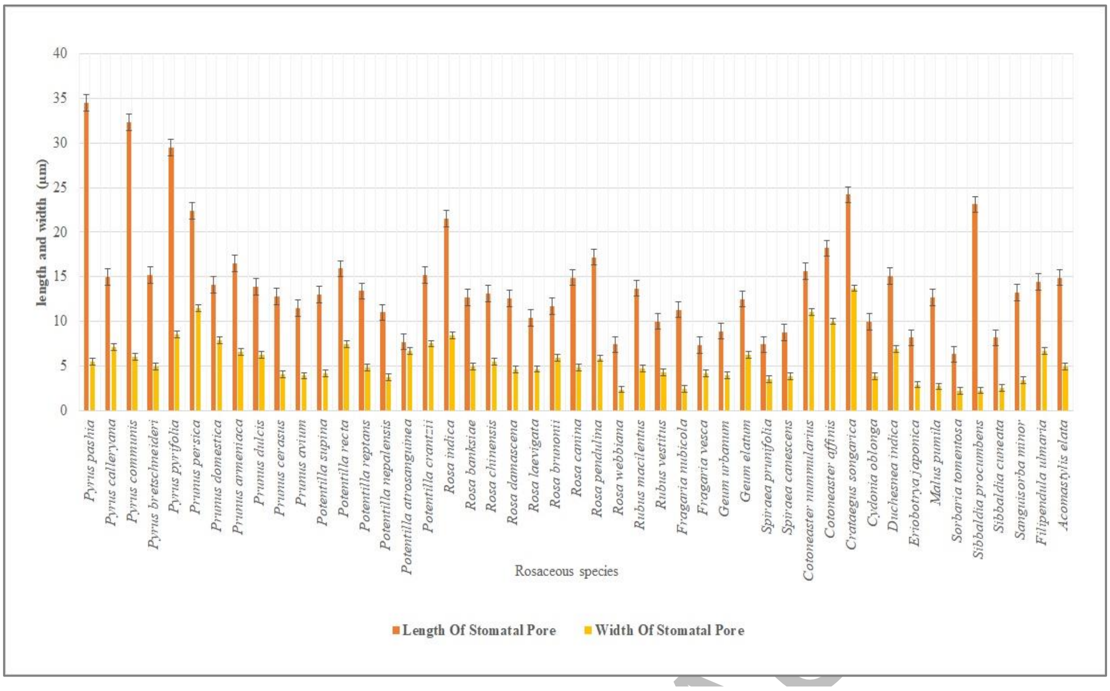


Fig 3.5: Graphical representation of length and width of Subsidiary cells on abaxial surface**.**

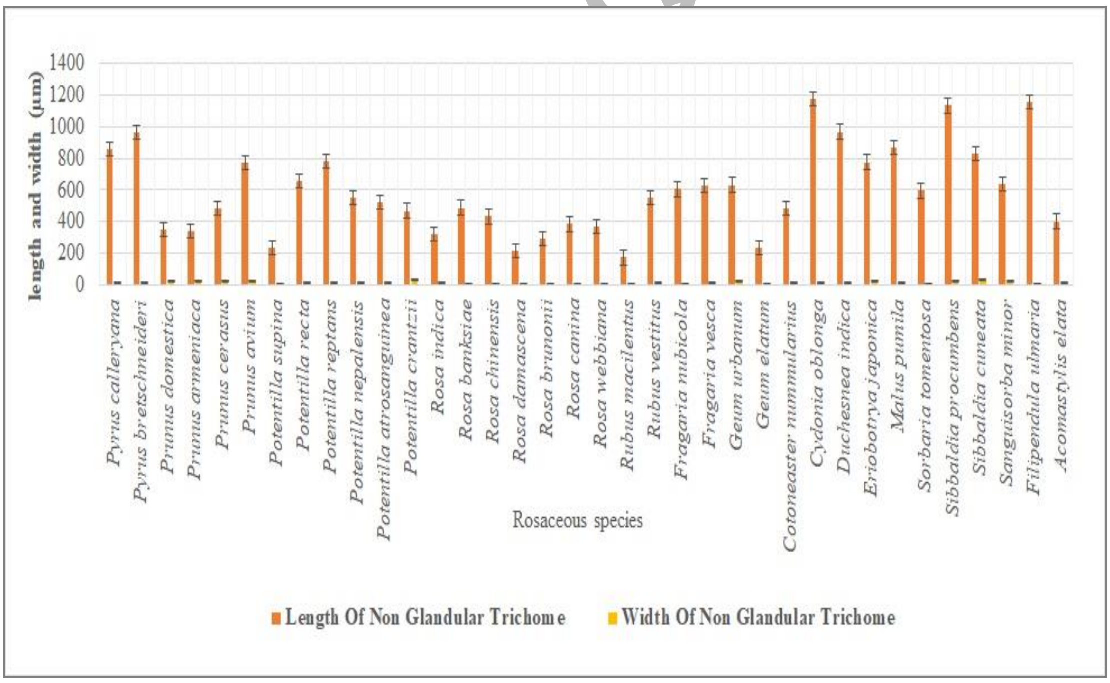


Fig 3.6: Graphical representation of length and width of Subsidiary cells on adaxial surface**.**

Quantitatively significant variation in Guard cells were also observed in all Rosaceous taxa. Maximum lengthwise guard cell on abaxial surface was noted in *Pyrus pyrifolia* (42.6±0.72 µm), while minimum lengthwise guard cell on abaxial surface was observed in *Sorbaria tomentosa* (15.6±0.45 µm) as examined in Figure 3.7. Similarly maximum lengthwise guard cell on adaxial surface was noted in *Geum elatum* (31.0±0.68 µm), while minimum lengthwise guard cell on adaxial surface was noted in *Geum urbanum* (20.1±0.23 µm) as mentioned in Figure 3.8. Significant variation in quantitative data in stomatal pore were also found in rosaceous taxa. Maximum lengthwise stomatal pore on abaxial surface was found in *Pyrus pashia* (34.5±2.10 µm), while minimum lengthwise stomatal pore on abaxial surface was noted in *Sorbaria tomentosa* (6.30±0.61 µm) as shown in Figure 3.9. Similarly maximum lengthwise stomatal pore on adaxial surface was found in *Potentilla supina* (16.0±1.15 µm), while minimum lengthwise stomatal pore on adaxial surface was found in *Sibbaldia procumbens* (7.60±1.52 µm) as examined in Figure 3.10. Maximum widthwise stomatal pore on abaxial surface was found in *Crataegus songarica* (13.7±1.22 µm), while minimum is found on the same surface in *Sorbaria tomentosa* (2.20±0.34 µm) as examined in Figure 3.9. Similarly, on adaxial surface largest stomatal pore width was found in *Potentilla crantzii* (7.35±0.23 µm), while minimum is found in *Sibbaldia cuneata* (2.15±0.23 µm) as examined in Figure 3.10

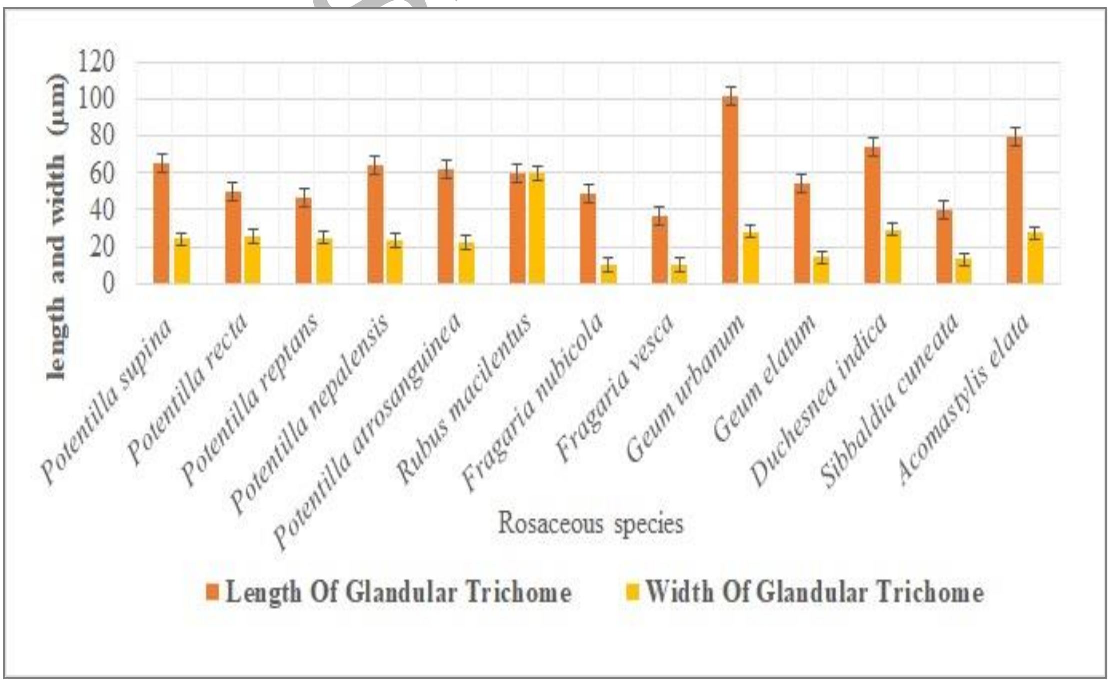


Fig 3.7: Graphical representation of length and width of Guard cells on abaxial surface**.**

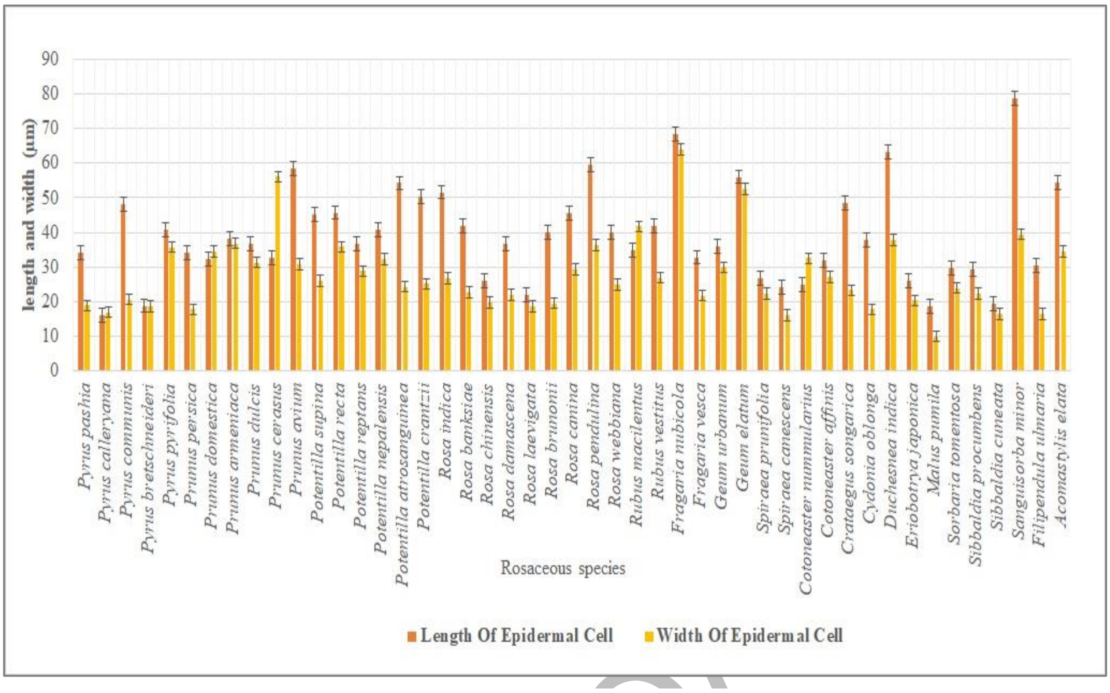


Fig 3.8: Graphical representation of length and width of Guard cells on adaxial surface.

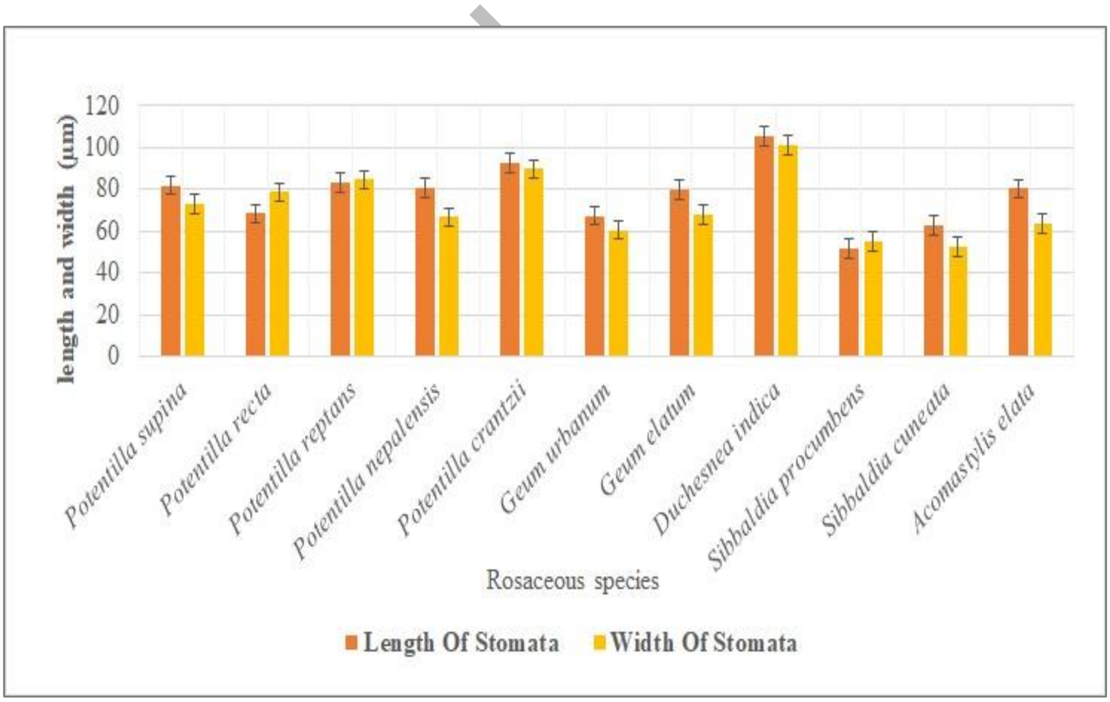


Fig 3.9: Graphical representation of length and width of Stomatal pore on abaxial surface.

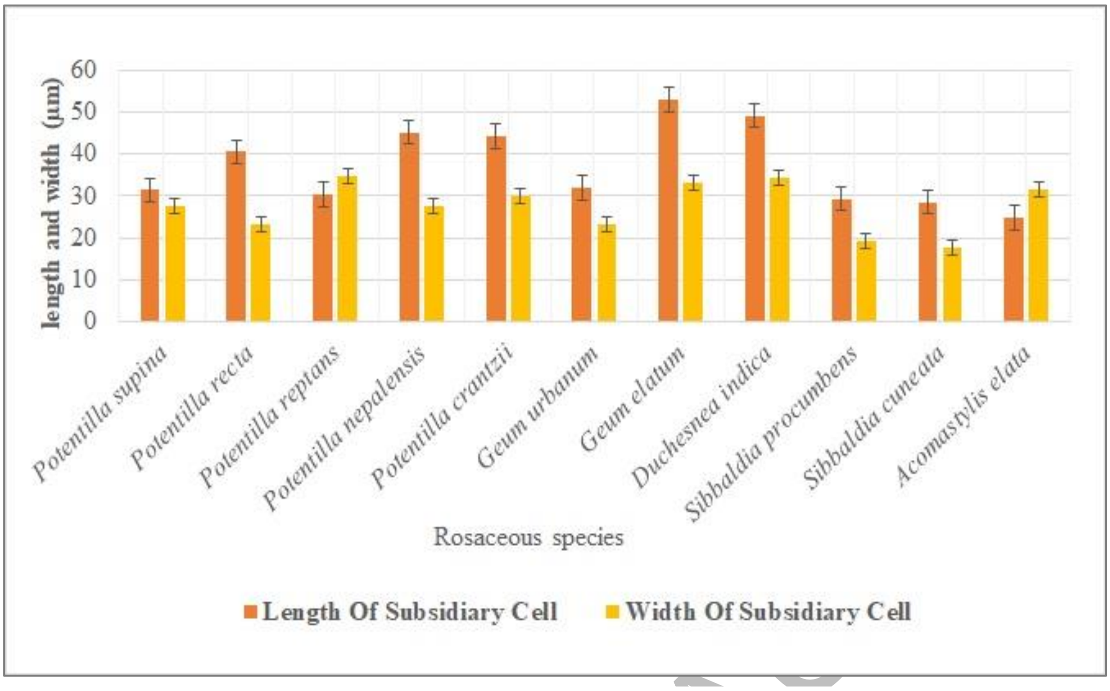


Fig 3.10: Graphical representation of length and width of Stomatal pore on adaxial surface**.**

Both the abaxial and adaxial surfaces of the epidermis have been used to calculate the stomatal index for each species. Maximum stomatal index on adaxial surface has been calculated in *Geum urbanum* 47.6 %, while minimum has been calculated in *Sibbaldia cuneata* 2.09 % as. Similarly maximum stomatal index on abaxial surface has been calculated in *Potentilla nepalensis* 55.3 %, while minimum is calculated in *Pyrus communis* 5.51 % as examined in Table 3.4.

3.2.3 Morphology of non-glandular trichomes

Current study revealed that 36 out of 47 Rosaceous taxa have been observed having non-glandular trichome (cylindrical, conical, and stellate) while remaining 11 species lack trichome. A significant variation has been observed in the quantitative data of non-glandular trichome in Rosaceous taxa. Maximum lengthwise non-glandular trichome on abaxial surface was observed in *Cydonia oblonga* (1176.4±82.1 µm), while minimum non-glandular trichome was observed in *Rubus macilentus* (172.0±5.52 µm) as examined in Figure 3.11. Similarly maximum lengthwise non-glandular trichome on adaxial surface was found in *Cydonia oblonga* (1131.5±11.4 µm), while minimum length was noted in *Prunus avium* (132.7±25.5 µm) as shown in Figure 3.12**.**

Maximum width in non-glandular trichome on abaxial surface was found in *Sibbaldia cuneata* (35.2±4.28 µm), while minimum was found in *Filipendula ulmaria* (7.5±0.17 µm) as illustrated in Figure 3.11. Similarly maximum width in non-glandular trichome on adaxial surface was found in *Potentilla crantzii* (34.4±2.45 µm), while minimum was found in *Potentilla atrosanguinea* (8.85±0.30 µm) as described in Figure 3.12

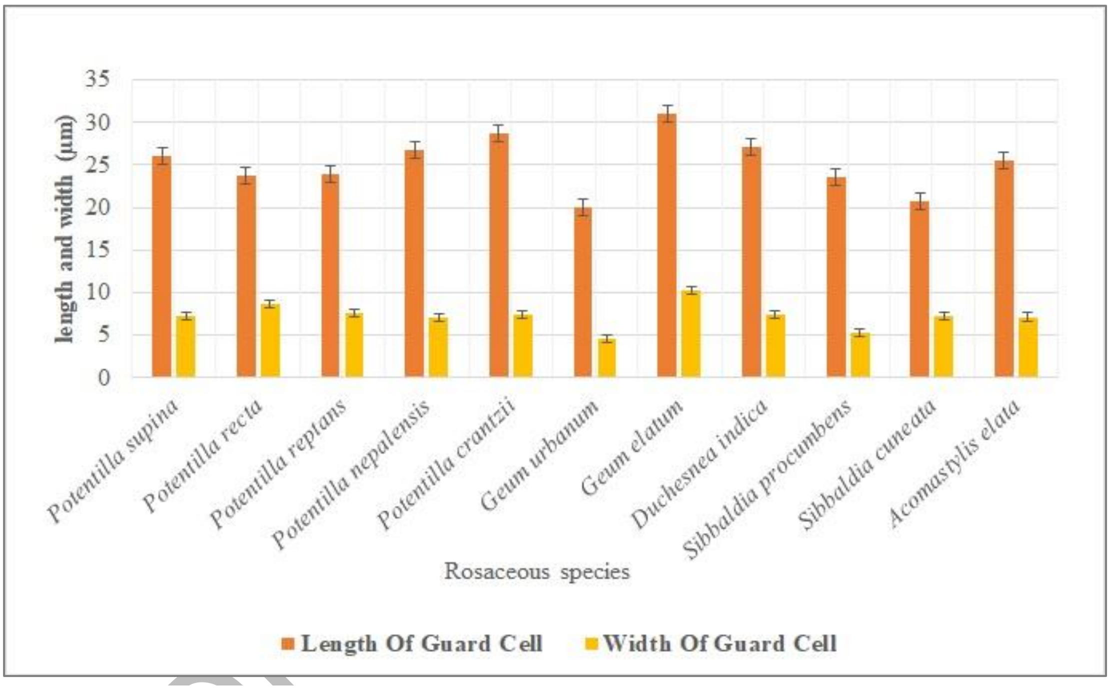


Fig 3.11: Graphical representation of length and width of non-glandular trichome on abaxial surface**.**

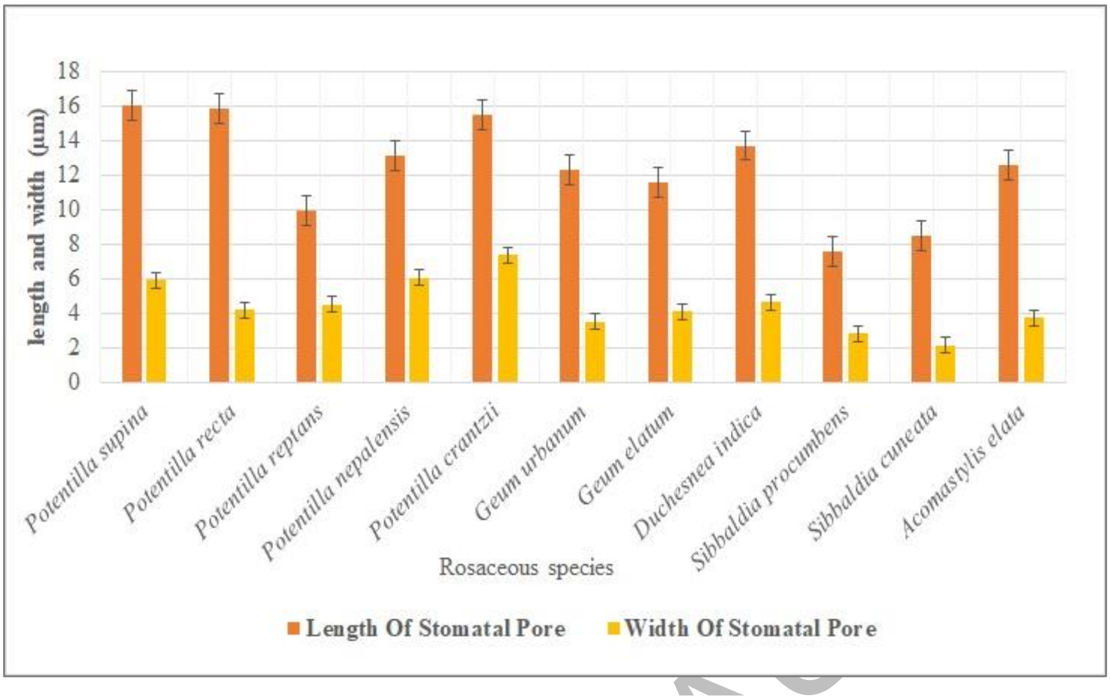


Fig 3.12: Graphical representation of length and width of non-glandular trichome on adaxial surface**.**

3.2.4 Morphology of glandular trichomes

Current observations revealed that 13 out of 47 Rosaceous taxa have glandular trichome (Capitate) on both abaxial and adaxial surface with a significant variation in quantitative data. Maximum length of glandular trichome on abaxial surface was found in *Geum urbanum* (101.7±10.3 µm), while minimum length of glandular trichome on abaxial surface was noted in *Fragaria vesca* (37.0±3.14 µm). Similarly maximum width of glandular trichome on abaxial surface was found in *Rubus macilentus* (59.6±0.79 µm), while minimum width was found in *Fragaria vesca* (10.1±0.26 µm) as examined in Figure 3.13**.**

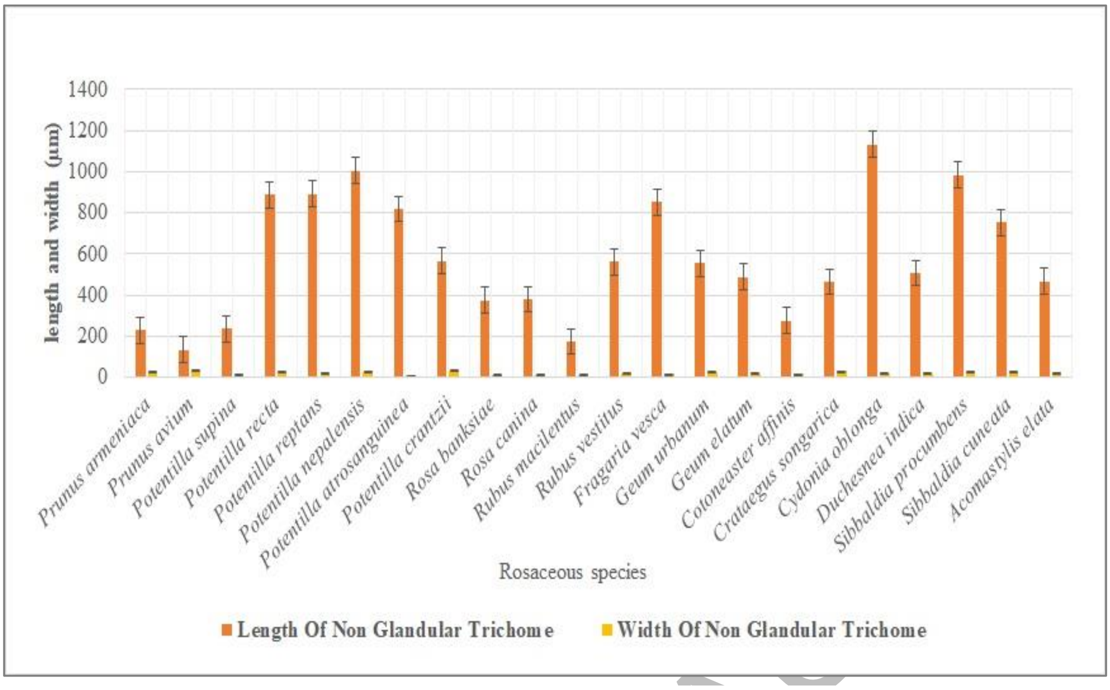


Fig 3.13: Graphical representation of length and width of glandular trichome on abaxial surface**.**

3.2.5 UPGMA Cluster Analysis

The dendrogram revealed hierarchical clustering between foliar micro-morphological qualitative and quantitative traits of 47 Rosaceous species from District Swat. The Euclidean cluster analysis based on similar traits reveals various levels of phenotypic relationships (Figure 3.14). The cluster analysis was carried out by Euclidean distance method, based on 47 foliar micromorphological attributes. The main cluster (C1) of the dendrogram based on similar characters using qualitative and quantitative data is divided into 2 main groups represented by A1 and A2. Group 1 (A1) has 11 species including *C. oblonga, D. indica, E. japonica, F. ulmaria, M. pumila, P. avium, P.bretschneideri, P. calleryana, P. reptans, S. cuneata* and *S. procumbens*, while group 2 (A2) consists of 36 species. Additionally, group 1 is split into two subgroups (A1a and A1b), and group 2 is similarly separated into two subgroups (A2a) and (A2b). Due to the presence of similar length cylindrical trichome on adaxial surface, *P. avium* was closely placed with *E. japonica*. In group 2 (A2) *G. elatum, P. supina, R. damascene* and *R. macilentus* were closely placed due to less euclidean distance between similar quantitative epidermal characters.

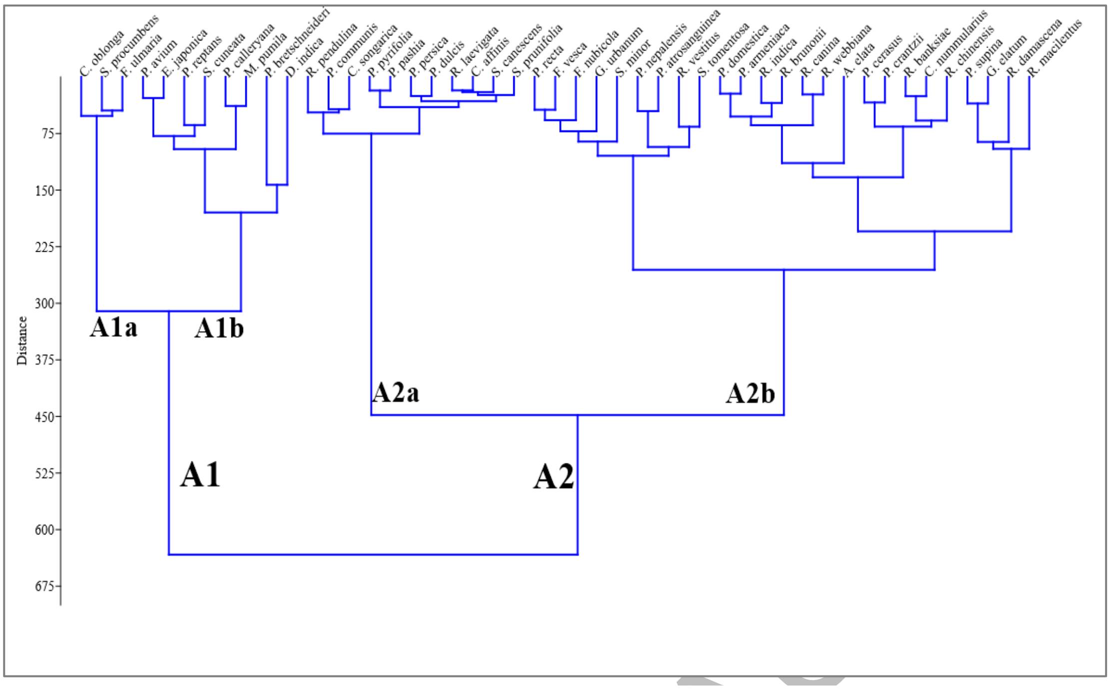


Fig 3.14: Dendrogram based on morpho-anatomical features showing two major clusters and sub-clusters (Past version 3).

3.2.6 PCA Cluster Analysis

To show resemblance in the attributes between Rosaceous taxa principal component analysis (PCA) was performed using microanatomical traits of 47 Rosaceous species (Figure 3.15, Table 3.1). Total number of variables in principle component analysis is represented by Eigenvalues, which is frequently used to assess the number of factors to retain. According to bioinformatic data of PCA analysis, a total of (98.1%) variations were observed on abaxial surface in the epidermal cell length, 20 out of 47 species (*S. minor, C. songarica, R. penduline, P. crantzii, P. communis, R. webbiana, P. cerasus, F. nubicola, G. elatum, G. urbanum, D. indica, P. supina, P. recta, P. reptans, P. nepalensis, P. atrosanguinea, F. vesca, S. cuneata, A. elata* and *R. macilentus*) show strong positive relation with respect to epidermal cell length while 27 species out of 47 show strong negative relation between the epidermal cell length. A very less variations only in 10 species (*P. supina, P. recta, P. reptans, P. nepalensis, P. atrosanguinea, F. vesca , S. cuneata, A. elata, G. urbanum* and *R. macilentus*) were observed in the width of glandular trichome which is about (0.01%) in positive axis show strong positive relationship with respect to glandular trichome width.

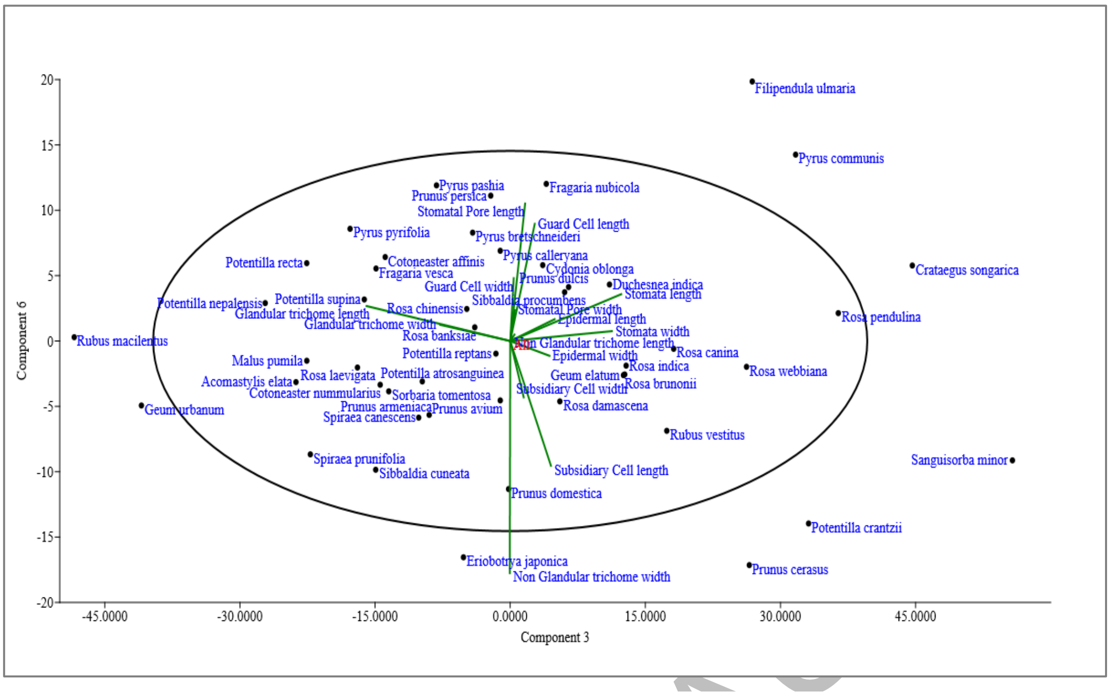


Fig 3.15: Principle component analysis shows micro-morphological variations along abaxial side

Table 3.1: Eigenvalues, percentage of total variance explained by each axis among Rosaceous species.

PC	Eigen value	% Variance
PC1	121353	98.14
PC2	1418.1	1.14
PC3	460.5	0.37
PC4	120.0	0.097
PC5	77.1	0.062
PC6	62.0	0.050
PC7	45.2	0.036
PC8	37.0	0.029
PC9	30.1	0.024
PC10	17.8	0.014
PC11	9.6	0.007
PC12	6.6	0.005
PC13	2.9	0.002
PC14	2.3	0.001

Table 3.2: Qualitative foliar micromorphological traits of Rosaceous species.

Taxa	Leaves condition	Ad x Ab	Stomata	Stomatal Appearance	Stomatal frequency	E.C Shapes	Lobes in E.C	Anticlinal walls
***Pyrus pashia* Buch.-Ham. ex D.Don**	Hypostomatic	Ad	-	-	-	Tetra / Hexagonal	Up to 4	Deeply undulate
		Ab	Stephanocytic	Raised	Common	Irregular	Up to 7	Roughly straight
***Pyrus calleryana* Decne.**	Hypostomatic	Ad	-	-	-	Tetragonal	Up to 4	Undulate
		Ab	Stephanocytic	Raised /Sunken	Common	Irregular	Up to 3	Slightly straight
***Pyrus communis* L.**	Hypostomatic	Ad	-	-	-	Tri / Pentagonal	Up to 5	Roughly undulate
		Ab	Stephanocytic	Slightly raised	Common	Trigonal	Up to 5	Slightly curved
***Pyrus bretschneideri* Rehder**	Hypostomatic	Ad	-	-	-	Tri / Pentagonal	Up to 3	undulate
		Ab	Anomocytic	Slightly sunken	Abundant	Tetragonal	Up to 3	Smoothly curved
***Pyrus pyrifolia* (Burm.f.) Nakai**	Hypostomatic	Ad	-	-	-	Trigonal	Up to 4	Straight
		Ab	Anomocytic	Sunken	Common	Polygonal	Up to 3	Slightly curved
***Prunus persica* L.Batsch**	Hypostomatic	Ad	-	-	-	Pentagonal	Up to 2	Roughly undulate
		Ab	Anomocytic	Slightly sunken	Abundant	Polygonal	Up to 3	Straight
***Prunus domestica* L.**	Hypostomatic	Ad	-	-	-	Polygonal	Up to 2	Straight
		Ab	Anomocytic	Raised	Abundant	Tetragonal	Up to 7	Simple wavy
***Prunus armeniaca* L.**	Hypostomatic	Ad	-	-	-	Tetra / polygonal	Up to 2	Straight
		Ab	Anomocytic	Sunken	Abundant	Tri / Pentagonal	Up to 6	Straight
***Prunus dulcis* Mill.D.A.Webb**	Hypostomatic	Ad	-	-	-	Polygonal	Up to 5	Straight
		Ab	Tetracytic	Very Raised	Common	Tri / tetragonal	Up to 3	Wavy
***Prunus cerasus* L.**	Hypostomatic	Ad	-	-	-	Wavy	Up to 9	Undulate
		Ab	Tetracytic	Raised	Abundant	Wavy	Up to 9	Sinuate
***Prunus avium* L.**	Hypostomatic	Ad	-	-	-	Irregular	Up to 4	Undulate
		Ab	Stephanocytic	Very Raised	Abundant	Irregular	Up to 7	Sinuate
***Potentilla supina* L.**	Amphistomatic	Ad	Laterocytic	Slightly sunken	Rare	Tri-tetragonal	Up to 3	Slightly curved
		Ab	Laterocytic	Slightly raised	Abundant	Irregular	Up to 7	Slightly curved
***Potentilla recta* L.**	Amphistomatic	Ad	Laterocytic	Sunken	Very Rare	Irregular	Up to 4	Deeply undulate
		Ab	Laterocytic	Very Raised	Abundant	Irregular	Up to 5	Undulate
***Potentilla reptans* L.**	Amphistomatic	Ad	Laterocytic	Slightly raised	Rare	Polygonal	Up to 2	Straight
		Ab	Laterocytic	Slightly sunken	Abundant	Tetragonal	Up to 4	Straight
***Potentilla nepalensis* Hook.**	Amphistomatic	Ad	Stephanocytic	Raised	Common	Irregular	Up to 6	Slightly curved
		Ab	Laterocytic	Very Raised	Common	Polygonal	Up to 5	Slightly curved

***Potentilla atrosanguinea* G.Lodd. ex D.Don**	Hypostomatic	Ad	-	-	-	Pentagonal	Up to 3	Deeply undulate
		Ab	Laterocytic	Raised	Rare	Polygonal	Up to 5	Slightly curved
***Potentilla crantzii* (Crantz) Beck ex Fritsch**	Amphistomatic	Ad	Staurocytic	Slightly raised	Rare	Tri-tetragonal	Up to 3	Roughly straight
		Ab	Laterocytic	Sunken	Abundant	Irregular	Up to 6	Undulate
***Rosa indica* L.**	Hypostomatic	Ad	-	-	-	Irregular	Up to 3	Straight
		Ab	Paracytic	Raised	Common	Tri-tetragonal	Up to 4	Wavy
***Rosa banksiae* R.Br.**	Hypostomatic	Ad	-	-	-	Polygonal	Up to 5	Wavy
		Ab	Actinocytic	Sunken	Common	Polygonal	Up to 5	Undulate
***Rosa chinensis* Jacq.**	Hypostomatic	Ad	-	-	-	Irregular	Up to 4	Wavy
		Ab	Tetracytic	Slightly sunken	Abundant	Wavy	Up to 6	Undulate
***Rosa × damascena* Herrm.**	Hypostomatic	Ad	-	-	-	Tetragonal	Up to 2	Undulate
		Ab	Stephanocytic	Slightly raised	Common	Wavy	Up to 5	Straight
***Rosa laevigata* Michx.**	Hypostomatic	Ad	-	-	-	Polygonal	Up to 5	Wavy
		Ab	Paracytic	Slightly sunken	Common	Irregular	Up to 2	Smoothly curved
***Rosa brunonii* Lindl.**	Hypostomatic	Ad	-	-	-	Tri-tetragonal	Up to 3	Undulate
		Ab	Paracytic	Very raised	Abundant	Wavy	Up to 7	Sinuate
***Rosa canina* L.**	Hypostomatic	Ad	-	-	-	Tetragonal	Up to 2	Straight
		Ab	Paracytic	Very raised	Common	Wavy	Up to 9	Sinuate
***Rosa pendulina* L.**	Hypostomatic	Ad	-	-	-	Wavy	Up to 6	Sinuate
		Ab	Paracytic	Slightly raised	Rare	Wavy	Up to 9	Sinuate
***Rosa webbiana* Wall. ex Royle**	Hypostomatic	Ad	-	-	-	Tri-tetragonal	Up to 2	Sinuate
		Ab	Paracytic	Sunken	Abundant	Polygonal	Up to 6	Wavy
***Rubus macilentus* Jacquem. ex Cambess.**	Hypostomatic	Ad	-	-	-	Pentagonal	Up to 4	Roughly curved
		Ab	Stephanocytic	Very raised	Abundant	Irregular	Up to 3	Undulate
***Rubus vestitus* Weihe**	Hypostomatic	Ad	-	-	-	Wavy	Up to 7	Sinuate
		Ab	Stephanocytic	Raised	Common	Wavy	Up to 6	Sinuate
***Fragaria nubicola* (Lindl. ex.Hook.f.) Lacaita**	Hypostomatic	Ad	-	-	-	Hexagonal	Up to 3	Roughly curved
		Ab	Actinocytic	Sunken	Abundant	Hexagonal	Up to 3	Roughly curved
***Fragaria vesca* L.**	Hypostomatic	Ad	-	-	-	Tri-tetragonal	Up to 3	Undulate
		Ab	Laterocytic	Sunken	Abundant	Wavy	Up to 6	Wavy
***Geum urbanum* L.**	Amphistomatic	Ad	Tetracytic	Raised	Rare	Polygonal	Up to 6	Curved
		Ab	Tetracytic	Slightly sunken	Abundant	Polygonal	Up to 7	Sinuate
***Geum elatum* var. humile (Royle).**	Amphistomatic	Ad	Stephanocytic	sunken	Rare	Polygonal	Up to 3	Curved
		Ab	Tetracytic	sunken	Common	Wavy	Up to 8	Sinuate

***Spiraea prunifolia* Siebold & Zucc.**	Hypostomatic	Ad	-	-	-	Tri-tetragonal	Up to 5	Curved
		Ab	Paracytic	Raised	Abundant	Tri-tetragonal	Up to 5	Curved
***Spiraea canescens* D.Don**	Hypostomatic	Ad	-	-	-	Tetragonal	Up to 3	Curved
		Ab	Actinocytic	sunken	Common	Tetragonal	Up to 2	Sinuate
***Cotoneaster nummularius* Fisch. & C.A.Mey.**	Hypostomatic	Ad	-	-	-	Tri- pentagonal	Up to 3	Wavy
		Ab	Paracytic	Sunken	Abundant	Irregular	Up to 3	Wavy
***Cotoneaster affinis* Lindl.**	Hypostomatic	Ad	-	-	-	Pentagonal	Up to 2	Straight
		Ab	Actinocytic	Slightly sunken	Common	Irregular	Up to 3	Wavy
***Crataegus songarica* K. Koch**	Hypostomatic	Ad	-	-	-	Pentagonal	Up to 4	Undulate
		Ab	Paracytic	Very raised	Common	Wavy	Up to 5	Sinuate
***Cydonia oblonga* Mill.**	Hypostomatic	Ad	-	-	-	Wavy	Up to 5	Sinuate
		Ab	Paracytic	Raised	Abundant	Wavy	Up to 6	Sinuate
***Duchesnea indica* (Jacks.) Focke**	Amphistomatic	Ad	Paracytic	Slightly sunken	Very rare	Polygonal	Up to 7	Undulate
		Ab	Paracytic	Slightly raised	Abundant	Wavy	Up to 8	Sinuate
***Eriobotrya japonica* (Thunb.) Lindl.**	Hypostomatic	Ad	-	-	-	Polygonal	Up to 4	Curved
		Ab	Staurocytic	Slightly sunken	Abundant	Polygonal	Up to 3	Undulate
***Malus pumila* Mill.**	Hypostomatic	Ad	-	-	-	Polygonal	Up to 3	Curved
		Ab	Paracytic	Slightly raised	Abundant	Wavy	Up to 5	Sinuate
***Sorbaria tomentosa* (Lindl.) Rehder**	Hypostomatic	Ad	-	-	-	Pentagonal	Up to 3	Curved
		Ab	Anomocytic	Raised	Abundant	Pentagonal	Up to 3	Curved
***Sibbaldia procumbens* L.**	Amphistomatic	Ad	Stephanocytic	Slightly sunken	Common	Polygonal	Up to 3	Straight
		Ab	Stephanocytic	Slightly raised	Common	Wavy	Up to 4	Undulate
***Sibbaldia cuneata* Hornem. ex Kuntze**	Amphistomatic	Ad	Staurocytic	Sunken	Rare	Polygonal	Up to 2	Curved
		Ab	Stephanocytic	Sunken	Common	Polygonal	Up to 3	Undulate
***Sanguisorba minor* Scop.**	Hypostomatic	Ad	-	-	-	Wavy	Up to 4	Undulate
		Ab	Paracytic	Raised	Abundant	Wavy	Up to 7	Sinuate
***Filipendula ulmaria* (L.) Maxim.**	Hypostomatic	Ad	-	-	-	Tri- pentagonal	Up to 3	Wavy
		Ab	Stephanocytic	Slightly Sunken	Common	Hexagonal	Up to 3	Undulate
***Acomastylis elata* (Wall. ex G.Don) F.Bolle**	Amphistomatic	Ad	Stephanocytic	Sunken	Rare	Polygonal	Up to 2	Curved
		Ab	Stephanocytic	Slightly sunken	Abundant	Polygonal	Up to 4	Undulate

Key notes* Ad=Adaxial; Ab=Abaxial; EC= Epidermal cell.

Table 3.3: Qualitative micromorphological trichomes microanatomical features of Rosaceous species.

Botanical name	Foliar Trichome Description							
	Trichome types	Coastal region	Inter - coastal	Marginal	Frequency	Trichome shape	Unicellular / Multicellular	Uniseriate / Multiseriate
Pyrus pashia **Buch.-Ham. ex D.Don**	-	-	-	-	-	-	-	-
Pyrus calleryana **Decne.**	1	+	-	-	Rare	Elongated Conical	Unicellular	Uniseriate
Pyrus communis **L.**	-	-	-	-	-	-	-	-
Pyrus bretschneideri **Rehder**	1	+	+	-	Abundant	Cylindrical	Unicellular	Uniseriate
Pyrus pyrifolia **(Burm.f.) Nakai**	-	-	-	-	-	-	-	-
Prunus persica **L. Batsch**	-	-	-	-	-	-	-	-
Prunus domestica **L.**	1	+	-	-	Common	Cylindrical	Unicellular	Uniseriate
Prunus armeniaca **L.**	1	+	-	-	Rare	Conical	Unicellular	Uniseriate
Prunus dulcis **(Mill.) D.A.Webb**	-	-	-	-	-	-	-	-
Prunus cerasus **L.**	1	+	-	-	Very Rare	Cylindrical	Unicellular	Uniseriate
Prunus avium **L.**	1	+	-	-	Rare	Conical & Cylindrical	Unicellular	Uniseriate
Potentilla supina **L.**	2	+	+	+	Abundant	Conical & Elongated Capitate	Both	Uniseriate
Potentilla recta **L.**	2	+	+	+	Abundant	Conical & Elongated Capitate	Both	Uniseriate
Potentilla reptans **L.**	2	+	+	+	Abundant	Conical & Elongated Capitate	Both	Uniseriate
Potentilla nepalensis **Hook.**	2	+	+	-	Rare	Conical & Elongated Capitate	Both	Uniseriate
Potentilla atrosanguinea **G.Lodd. ex D.Don**	2	+	+	+	Abundant	Conical & Elongated Capitate	Both	Uniseriate
Potentilla crantzii **(Crantz) Beck ex Fritsch**	1	+	+	-	Abundant	Conical	Unicellular	Uniseriate

***Rosa indica* L.**	1	+	+	-	Very Rare	Cylindrical	Unicellular	Uniseriate
***Rosa banksiae* R.Br.**	1	+	-	-	Very Rare	Cylindrical	Unicellular	Uniseriate
***Rosa chinensis* Jacq.**	1	+	-	-	Very Rare	Cylindrical	Unicellular	Uniseriate
***Rosa* × *damascena* Herrm.**	1	+	+	+	Abundant	Cylindrical	Unicellular	Uniseriate
***Rosa laevigata* Michx.**	-	-	-	-	-	-	-	-
***Rosa brunonii* Lindl.**	1	+	-	-	Rare	Cylindrical	Unicellular	Uniseriate
***Rosa canina* L.**	1	+	+	-	Common	Cylindrical	Unicellular	Uniseriate
***Rosa pendulina* L.**	-	-	-	-	-	-	-	-
***Rosa webbiana* Wall. ex Royle**	1	+	-	-	Rare	Cylindrical	Unicellular	Uniseriate
***Rubus macilentus* Jacquem. ex Cambess.**	2	+	-	-	Very Rare	Cylindrical & Capitate	Both	Uniseriate
***Rubus vestitus* Weihe**	1	+	+	+	Abundant	Stellate & Cylindrical	Unicellular	Uniseriate
***Fragaria nubicola* (Lindl. ex.Hook.f.) Lacaita**	2	+	+	-	Common	Cylindrical & Dumble Capitate	Both	Uniseriate
***Fragaria vesca* L.**	2	+	+	+	Abundant	Cylindrical & Dumble Capitate	Both	Uniseriate
***Geum urbanum* L.**	3	+	+	+	Abundant	Cylindrical, Elongated Capitate & Slender acute	Both	Uniseriate
***Geum elatum* var. humile (Royle) Franch.**	2	+	+	+	Abundant	Cylindrical & Elongated Capitate	Both	Uniseriate
***Spiraea prunifolia* Siebold & Zucc.**	-	-	-	-	-	-	-	-
***Spiraea canescens* D.Don**	-	-	-	-	-	-	-	-
***Cotoneaster nummularius* Fisch. & C.A.Mey.**	1	+	+	-	Common	Cylindrical	Unicellular	Uniseriate
***Cotoneaster affinis* Lindl.**	1	+	-	-	Rare	Conical	Unicellular	Uniseriate
***Crataegus songarica* K. Koch**	1	+	-	-	Rare	Conical	Unicellular	Uniseriate
***Cydonia oblonga* Mill.**	1	+	+	+	Abundant	Cylindrical	Unicellular	Uniseriate

***Duchesnea indica* (Jacks.) Focke**	2	+	+	+	Abundant	Cylindrical & Glandular Capitate	Both	Uniseriate
***Eriobotrya japonica* (Thunb.) Lindl.**	1	+	+	+	Abundant	Cylindrical	Unicellular	Uniseriate
***Malus pumila* Mill.**	1	+	-	-	Rare	Cylindrical	Unicellular	Uniseriate
***Sorbaria tomentosa* (Lindl.) Rehder**	1	+	-	-	Very Rare	Conical	Unicellular	Uniseriate
***Sibbaldia procumbens* L.**	1	+	+	-	Common	Broad Conical	Unicellular	Uniseriate
***Sibbaldia cuneata* Hornem. ex Kuntze**	2	+	+	+	Abundant	Cylindrical & Short Capitate	Unicellular	Uniseriate
***Sanguisorba minor* Scop.**	1	+	-	-	Very Rare	Cylindrical	Unicellular	Uniseriate
***Filipendula ulmaria* L. Maxim.**	1	+	+	+	Abundant	Cylindrical	Unicellular	Uniseriate
***Acomastylis elata* (Wall. ex G.Don) F.Bolle**	2	+	+	-	Abundant	Cylindrical & Elongated capitate	Both	Uniseriate

Key words: - (Absent) + (Present)

Table 3.4: Quantitative leaf epidermal characters of family Rosaceae based on light microscopy.

Taxa	L × W	Epidermal Cell (Mean ± SE) Ad x Ab	Guard Cell (Mean ± SE) Ad x Ab	Stomata (Mean ± SE) Ad x Ab	Subsidiary Cell (Mean ± SE) Ad x Ab	Stomatal Pore (Mean ± SE) Ad x Ab	Stomatal Index (Mean ± SE) Ad x Ab
***Pyrus pashia* Buch.-Ham. ex D.Don**	L (Ad)	(34.1±4.64)	-	-	-	-	-
	W (Ad)	(18.9±2.21)					
	L (Ab)	(38.2±3.88)	(38.6±1.48)	(53.6±2.72)	(27.6±1.09)	(34.5±2.10)	7.69
	W (Ab)	(20.8±1.62)	(14.0±0.61)	(30.5±0.87)	(13.0±0.57)	(5.45±0.44)	
***Pyrus calleryana* Decne.**	L (Ad)	(16.1±0.80)	-	-	-	-	-
	W (Ad)	(16.9±0.57)					
	L (Ab)	(21.2±3.59)	(22.2±2.83)	(41.8±4.84)	(10.4±1.07)	(15.0±2.78)	5.88
	W (Ab)	(15.9±1.35)	(7.70±0.16)	(46.7±1.78)	(12.4±0.56)	(7.10±1.29)	
***Pyrus communis* L.**	L (Ad)	(48.1±4.94)	-	-	-	-	-
	W (Ad)	(20.6±3.44)					
	L (Ab)	(26.6±2.96)	(39.3±1.71)	(74.5±2.02)	(26.4±4.64)	(32.3±0.33)	5.51
	W (Ab)	(32.9±4.60)	(12.3±0.23)	(99.6±2.39)	(17.8±1.87)	(6.05±0.46)	
***Pyrus bretschneideri* Rehder**	L (Ad)	(18.8±2.69)	-	-	-	-	-
	W (Ad)	(18.7±1.64)					
	L (Ab)	(11.0±0.72)	(25.5±1.90)	(43.6±1.91)	(10.2±0.69)	(15.2±2.28)	11.34
	W (Ab)	(19.5±2.48)	(10.4±0.70)	(35.3±2.15)	(13.6±1.43)	(4.95±1.35)	
***Pyrus pyrifolia* (Burm.f.) Nakai**	L (Ad)	(40.6±3.11)	-	-	-	-	-
	W (Ad)	(35.7±2.98)					
	L (Ab)	(28.8±2.38)	(42.6±0.72)	(43.4±0.30)	(26.4±0.38)	(29.5±0.82)	11.9
	W (Ab)	(18.0±1.08)	(11.6±0.25)	(24.3±0.30)	(18.3±0.33)	(8.55±0.44)	
***Prunus persica* L.Batsch**	L (Ad)	(34.1±4.33)	-	-	-	-	-
	W (Ad)	(17.8±0.76)					
	L (Ab)	(20.2±1.29)	(36.2±2.61)	(60.2±4.44)	(15.1±0.87)	(22.4±1.86)	14.7
	W (Ab)	(14.8±0.95)	(9.35±0.43)	(54.5±3.61)	(13.3±0.53)	(11.5±1.56)	
***Prunus domestica* L.**	L (Ad)	(32.4±4.43)	-	-	-	-	-

	W (Ad)	(34.4±5.29)					
	L (Ab)	(29.7±2.16)	(24.8±2.22)	(50.6±1.25)	(21.3±2.56)	(14.1±1.81)	31.4
	W (Ab)	(19.0±1.15)	(6.45±0.90)	(50.2±0.69)	(17.7±2.28)	(7.85±1.22)	
***Prunus armeniaca* L.**	L (Ad)	(38.1±6.26)	-	-	-	-	-
	W (Ad)	(36.8±3.33)					
	L (Ab)	(27.4±4.29)	(28.3±0.88)	(48.1±0.87)	(14.5±0.78)	(16.5±1.54)	53.0
	W (Ab)	(22.2±2.78)	(9.75±1.06)	(34.5±0.41)	(17.2±0.36)	(6.55±0.96)	
***Prunus dulcis* (Mill.) D.A.Webb**	L (Ad)	(36.7±5.73)	-	-	-	-	-
	W (Ad)	(31.3±1.73)					
	L (Ab)	(36.3±3.88)	(25.5±0.51)	(65.2±0.35)	(17.0±1.12)	(13.9±0.53)	14.2
	W (Ab)	(24.4±3.28)	(8.25±0.17)	(61.5±0.74)	(13.1±0.69)	(6.25±0.35)	
***Prunus cerasus* L.**	L (Ad)	(32.5±2.97)	-	-	-	-	-
	W (Ad)	(56.1±2.13)					
	L (Ab)	(30.7±1.73)	(24.3±0.59)	(70.0±1.46)	(34.9±1.24)	(12.8±0.71)	29.5
	W (Ab)	(45.0±4.86)	(6.40±0.55)	(67.8±1.91)	(28.9±2.34)	(4.05±0.28)	
***Prunus avium* L.**	L (Ad)	(58.3±2.84)	-	-	-	-	-
	W (Ad)	(30.7±4.25)					
	L (Ab)	(32.2±1.11)	(24.9±0.52)	(36.5±0.80)	(19.7±0.30)	(11.5±0.91)	23.9
	W (Ab)	(24.0±1.57)	(5.90±0.33)	(44.6±1.28)	(12.2±0.35)	(3.90±0.55)	
***Potentilla supina* L.**	L (Ad)	(45.3±4.69)	(26.0±0.45)	(81.9±8.79)	(31.4±2.16)	(16.0±1.15)	15.3
	W (Ad)	(26.1±1.70)	(7.25±0.17)	(72.9±4.15)	(27.7±2.87)	(5.90±0.85)	
	L (Ab)	(45.8±4.86)	(26.7±0.77)	(85.2±4.46)	(36.3±4.38)	(13.0±0.85)	33.3
	W (Ab)	(24.6±1.70)	(6.95±0.21)	(73.1±5.38)	(29.2±4.27)	(4.15±0.50)	
***Potentilla recta* L.**	L (Ad)	(45.7±1.55)	(23.8±0.66)	(68.3±2.81)	(40.5±2.64)	(15.8±1.39)	14.5
	W (Ad)	(35.8±0.88)	(8.60±0.58)	(78.6±1.56)	(23.1±1.08)	(4.20±0.42)	
	L (Ab)	(33.0±1.71)	(26.0±0.81)	(56.0±6.94)	(23.2±1.83)	(15.9±1.12)	30.5
	W (Ab)	(26.3±0.62)	(9.10±0.44)	(61.9±3.65)	(19.9±0.54)	(7.40±0.70)	
***Potentilla reptans* L.**	L (Ad)	(36.7±5.31)	(24.0±0.42)	(83.2±7.46)	(30.3±2.24)	(9.95±0.86)	14.2
	W (Ad)	(28.8±2.13)	(7.65±043)	(84.5±8.05)	(34.7±3.27)	(4.50±0.25)	
	L (Ab)	(40.7±4.29)	(20.2±2.08)	(77.9±7.81)	(38.5±3.78)	(13.4±1.55)	54.0

	W (Ab)	(27.7±2.17)	(7.35±0.35)	(66.3±9.40)	(32.2±4.62)	(4.80±0.86)	
***Potentilla nepalensis* Hook.**	L (Ad)	(40.6±4.24)	(26.7±1.60)	(80.5±5.28)	(45.1±5.89)	(13.1±0.50)	34.1
	W (Ad)	(32.3±2.61)	(7.10±0.48)	(66.6±4.32)	(27.6±2.04)	(6.05±0.62)	
	L (Ab)	(38.2±1.30)	(20.9±1.51)	(68.5±4.19)	(27.8±3.08)	(11.0±0.57)	55.3
	W (Ab)	(29.3±1.31)	(6.75±0.39)	(57.6±1.84)	(22.2±1.24)	(3.75±0.35)	
***Potentilla atrosanguinea* G.Lodd. ex D.Don**	L (Ad)	(54.2±1.84)	-	-	-	-	-
	W (Ad)	(24.3±3.29)					
	L (Ab)	(42.1±3.39)	(27.5±0.17)	(68.1±0.95)	(49.5±3.65)	(7.70±1.14)	10.8
	W (Ab)	(31.8±4.75)	(8.90±0.58)	(83.3±0.94)	(23.1±1.24)	(6.70±0.21)	
***Potentilla crantzii* (Crantz) Beck ex Fritsch**	L (Ad)	(50.4±6.11)	(28.7±0.48)	(92.5±4.40)	(44.2±4.90)	(15.5±0.64)	11.6
	W (Ad)	(25.1±3.03)	(7.50±0.17)	(89.6±3.13)	(29.8±3.48)	(7.35±0.23)	
	L (Ab)	(40.7±3.60)	(30.5±0.79)	(82.8±71.8)	(35.7±3.73)	(15.2±1.13)	32.8
	W (Ab)	(23.8±2.76)	(7.35±0.23)	(71.8±3.39)	(23.8±2.62)	(7.50±0.17)	
***Rosa indica* L.**	L (Ad)	(51.6±3.51)	-	-	-	-	-
	W (Ad)	(26.7±2.57)					
	L (Ab)	(45.5±4.17)	(32.2±1.37)	(56.4±2.73)	(35.4±1.06)	(21.5±1.08)	34.8
	W (Ab)	(28.2±1.93)	(9.50±0.48)	(55.9±5.13)	(18.2±1.61)	(8.45±0.65)	
***Rosa banksiae* R.Br.**	L (Ad)	(42.0±5.56)	-	-	-	-	-
	W (Ad)	(22.6±3.97)					
	L (Ab)	(32.7±3.26)	(24.7±0.42)	(44.0±5.29)	(20.1±2.77)	(12.7±0.99)	33.8
	W (Ab)	(19.3±2.15)	(8.45±0.56)	(42.9±1.54)	(13.1±0.65)	(4.95±0.81)	
***Rosa chinensis* Jacq.**	L (Ad)	(26.1±2.25)	-	-	-	-	-
	W (Ad)	(19.7±2.69)					

	L (Ab)	(23.2±2.52)	(27.6±1.66)	(49.3±3.03)	(19.1±2.47)	(13.1±0.82)	18.2
	W (Ab)	(15.0±1.17)	(8.15±0.53)	(43.4±2.46)	(9.50±1.32)	(5.45±0.15)	
***Rosa* × *damascena* Herrm.**	L (Ad)	(36.7±3.52)	-	-	-	-	-
	W (Ad)	(21.9±2.04)					
	L (Ab)	(31.1±3.21)	(24.6±1.18)	(69.3±6.68)	(27.6±3.94)	(12.6±1.19)	26.0
	W (Ab)	(20.0±1.79)	(5.05±0.34)	(45.7±1.53)	(16.7±0.77)	(4.60±0.24)	
***Rosa laevigata* Michx.**	L (Ad)	(21.8±2.27)	-	-	-	-	-
	W (Ad)	(18.7±1.16)					
	L (Ab)	(24.4±3.27)	(22.1±1.20)	(46.4±2.47)	(16.7±1.69)	(10.4±0.81)	18.9
	W (Ab)	(18.2±1.30)	(6.45±0.24)	(37.9±3.38)	(9.55±1.12)	(4.65±0.56)	
***Rosa brunonii* Lindl.**	L (Ad)	(39.9±1.35)	-	-	-	-	-
	W (Ad)	(19.5±1.32)					
	L (Ab)	(35.0±1.96)	(26.8±0.32)	(68.3±0.93)	(33.5±2.32)	(11.7±0.97)	13.9
	W (Ab)	(22.2±1.28)	(6.45±0.26)	(54.6±0.95)	(15.8±2.23)	(5.90±0.68)	
***Rosa canina* L.**	L (Ad)	(45.6±0.86)	-	-	-	-	-
	W (Ad)	(29.3±3.00)					
	L (Ab)	(43.7±1.77)	(24.9±0.21)	(72.3±1.76)	(32.9±2.02)	(14.9±0.35)	23.2
	W (Ab)	(24.5±0.87)	(7.50±0.17)	(54.3±2.32)	(16.7±0.43)	(4.80±0.21)	
***Rosa pendulina* L.**	L (Ad)	(59.4±7.38)	-	-	-	-	-
	W (Ad)	(36.4±3.63)					
	L (Ab)	(52.7±4.62)	(27.2±0.75)	(94.4±3.32)	(37.9±4.00)	(17.2±0.30)	9.80
	W (Ab)	(26.1±1.40)	(7.45±0.14)	(80.0±4.73)	(22.7±2.98)	(5.85±0.40)	
***Rosa webbiana* Wall. ex Royle**	L (Ad)	(40.1±4.74)	-	-	-	-	-

	W (Ad)	(24.9±2.27)					
	L (Ab)	(38.5±1.34)	(26.5±0.87)	(81.1±1.61)	(30.6±1.68)	(7.40±0.33)	18.6
	W (Ab)	(28.5±1.50)	(8.70±0.35)	(66.1±1.50)	(18.1±0.88)	(2.35±0.23)	
***Rubus macilentus* Jacquem. ex Cambess.**	L (Ad)	(34.9±3.88)	-	-	-	-	-
	W (Ad)	(41.7±6.51)					
	L (Ab)	(36.2±1.51)	(20.1±0.56)	(55.0±2.60)	(23.1±0.85)	(13.7±1.89)	51.2
	W (Ab)	(43.3±3.74)	(4.90±0.26)	(55.9±1.42)	(23.5±3.29)	(4.70±0.39)	
***Rubus vestitus* Weihe**	L (Ad)	(41.8±4.62)	-	-	-	-	-
	W (Ad)	(26.9±3.75)					
	L (Ab)	(35.4±3.12)	(21.7±0.57)	(71.4±4.07)	(28.1±2.78)	(10.0±0.81)	20.4
	W (Ab)	(29.2±2.42)	(6.30±0.53)	(49.7±2.37)	(32.3±2.31)	(4.30±0.70)	
***Fragaria nubicola* (Lindl. ex.Hook.f.) Lacaita**	L (Ad)	(68.4±5.59)	-	-	-	-	-
	W (Ad)	(63.9±3.04)					
	L (Ab)	(38.1±2.07)	(25.6±0.87)	(92.6±2.89)	(25.6±0.85)	(11.3±0.56)	22.3
	W (Ab)	(25.1±1.64)	(7.00±0.25)	(71.4±2.09)	(23.2±1.88)	(2.45±0.42)	
***Fragaria vesca* L.**	L (Ad)	(32.8±3.91)	-	-	-	-	-
	W (Ad)	(21.7±3.94)					
	L (Ab)	(20.3±1.50)	(18.0±0.74)	(59.7±0.96)	(18.9±0.38)	(7.35±0.23)	41.3
	W (Ab)	(14.6±0.78)	(15.6±2.18)	(63.7±0.57)	(14.9±0.57)	(4.15±0.23)	
***Geum urbanum* L.**	L (Ad)	(35.9±4.65)	(20.1±0.23)	(67.4±2.93)	(32.0±3.18)	(12.3±0.23)	47.6
	W (Ad)	(29.9±6.38)	(4.55±0.41)	(60.6±1.51)	(23.2±2.61)	(3.50±0.22)	
	L (Ab)	(42.4±6.43)	(20.7±0.42)	(72.1±5.19)	(45.9±6.33)	(8.90±0.58)	7.3
	W (Ab)	(24.0±2.86)	(7.05±0.48)	(68.4±11.4)	(22.1±2.34)	(3.95±0.85)	

***Geum elatum* var. humile (Royle) Franch.**	L (Ad)	(56.0±3.99)	(31.0±0.68)	(79.7±4.75)	(53.0±5.71)	(11.6±0.65)	5.12
	W (Ad)	(52.5±3.32)	(10.3±0.56)	(67.9±4.32)	(33.1±0.95)	(4.10±0.40)	
	L (Ab)	(63.8±4.06)	(27.4±0.97)	(100.8±8.31)	(53.9±9.86)	(12.5±0.51)	28.8
	W (Ab)	(32.4±1.16)	(6.90±0.74)	(80.5±6.17)	(32.4±5.20)	(6.25±0.17)	
***Spiraea prunifolia* Siebold & Zucc.**	L (Ad)	(26.9±3.06)	-	-	-	-	-
	W (Ad)	(22.4±2.84)					
	L (Ab)	(15.7±0.88)	(17.1±0.73)	(35.2±5.86)	(15.8±0.73)	(7.40±0.64)	19.9
	W (Ab)	(22.8±0.94)	(5.10±0.20)	(41.1±1.50)	(18.3±0.71)	(3.50±0.43)	
***Spiraea canescens* D.Don**	L (Ad)	(24.3±1.25)	-	-	-	-	-
	W (Ad)	(16.1±1.72)					
	L (Ab)	(16.7±0.41)	(20.1±0.21)	(56.7±1.59)	(22.5±0.56)	(8.75±0.91)	24.7
	W (Ab)	(14.4±0.46)	(5.35±0.46)	(44.5±0.87)	(17.6±0.23)	(3.80±0.35)	
***Cotoneaster nummularius* Fisch. & C.A.Mey.**	L (Ad)	(24.8±3.73)	-	-	-	-	-
	W (Ad)	(32.5±2.42)					
	L (Ab)	(12.8±1.04)	(22.6±4.05)	(37.4±4.49)	(13.7±1.94)	(15.6±3.24)	12.3
	W (Ab)	(17.9±2.05)	(8.00±1.32)	(38.3±5.99)	(9.35±1.00)	(11.0±2.06)	
***Cotoneaster affinis* Lindl.**	L (Ad)	(31.9±7.74)	-	-	-	-	-
	W (Ad)	(27.2±3.85)					
	L (Ab)	(24.2±3.88)	(31.8±4.39)	(49.2±4.89)	(13.2±1.81)	(18.2±3.33)	14.6
	W (Ab)	(10.5±0.90)	(8.15±1.03)	(41.8±3.80)	(15.5±2.91)	(10.0±1.90)	
***Crataegus songarica* K. Koch**	L (Ad)	(48.6±1.81)	-	-	-	-	-
	W (Ad)	(23.3±1.38)					
	L (Ab)	(34.6±1.53)	(38.7±0.57)	(89.3±3.56)	(40.0±2.18)	(24.2±3.89)	10.1

	W (Ab)	(66.5±38.6)	(10.0±0.52)	(91.4±5.87)	(24.4±1.65)	(13.7±1.22)	
***Cydonia oblonga* Mill.**	L (Ad)	(37.8±4.30)	-	-	-	-	-
	W (Ad)	(17.8±1.97)					
	L (Ab)	(47.9±1.07)	(17.7±1.34)	(40.5±3.06)	(16.5±1.69)	(9.95±0.73)	42.2
	W (Ab)	(19.4±1.30)	(4.75±0.48)	(32.8±2.03)	(7.30±0.60)	(3.85±0.57)	
***Duchesnea indica* (Jacks.) Focke**	L (Ad)	(63.1±5.18)	(27.1±1.06)	(105.5±8.49)	(49.1±5.67)	(13.7±0.35)	3.38
	W (Ad)	(37.8±3.11)	(7.45±0.31)	(101.3±5.99)	(34.4±3.35)	(4.65±0.39)	
	L (Ab)	(89.1±3.38)	(27.3±0.29)	(89.7±2.07)	(66.1±9.63)	(15.1±1.01)	14.5
	W (Ab)	(43.2±5.13)	(9.15±0.43)	(76.0±6.32)	(35.4±3.20)	(6.90±0.43)	
***Eriobotrya japonica* (Thunb.) Lindl.**	L (Ad)	(25.9±3.09)	-	-	-	-	-
	W (Ad)	(20.3±2.48)					
	L (Ab)	(19.8±2.15)	(16.0±1.42)	(33.5±0.64)	(40.7±1.81)	(8.15±0.53)	12.4
	W (Ab)	(17.2±2.31)	(7.30±0.32)	(40.7±1.18)	(11.40±0.55	(2.90±0.30)	
***Malus pumila* Mill.**	L (Ad)	(18.6±0.32)	-	-	-	-	-
	W (Ad)	(9.95±0.21)					
	L (Ab)	(13.0±0.14)	(23.5±0.21)	(23.7±0.28)	(21.3±0.37)	(12.7±0.17)	23.2
	W (Ab)	(10.7±0.35)	(11.0±0.25)	(18.1±0.25)	(12.7±0.7)	(2.70±0.16)	
***Sorbaria tomentosa* (Lindl.) Rehder**	L (Ad)	(29.6±3.53)	-	-	-	-	-
	W (Ad)	(23.9±2.52)					
	L (Ab)	(15.5±1.82)	(15.6±0.45)	(41.8±1.45)	(16.0±1.08)	(6.30±0.61)	24.0
	W (Ab)	(10.1±0.89)	(4.85±0.23)	(35.3±1.39)	(10.9±1.12)	(2.20±0.34)	
***Sibbaldia procumbens* L.**	L (Ad)	(29.2±3.23)	(23.5±1.15)	(51.6±10.2)	(29.3±2.51)	(7.60±1.52)	12.3
	W (Ad)	(22.4±1.32)	(5.35±0.39)	(55.3±1.92)	(19.4±1.02)	(2.80±0.57)	

	L (Ab)	(25.3±1.92)	(16.8±1.35)	(47.3±3.34)	(18.0±2.61)	(23.1±14.2)	21.3
	W (Ab)	(18.3±1.46)	(6.55±0.41)	(40.0±1.44)	(13.6±1.48)	(2.25±0.17)	
***Sibbaldia cuneata* Hornem. ex Kuntze**	L (Ad)	(19.3±1.17)	(20.7±0.54)	(62.6±3.04)	(28.5±1.80)	(8.50±0.52)	2.09
	W (Ad)	(16.5±1.34)	(7.30±0.21)	(52.6±3.22)	(17.7±2.03)	(2.15±0.23)	
	L (Ab)	(22.1±1.95)	(20.7±0.55)	(62.0±3.17)	(28.0±2.36)	(8.15±0.49)	10.3
	W (Ab)	(16.7±1.27)	(7.25±0.17)	(53.6±3.08)	(16.2±2.05)	(2.50±0.17)	
***Sanguisorba minor* Scop.**	L (Ad)	(78.8±8.29)	-	-	-	-	-
	W (Ad)	(39.4±1.76)					
	L (Ab)	(45.2±5.11)	(28.2±0.78)	(96.4±3.61)	(46.6±4.36)	(13.2±3.09)	51.2
	W (Ab)	(28.8±4.19)	(7.35±0.23)	(94.4±1.90)	(23.9±3.48)	(3.40±0.70)	
***Filipendula ulmaria* L. Maxim.**	L (Ad)	(30.5±3.92)	-	-	-	-	-
	W (Ad)	(16.4±1.21)					
	L (Ab)	(30.7±2.08)	(28.8±2.12)	(69.4±0.87)	(26.9±2.14)	(14.4±1.35)	17.2
	W (Ab)	(21.6±3.23)	(15.4±0.73)	(53.2±3.60)	(14.2±1.13)	(6.70±0.39)	
***Acomastylis elata* (Wall. ex G.Don) F.Bolle**	L (Ad)	(54.5±3.54)	(25.5±1.27)	(80.3±4.56)	(24.8±2.29)	(12.6±0.71)	6.23
	W (Ad)	(34.5±1.27)	(7.15±0.32)	(63.6±4.09)	(31.6±1.41)	(3.75±0.70)	
	L (Ab)	(52.6±3.63)	(25.0±0.97)	(77.9±3.33)	(45.1±2.32)	(14.9±0.73)	17.6
	W (Ab)	(34.4±1.35)	(7.35±0.23)	(68.5±1.76)	(32.7±1.08)	(4.95±0.41)	

Keywords: *AB= Abaxial surface; AD= Adaxial surface; L= Length; Mean= Average value; SE= Standard error; W= Width; - (Absent).

Table 3.5: Quantitative micro-morphological features of trichomes of family Rosacea.

Taxa	Non-Glandular Trichome					Glandular Trichome		
	Length AD (Mean ± SE)	Width AD (Mean ± SE)	Length AB (Mean ± SE)	Width AB (Mean ± SE)	NGTI AD x AB	Length AB (Mean ± SE)	Width AB (Mean ± SE)	GTI (%)
***Pyrus pashia* Buch.-Ham. ex D.Don**	-	-	-	-	-	-	-	-
***Pyrus calleryana* Decne.**	-	-	(858.2±34.6)	(16.1±1.25)	1.54	-	-	-
***Pyrus communis* L.**	-	-	-	-	-	-	-	-
***Pyrus bretschneideri* Rehder**	-	-	(966.4±32.2)	(17.8±0.34)	0.98	-	-	-
***Pyrus pyrifolia* (Burm.f.) Nakai**	-	-	-	-	-	-	-	-
***Prunus persica* L. Batsch**	-	-	-	-	-	-	-	-
***Prunus domestica* L.**	-	-	(351.0±76.2)	(24.6±1.79)	3.22	-	-	-
***Prunus armeniaca* L.**	(228.5±36.31)	(25.5±1.72)	(339.3±19.0)	(22.1±0.62)	0.96 1.02	-	-	-
***Prunus dulcis* (Mill.) D.A.Webb**	-	-	-	-	-	-	-	-
***Prunus cerasus* L.**	-	-	(484.3±37.3)	(28.3±0.72)	1.78	-	-	-
***Prunus avium* L.**	(132.7±25.5)	(30.7±2.0)	(771.7±11.9)	(23.2±0.83)	1.38 6.81	-	-	-
***Potentilla supina* L.**	(236.4±48.5)	(11.9±3.13)	(233.8±34.7)	(10.0±0.22)	1.61 5.12	(65.7±0.78)	(24.1±0.23)	2.56
***Potentilla recta* L.**	(885.5±57.9)	(25.1±1.22)	(656.0±46.2)	(19.3±0.86)	6.38 8.51	(49.6±1.30)	(25.8±1.17)	6.12
***Potentilla reptans* L.**	(891.9±59.7)	(20.6±1.50)	(779.8±15.9)	(21.1±2.78)	1.92 6.25	(46.5±1.96)	(25.0±0.17)	9.37
***Potentilla nepalensis* Hook.**	(1003.0±20.2)	(25.1±0.23)	(551.4±42.8)	(15.9±0.63)	2.63 4.76	(64.2±3.72)	(23.3±1.59)	4.76
***Potentilla atrosanguinea* G.Lodd. ex D.Don**	(817.5±10.1)	(8.85±0.30)	(522.7±61.3)	(15.2±1.31)	14.1 43.7	(62.4±2.12)	(22.4±1.01)	2.08

***Potentilla crantzii* (Crantz) Beck ex Fritsch**	(566.1±1.17)	(34.4±2.45)	(467.1 ±1.26)	(34.3±6.77)	1.61 7.31	-	-	-
***Rosa indica* L.**	-	-	(319.8±69.0)	(13.6±1.04)	1.58	-	-	-
***Rosa banksiae* R.Br.**	(374.6±43.5)	(12.4±0.88)	(488.1±23.5)	(10.0±0.17)	1.16 1.06	-	-	-
***Rosa chinensis* Jacq.**	-	-	(431.3±4.74)	(9.95±0.21)	0.49	-	-	-
***Rosa × damascena* Herrm.**	-	-	(212.5±46.4)	(9.70±1.52)	14.6	-	-	-
***Rosa laevigata* Michx.**	-	-	-	-	-	-	-	-
***Rosa brunonii* Lindl.**	-	-	(293.1±35.3)	(7.50±0.17)	2.77	-	-	-
***Rosa canina* L.**	(378.4±56.1)	(9.30±0.39)	(384.1±83.0)	(9.80±0.33)	1.13 1.66	-	-	-
***Rosa pendulina* L.**	-	-	-	-	-	-	-	-
***Rosa webbiana* Wall. ex Royle**	-	-	(369.8±41.3)	(10.2±0.26)	1.72	-	-	-
***Rubus macilentus* Jacquem. ex Cambess.**	(174.0±6.55)	(10.7±0.35)	(172.0±5.52)	(10.3±0.25)	1.12 1.63	(60.1±12.9)	(59.6±0.79)	1.08
***Rubus vestitus* Weihe**	(561.5±94.5)	(17.7±2.46)	(551.6±1.01)	(16.0±1.87)	2.4 24.48	-	-	-
***Fragaria nubicola* (Lindl. ex.Hook.f.) Lacaita**	-	-	(606.1±1.02)	(10.0±1.76)	1.72	(49.0±0.65)	(10.3±1.42)	4.91
***Fragaria vesca* L.**	(851.7±1.13)	(15.9±2.53)	(626.1±1.10)	(12.2±0.32)	1.52 2.77	(37.0±3.14)	(10.1±0.26)	4.16
***Geum urbanum* L.**	(553.3±98.1)	(25.5±1.57)	(631.4±1.16)	(26.5±1.59)	2.53 1.02	(101.7±10.3)	(28.1±0.87)	1.26
***Geum elatum* var. humile (Royle) Franch.**	(486.4±93.3)	(18.8±2.28)	(234.8±43.2)	(10.8±0.51)	3.57 17.0	(54.3±25.6)	(14.1±1.17)	24.3
***Spiraea prunifolia* Siebold & Zucc.**	-	-	-	-	-	-	-	-
***Spiraea canescens* D.Don**	-	-	-	-	-	-	-	-
***Cotoneaster nummularius* Fisch. & C.A.Mey.**	-	-	(484.8±39.0)	(18.7±1.63)	0.90	-	-	-

***Cotoneaster affinis* Lindl.**	(276.0±4.17)	(14.8±0.26)	-	-	0.62	-	-	-
***Crataegus songarica* K. Koch**	(464.0±49.8)	(30.2±1.14)	-	-	1.38	-	-	-
***Cydonia oblonga* Mill.**	(1131.5±11.4)	(18.5±1.63)	(1176.4±82.1)	(19.4±1.78)	1.14 8.33	-	-	-
***Duchesnea indica* (Jacks.) Focke**	(506.4±1.07)	(18.3±1.56)	(968.4±1.32)	(19.2±0.41)	2.85 2.56	(74.4±2.34)	(29.3±0.97)	2.56
***Eriobotrya japonica* (Thunb.) Lindl.**	-	-	(776.1±1.66)	(22.0±1.96)	8.43	-	-	-
***Malus pumila* Mill.**	-	-	(867.4±54.7)	(17.0±0.79)	0.49	-	-	-
***Sorbaria tomentosa* (Lindl.) Rehder**	-	-	(594.4±1.06)	(11.3±1.12)	0.74	-	-	-
***Sibbaldia procumbens* L.**	(982.1±37.0)	(25.5±3.29)	(1132.6±9.80)	(26.1±0.60)	0.41 0.71	-	-	-
***Sibbaldia cuneata* Hornem. ex Kuntze**	(751.4±11.8)	(25.8±4.0)	(829.0±1.23)	(35.2±4.28)	0.4 0.81	(40.3±0.23)	(13.2±0.01)	0.81
***Sanguisorba minor* Scop.**	-	-	(637.8±11.4)	(27.0±0.53)	1.17	-	-	-
***Filipendula ulmaria* (L.) Maxim.**	-	-	(1155.6±46.4)	(7.5±0.17)	16.9	-	-	-
***Acomastylis elata* (Wall. ex G.Don) F.Bolle**	(467.4±49.6)	(20.3±1.43)	(401.7±62.4)	(19.5±1.30)	3.57 2.43	(80.0±0.71)	(27.5±0.31)	2.43

Key words: *AD= Adaxial surface; AB= Abaxial surface; NGTI= non-glandular trichome index; GTI= Glandular trichome Index; - (Absent).

Table 3.6: Dichotomous key based on foliar micromorphological characters of Rosaceous species.

Link character	Present (+) Absent (-)	Diagnostic characters	Species name
1	+	Leaves amphistomatic, tetracytic stomata, curved to the sinuate anticlinal wall, up to 6 epidermal lobes, capitate trichomes	*Geum urbanum*
	-	Stephanocytic sunken stomata, 3 to 8 epidermal lobes……………………………….	2
2	+	Sinuate anticlinal wall, cylindrical and uniseriate trichomes	*Geum elatum* var. *humile*
	-	Undulate anticlinal wall, glandular capitate trichomes	3
3	+	Paracytic stomata and slightly raised, epidermal lobes 7 to 8	*Duchesnea indica*
	-	Curved to undulate anticlinal wall, up to 4 epidermal lobes	4
4	+	Stephanocytic sunken stomata, cylindrical and elongated capitate trichomes	*Acomastylis elata*
	-	Deeply undulate anticlinal wall, up to 5 epidermal lobes	5
5	+	Conical uniseriate trichomes, laterocytic stomata	*Potentilla recta*
	-	Unicellular conical trichomes, slightly straight anticlinal wall	6
6	+	Staurocytic to laterocytic stomata, up to 6 epidermal lobes	*Potentilla crantzii*
	-	Laterocytic stomata, up to 4 epidermal lobes	7
7	+	Conical uniseriate capitate trichomes, straight anticlinal wall	*Potentilla reptans*
	-	Stephanocytic stomata, up to 6 epidermal lobes	8
8	+	Slightly curved anticlinal wall, uniseriate conical trichomes	*Potentilla nepalensis*
	-	Slightly curved anticlinal wall, elongated capitate trichomes	9
9	+	Laterocytic slightly sunken stomata, up to 3 epidermal lobes	*Potentilla supina*
	-	Curved to undulate anticlinal wall, cylindrical short capitate trichomes	10

10	+	Staurocytic stomata, up to 3 epidermal lobes	*Sibbaldia cuneata*
	-	Stephanocytic stomata, up to 4 epidermal cell lobes	11
11	+	Undulate anticlinal wall, unicellular trichomes	*Sibbaldia procumbens*
	-	Hypostomatic leaves, wavy anticlinal wall	12
12	+	Paracytic stomata, cylindrical uniseriate trichomes	*Cotoneaster nummularius*
	-	Straight to wavy anticlinal walls, unicellular trichomes	13
13	+	Up to 3 epidermal lobes, actinocytic stomata	*Cotoneaster affinis*
	-	Raised paracytic stomata, conical uniseriate trichomes	14
14	+	Undulate to sinuate anticlinal walls, up to 5 epidermal lobes	*Crataegus songarica*
	-	Paracytic stomata, up to 5 epidermal lobes	15
15	+	Sinuate anticlinal walls, uniseriate trichomes	*Cydonia oblonga*
	-	Curved to undulate anticlinal wall, up to 4 epidermal lobes	16
16	+	Staurocytic stomata, cylindrical uniseriate trichomes	*Eriobotrya japonica*
	-	Unicellular trichomes, up to 3 epidermal lobes	17
17	+	Stephanocytic stomata, wavy to undulate anticlinal wall	*Filipendula ulmaria*
	-	Undulate to wavy anticlinal wall, up to 6 epidermal lobes	18
18	+	Laterocytic stomata, multicellular capitate trichomes	*Fragaria vesca*
	-	Roughly curved anticlinal wall, Multicellular dumbbell capitate trichomes	19
19	+	Actinocytic stomata, up to 3 epidermal lobes	*Fragaria nubicola*
	-	Paracytic stomata, up to 5 epidermal lobes	20
20	+	Curved to sinuate anticlinal wall, Uniseriate trichomes	*Malus pumila*

	-	Laterocytic stomata, up to 5 epidermal lobes	21
21	+	Deeply undulate anticlinal wall, Multicellular conical capitate trichomes	*Potentilla atrosanguinea*
	-	Undulate to sinuate anticlinal wall, cylindrical unicellular trichomes	22
22	+	Stephanocytic, up to 7 epidermal lobes	*Prunus avium*
	-	Undulate to sinuate anticlinal wall, uniseriate trichomes	23
23	+	Tetracytic stomata, up to 9 epidermal lobes	*Prunus cerasus*
	-	Up to 3 epidermal lobes, tetracytic stomata	24
24	+	Straight to wavy anticlinal wall, trichomes absent	*Prunus dulcis*
	-	Straight anticlinal wall, unicellular conical trichomes	25
25	+	Anomocytic stomata, up to 6 epidermal lobes	*Prunus armeniaca*
	-	Cylindrical trichomes, simply wavy anticlinal wall	26
26	+	Up to 7 epidermal lobes, anomocytic stomata	*Prunus domestica*
	-	Trichomes absent, up to 3 epidermal lobes	27
27	+	Roughly undulate anticlinal wall, anomocytic stomata	*Prunus persica*
	-	Up to 4 epidermal lobes, anomocytic stomata	28
28	+	Slightly curved anticlinal wall, trichomes absent	*Pyrus pyrifolia*
	-	Uniseriate trichomes, up to 3 epidermal lobes	29
29	+	Smoothly curved anticlinal wall, anomocytic stomata	*Pyrus bretschneideri*
	-	Stephanocytic stomata, up to 5 epidermal lobes	30
30	+	Roughly undulate anticlinal wall, trichomes absent	*Pyrus communis*
	-	Undulate anticlinal wall, up to 4 epidermal lobes	31

31	+	Elongated conical trichomes, stephanocytic stomata	*Pyrus calleryana*
	-	Stephanocytic stomata, up to 7 epidermal lobes	32
32	+	Deeply undulate anticlinal wall, trichomes absent	*Pyrus pashia*
	-	Straight to wavy anticlinal walls, up to 4 epidermal lobes	33
33	+	Paracytic stomata, uniseriate trichomes	*Rosa indica*
	-	Wavy to undulate anticlinal wall, cylindrical unicellular trichomes	34
34	+	Actinocytic stomata, up to 5 epidermal lobes	*Rosa banksiae*
	-	Up to 6 epidermal lobes, unicellular trichomes	35
35	+	Tetracytic stomata, undulate anticlinal wall	*Rosa chinensis*
	-	Stephanocytic stomata, up to 5 epidermal lobes	36
36	+	Undulate to straight anticlinal wall, uniseriate trichomes	*Rosa × damascena*
	-	Cylindrical unicellular trichomes, up to 7 epidermal lobes	37
37	+	Paracytic stomata, sinuate anticlinal wall	*Rosa brunonii*
	-	Cylindrical trichomes, paracytic stomata	38
38	+	Sinuate anticlinal walls, up to 9 epidermal lobes	*Rosa canina*
	-	Trichomes absent, paracytic stomata	39
39	+	Smoothly curved anticlinal wall, up to 5 epidermal lobes	*Rosa laevigata*
	-	Paracytic stomata, trichomes absent	40
40	+	Sinuate anticlinal wall, up to 9 epidermal lobes	*Rosa pendulina*
	-	Unicellular trichomes, up to 6 epidermal lobes	41
41	+	Paracytic stomata, wavy anticlinal wall	*Rosa webbiana*
	-	Up to 7 epidermal lobes, sinuate anticlinal walls	42

42	+	Stephanocytic stomata, multicellular capitate trichomes	*Rubus macilentus*
	-	Sinuate anticlinal wall, up to 6 epidermal lobes	43
43	+	Stellate and cylindrical trichomes, stephanocytic stomata	*Rubus vestitus*
	-	Paracytic stomata, up to 7 epidermal lobes	44
44	+	Undulate anticlinal wall, unicellular cylindrical trichomes	*Sanguisorba minor*
	-	Conical trichomes, up to 5 epidermal cells	45
45	+	Curved anticlinal wall, anomocytic stomata	*Sorbaria tomentosa*
	-	Actinocytic stomata, up to 3 epidermal lobes	46
46	+	Curved to sinuate anticlinal wall, trichomes absent	*Spiraea canescens*
	-	Paracytic stomata, up to 5 epidermal lobes	47
47	+	Curved anticlinal wall, trichomes absent	*Spiraea prunifolia*

3.3 POLLEN MORPHOLOGICAL DESCRIPTION

(1) *Pyrus pashia* Buch.-Ham D.Don

Pollen grains were revealed to be sub-oblate in equatorial views and medium in size, tricolpate, and triangular in polar views. Prolate spheroidal was identified as the pollen's class. It was discovered that the polar and equatorial diameters were 26.6±2.47 µm and 24.7±1.87 µm, respectively. Colpi were 6.15±0.55 µm in length and probably 7.75±0.26 µm in width. calculated exine thickness was 3.5± 0.25µm. P/E ratio was computed to be 1.03.

(2) *Rosa indica* L.

Pollen grains were revealed to be slightly circular in polar views, large in size, tricolporate, and prolate in Equatorial view. Prolate was determined to be the pollen's class. The diameters were measured to be 34.8±2.47 µm for the polar orientation and 22.6±0.76 µm for the equatorial orientation. Colpi's length and width were 5.75±0.26 µm and 5.55±0.14 µm, separately. The typical length of pore was 0.6±0.12 µm while the median width of pore was 0.4±0.10 µm. assessed exine thickness was 4.65±0.20 µm. P/E ratio was noticed to be 1.53.

(3) *Prunus persica* L. Batsch

Pollen grains were determined to be slightly circular in polar view, medium in size, tricolpate and sub-prolate in Equatorial view. Sub-prolate was determined to be the pollen's class. The diameters were measured to be 34.6±2.17 µm for the polar orientation and 26.7±2.13 µm for the equatorial orientation. Colpi's length and width were 6.50±0.39 µm and 6.50±0.35 µm, respectively. Analyzed exine thickness was 4.55±0.64 µm. P/E ratio was noticed to be 1.29.

(4) *Cydonia oblonga* Mill.

A polar view revealed that pollen grains were large, tricolpate, and triangular, while an equatorial view revealed that they were sub-oblate. Sub-prolate was determined to be the pollen's class. The diameters were measured to be 40.9±0.95 µm for the polar region and 35.0±0.75 µm for the equatorial region. Colpi's width was 9.55±0.46 µm and their length was 7.90±0.64 µm. Assessed exine thickness was 4.50±0.11 µm. P/E ratio was got to be 1.16.

(5) *Prunus domestica* L.

It was determined that pollen grains were small, tricolporate, and triangular in polar orientation, and oblate in equatorial orientation. Prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were 24.5±2.18 µm and 17.4±0.20 µm, correspondingly. Length of colpi was measured 73.95±0.21 µm and width was 5.70±0.42 µm. The standard length of pore was 0.95±0.18 µm while the regular width of pore was 0.65±0.16 µm. Calculated exine thickness was 5.40±0.10 µm. P/E ratio was found to be 1.40.

(6) *Prunus armeniaca* L.

In polar perspective, pollen grains were determined to be large, tricolpate, and triangular, whereas in equatorial view, they were prolate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 44.2±0.72 µm and 38.3±0.87 µm, respectively. Length of colpi was measured 4.55±0.93 µm and width was 5.2±0.53 µm. Calculated exine thickness was 6.40±0.38 µm. P/E ratio originated to be 1.15.

(7) *Rubus ellipticus* Sm.

Pollen grains were observed to be large size, tricolporate, and marginally circular in polar view and sub-prolate in equatorial position. A sub-prolate classification for the pollen was revealed. It was observed that the polar and equatorial diameters were, respectively, 23.9±1.40 µm and 18.9±0.71 µm . Colpi were measured at 7.65±0.30 µm and 7.3±0.30 µm in length as well as width, respectively. The average length of pore was 1.25±0.17 µm while the average width of pore was 1.50±0.27 µm. Calculated exine width was 5.60±0.18 µm. P/E ratio was got to be 1.26.

(8) *Duchesnea indica* (Jacks.) Focke

In polar perspective, pollen grains were revealed to be medium in size, tricolpate, and triangular, whereas in equatorial view, they were sub-prolate. Prolate spheroidal pollen was identified as its pollen type. The diameters at the polar and the equatorial were measured to be 32.2±1.04 µm and 29.3±1.39 µm, respectively. Colpi were measured at 4.55±0.93 µm in length and 5.55±0.14 µm in width. Calculated exine thickness was calculated 4.95±0.31 µm. P/E ratio was noticed to be 1.09

(9) *Malus pumila* Mill.

In polar perspective, pollen grains were determined to be large, tricolpate, and triangular, whereas in equatorial view, they were circular. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 35.9±1.72 µm and 29.5±1.17 µm, respectively. Colpi were 10.2±0.2 µm in length and 8.4±0.4 µm in width. 5.30±0.28 µm was calculated as the exine thickness. P/E ratio got to be 1.21.

(10) *Prunus dulcis* (Mill.) D.A.Webb

In polar perspective, pollen grains were revealed to be medium in size, tricolpate, and triangular, whereas in equatorial view, they were sub-prolate. Sub-prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were, respectively, 31.3±1.42 µm and 23.8±0.50 mµ. Colpi were measured to be 7.2±0.30 µm in length and 8.9±0.33 µm in width. Computed exine thickness was 5.25±0.36 µm. P/E ratio was observed to be 1.31.

(11) *Pyrus calleryana* Decne.

In polar orientation, pollen grains were observed to be small, tricolpate, and triangular whereas oblate in equatorial orientation. Prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were 35.6±1.14 µm and 24.8±1.27 µm , accordingly. Colpi were 5.75±0.26 µm in length and 7.2±0.50 µm in width. Exine thickness was measured to be 4.5±0.32 µm. P/E ratio was set up to be 1.43.

(12) *Rosa banksiae* R.Br.

In polar viewing, pollen grains were reported to be small, tricolporate, and triangular, whereas in equatorial view, they were prolate. Prolate spheroidal was found as the pollen's class. It was observed that the polar and equatorial diameters were 22.9±0.43 µm and 20.6±0.45 µm, accordingly. Colpi were measured at 4.45±0.33 µm in length and 6.1±0.38 µm in width. The average pore measured 0.85±0.25 µm in length and 1.5±0.25 µm in width. Calculated exine thickness was 4.05±0.40 µm. P/E ratio was observed to be 1.11.

(13) *Rosa chinensis* Jacq.

In polar viewing, pollen grains were observed to be large, tricolporate, and triangular, but in equatorial view, they were per-prolate. The pollen was classified as Prolate in class. The diameters at the polar and the equatorial were measured to be 27.0±2.35 µm and 19.8±0.43 µm, accordingly. Colpi were 5.30±0.20 µm long and 8.5± 0.23 µm wide. Pores had to have an average length of 0.65±0.12 µm and a typical width of 1.20±0.27 µm. Assessed exine thickness was 3.50±0.11 µm. P/E ratio was found to be 1.36.

(14) *Potentilla supina* L.

Pollen grains were revealed to be small, tricolporate, quadrangular in polar position, and per-prolate in equatorial orientation. Pollen was identified as belonging to the Sub-prolate class. It was observed that the polar and equatorial diameters were 22.3±1.31 µm and 19.1±0.43 µm, accordingly. Colpi were 4.95± 0.40 µm in length and 6.5±0.25 µm in width. The typical pore measured 1.75±0.17 µm in length and 0.70±0.14 µm in width. Calculated exine thickness is 4.00±0.17 µm. P/E ratio was got to be 1.16.

(15) *Prunus cerasus* L.

In polar oreintation, pollen grains were discovered to be medium in size, tricolpate, and circular, but in equatorial view, they were per-prolate. Prolate was recognized as the pollen's class. It was observed that the polar and equatorial diameters were 32.0±1.66 µm and 20.0±0.49 µm, respectively. Colpi were measured at 7.15±0.43 µm in width and 8.20±0.33 µm in length. 3.80±0.21 µm was calculated as the exine thickness. P/E ratio was got to be 1.59.

(16) *Pyrus communis* L.

In polar view, pollen grains were determined to be small, tricolporate, and circular, whereas in equatorial view, they were sub-prolate. Prolate spheroidal was recognized as the pollen's class. It was observed that the polar and equatorial diameters were 20.4±0.37 µm and 19.4±0.55 µm, accordingly. Colpi were 5.40±0.24 µm in length and 6.25±0.35 µm in width. The typical pore measured 1.4 0.18 m in length and 0.75 0.17 m in width. Exine thickness was estimated to be 3.9±0.31 µm. P/E ratio was observed to be 1.05.

(17) *Pyrus bretschneideri* Rehder

Pollen grains were discovered to be Oblate in equatorial view and Medium in size, Tricolpate, and Triangular in polar orientation. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 23.6±0.70 µm and 18.8±0.70 µm, respectively. Colpi were measured at 9.05± 0.4 µm in length and 10.3±0.35 µm in width. The computed exine thickness was 4.8±0.37 µm. P/E ratio was set up to be 1.25.

(18) *Rubus macilentus* Jacquem. ex Cambess.

In polar perspective, pollen grains were reported to be small, tricolporate, and slightly circular, whereas in equatorial view, they were sub-prolate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 25.4±0.67 µm and 19.9±0.41 µm, respectively. Colpi were 5.55±0.42 µm in length and 5.85±0.29 µm in width. The average pore measured 0.65±0.12 µm in length and 1.45±0.18 µm in width. Assessed exine thickness was 4.45±0.26 µm. P/E ratio was set up to be 1.27.

(19) *Pyrus pyrifolia* (Burm.f.) Nakai

In polar oreintation, pollen grains were revealed to be small, tricolporate, and circular, whereas in equatorial view, they were sub-oblate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were, 25.2±0.42 µm and 21.1±0.60 µm. Colpi were 9.75±0.57 µm in length and 10.8±0.43 µm in width. The average length of pore was 0.65±0.12 µm while the average width of pore was 1.85±0.16 µm. Estimated exine thickness was 4.5±0.25 µm. P/E ratio was noticed to be 1.19.

(20) *Prunus avium* (L.) L.

In polar oreintation, pollen grains were reported to be large, tricolpate, and triangular, whereas in equatorial view, they were sub-prolate. Prolate was recognized as the pollen's class. It was observed that the polar and equatorial diameters were 4.6±1.20 µm and 25.2±0.96 µm, accordingly. Colpi were 10.3±0.39 µm in length and 8.55±0.42 µm in width. 5.40±0.18 µm was evaluated as the exine thickness. P/E ratio was set up to be 1.37.

(21) *Rubus vestitus* Weihe

In polar viewing, pollen grains were determined to be small, tricolpate, and triangular, whereas in equatorial view, they were sub-oblate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 25.8±0.64 µm and 19.6±0.9 µm, respectively. Colpi were measured 9.0±0.35 µm in length and 9.65±0.43 µm in width. Assessed exine thickness was 4.50±0.28 µm. P/E ratio was found to be 1.31.

(22) *Rosa × damascena* Herrm.

In polar view, pollen grains were revealed to be small, tricolpate, and slightly circular, whereas in equatorial view, they were prolate. Sub-prolate was identified as the pollen's class. The diameters at the polar and the equatorial were observed to be 21.1±0.50 µm and 17.1±0.44 µm, accordingly. Colpi were 9.85±0.23 µm and 8.95±0.46 µm in length and width, respectively. 4.70±0.16 µm was calculated as the exine thickness. P/E ratio was observed to be 1.24.

(23) *Fragaria nubicola* (Lindl. ex.Hook.f.) Lacaita

A polar view revealed that pollen grains were small, tricolpate, and triangular, while an equatorial view revealed that they were prolate. Sub-prolate was identified as the pollen's class. The diameters at the polar and the equatorial were measured to be 20.9±0.18 µm and 116.9±0.30 µm, respectively. Colpi's width was 9.85±0.23 µm and their length was 9.05 0.31 m. 5.70±0.61 µm was calculated as the exine thickness. P/E ratio was noticed to be 1.23.

(24) *Cotoneaster nummularius* Fisch. & C.A.Mey.

In polar view, pollen grains were determined to be medium in size, tetracolpate, quadrangular, whereas equatorial views revealed them to be sub-oblate. Prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were 25.5±0.52 µm and 17.8±0.66 µm, respectively. Colpi were 9.05±0.31 µm in length and 7.0±0.48 µm in width. The typical pore measured 1.05±0.09 µm in length and 11.75±0.13 µm in width. 3.80±0.45 µm was calculated as the exine thickness. P/E ratio was observed to be 1.43.

(25) *Rosa laevigata* Michx.

Pollen grains were reported to be Medium in size, Tricolporate, and Circular in both Polar and Equatorial orientations. A sub-prolate classification for the pollen was observed. The diameters were measured to be 25.4±0.71 µm for the polar region and 19.2±0.39 µm for the equatorial region. Colpi were measured at 7.25±0.28 µm in width and 8.65±0.45 µm in length. In terms of average length and width, pores were 1.85±0.12 µm and 0.70±0.09 µm correspondingly. The exine thickness was calculated to be 33.8±0.45 µm. P/E ratio was set up to be 1.32.

(26) *Fragaria vesca* L.

In polar view, pollen grains were determined to be medium in size, tricolpate, and slightly triangular, whereas in equatorial view, they were prolate. Sub-prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were, respectively, 21.1±0.34 µm and 17.7±0.35 µm. The width of the colpi was 4.9±0.26 µm and its length was 6.65±0.53 µm. 4.85±0.23 µm was calculated as the exine thickness. P/E ratio was got to be 1.19.

(27) *Spiraea prunifolia* Siebold & Zucc.

In polar oreintation, pollen grains were reported to be small, tricolpate, and slightly triangular, whereas in equatorial view, they were sub-prolate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were, respectively, 18.7±0.30 µm and 14.0±0.31 µm. Colpi was measured at 6.25±0.28 µm in length and 4.0±0.28 µm in width. 3.75±0.30 µm was computed as the exine thickness. P/E ratio was noticed to be 1.33.

(28) *Rosa brunonii* Lindl.

In polar view, pollen grains were revealed to be medium in size, tricolpate, and slightly triangular, whereas in equatorial view, they were sub-oblate. Prolate spheroidal was identified as the pollen's class. It was observed that the polar and equatorial diameters were 18.1±0.26 µm and 16.2±0.33 µm, respectively. Colpi was 4.40±0.26 µm in length and 5.2±0.26 µm in width. Computed exine thickness was 4.40±0.18 µm. P/E ratio was found to be 1.11.

(29) *Spiraea canescens* D.Don

In polar view, pollen grains were determined to be small, tricolpate, and triangular, whereas in equatorial view, they were sub-oblate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 10.4±0.93 µm and 7.95±0.48 µm, respectively. Colpi were 3.85±0.30 µm in length and 3.5±0.25 µm in width. 3.20±0.16 µm was calculated as the exine thickness. P/E ratio was got to be 1.30.

(30) *Potentilla recta* L.

In polar view, pollen grains were revealed to be small, tricolpate, and triangular whereas in equatorial view, they were prolate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 21.3±0.55 µm and 16.4±0.28 µm, respectively. Colpi were measured at 5.65±0.30 µm in width and 6.50±0.35 µm in length. 3.65±0.12 µm was calculated as the exine thickness. P/E ratio was noticed to be 1.29.

(31) *Rubus niveus* Thunb.

In polar view, pollen grains were observed to be small, tricolporate, and circular, whereas in equatorial view, they were prolate. The pollen was classified as Sub-prolate. It was discovered that the polar and equatorial diameters were 1.9±0.52 µm and 18.3±0.68 µm, accordingly. Colpi were measured at 3.30±0.14 µm and width was 3.8±0.37 µm in length and width, correspondingly. The average pore measured 0.65±0.15 µm in length and 1.20±0.18 µm in width. 3.75±0.35 µm was computed as the exine thickness. P/E ratio was got to be 1.19.

(32) *Cotoneaster affinis* Lindl.

Pollen grains were discovered to be Circular in equatorial view and Medium in size, Tricolpate, and Quinquangular in polar perspective. Spherical was determined to be the pollen's class. It was observed that the polar and equatorial diameters were, respectively, 18.9±0.44 µm and 15.8±0.20 µm. Colpi were 5.65±0.32 µm in length and 6.95±0.28 µm in width. Calculated exine thickness was 4.35±0.32 µm. P/E ratio was noticed to be 1.00.

(33) *Sorbaria tomentosa* (Lindl.) Rehder

Pollen grains were reported to be small, tricolpate, and triangular in polar position and sub-prolate in equatorial view position. Pollen was identified as belonging to the Sub-prolate class. It was calculated that the polar and equatorial diameters were 10.7±0.10 µm and 8.70±0.21 µm, individually. Colpi were 6.40±0.26 µm in length and 4.9±0.26 µm in width. The exine thickness was calculated to be 4.05±0.21 µm. P/E ratio was got to be 1.22.

(34) *Rosa canina* L.

In polar view, pollen grains were revealed to be medium in size, tricolporate, and circular, whereas in equatorial view, they were prolate. The pollen was classified as Prolate in class. It was observed that the polar and equatorial diameters were 18.6±0.34 µm and 13.4±0.46 µm, respectively. Colpi were 6.9±0.29 µm in length and 5.9±0.29 µm in width. Pores seemed to have an average length of 0.45±0.93 µm and average width of 1.65±0.23 µm. Calculated exine thickness was 3.90±0.15 µm. P/E ratio was found to be 1.38.

(35) *Geum urbanum* L.

In polar view, pollen grains were reported to be small, tricolporate, and triangular, whereas in equatorial view, they were prolate. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 21.0±0.60 µm and 15.7±0.42 µm, respectively. Colpi were 7.25±0.30 µm in length and 5.05±0.21 µm in width. The typical pore measured 1.05±0.09 µm in length and 1.10±0.12 µm in width. 3.60±0.12 µm was calculated as the exine thickness. P/E ratio was found to be 1.33.

(36) *Crataegus songarica* K. Koch

Pollen grains were determined to be Prolate in equatorial view and Medium in size, Tricolporate, and Triangular in polar perspective. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 23.9±0.41 µm and 18.7±0.42 µm, respectively. Colpi were 9.35±0.45 µm in length and 8.3±0.39 µm in width. The typical pore measured 1.10±0.12 µm in length and 1.55±0.28 µm in width. Assessed exine thickness was 4.25±0.17 µm. P/E ratio was found to be 1.27.

(37) *Potentilla reptans* L.

Pollen grains were reported to be Prolate in equatorial view and Medium in size, Tricolpate, and Triangular in polar view. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 23.4±0.51 µm and 19.9±0.39 µm, respectively. Colpi were 7.1±0.35 µm in length and 6.5±0.79 µm in width. Estimated exine thickness was 4.35±0.16 µm. P/E ratio was found to be 1.17.

(38) *Eriobotrya japonica* (Thunb.) Lindl.

In polar view, pollen grains were determined to be small, tricolpate, and slightly circular, but in equatorial view, they were circular. Prolate spheroidal was identified as the pollen's class. It was observed that the polar and equatorial diameters were 6.2±1.09 µm and 25.2±1.15 µm, respectively. Colpi were 5.6±0.37 µm in length and 7.0±0.24 µm in width. Analyzed exine thickness was 4.65±0.25 µm. P/E ratio was found to be 1.03.

(39) *Rubus occidentalis* L.

Pollen grains were determined to be Prolate in equatorial view and Medium in size, Tricolpate, slightly triangular in polar view. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 23.7±0.35 µm and 18.5±0.27 µm, respectively. Colpi were 8.55±0.39 µm in length and 11.7±0.35 µm in width. 5.10±0.21 µm was calculated as the exine thickness. P/E ratio was got to be 1.28.

(40) *Potentilla nepalensis* Hook.

In polar view, pollen grains were determined to be small, tricolpate, and triangular whereas in equatorial view, they were prolate. Prolate spheroidal was identified as the pollen's class. It was observed that the polar and equatorial diameters were 26.2±0.25 µm and 23.8±0.35 µm, respectively. Colpi were measured at 4.7±0.16 µm and 6.15±0.16 µm in length and width, respectively. 3.40±0.39 µm was calculated as the exine thickness. P/E ratio was set up to be 1.09.

(41) *Sibbaldia procumbens* L.

In both polar and equatorial views, it was discovered that pollen grains were medium in size, tricolporate, and circular. Sub-prolate was identified as the pollen's class. It was revealed that the polar and equatorial diameters were, respectively, 220.7±0.82 µm and 15.9±0.59 µm. Colpi were measured at 6.45±0.40 µm in length along with 6.45±0.33 µm in width. The average length of pore was 0.55±0.07 µm while the average width of pore was 0.55±0.93 µm. Exine width was calculated 3.65±0.23 µm. P/E ratio was found to be 1.30.

(42) *Geum elatum* var. humile (Royle) Franch.

In polar view, pollen grains were reported to be large, tricolporate, and triangular, whereas in equatorial view, they were prolate. Sub-prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were, respectively, 18.4±0.41 µm and 14.7±0.39 µm. Colpi were measured at 7.10±0.33 µm and 6.40±0.48 µm in length and width, individually. The average length of pore was 0.6±0.12 µm while the average width of pore was 1.40±0.12 µm. Exine width was calculated 3.65±0.32 µm. P/E ratio was set up to be 1.25.

(43) *Potentilla atrosanguinea* G.Lodd. ex D.Don

In polar view, pollen grains were revealed to be small, tricolpate, and circular, whereas in equatorial view, they were prolate. Prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were 25.8±0.43 µm and 19.2±1.75 µm, respectively. Colpi were measured at 10.1±0.23 µm and 6.60±0.26 µm in length. Exine thickness was measured to be 19.9±0.26 µm. P/E ratio was found to be 1.34.

(44) *Potentilla crantzii* (Crantz) Beck ex Fritsch

In polar view, pollen grains were determined to be small, tricolpate, and round, whereas in equatorial view, they were prolate. The pollen was identified as Per-prolate in class. It was observed that the polar and equatorial diameters were 32.4±0.20 µm and 15.3±0.32 µm, respectively. Colpi were measured to be12.0±0.48 µm in length and 8.2±0.42 µm in width. Exine thickness was estimated to be 21.5±0.54 µm. P/E ratio was found to be 2.11.

(45) *Filipendula ulmaria* (L.) Maxim.

In both polar and equatorial views, the pollen grain was discovered to be Medium in size, Tricolporate, and Circular. Prolate was identified as the pollen's class. It was observed that the polar and equatorial diameters were 16.1±0.35 µm and 8.45±0.21 µm, respectively. Length of colpi was measured 12.2±0.28 µm and width was

7.45±0.54 µm. The typical length of pore was 1.75±0.17 µm while the standard width of pore was 0.9±0.16 µm. Exine thickness was calculated 9.4±0.38 µm. P/E ratio was noticed to be 1.90.

(46) *Sibbaldia cuneata* Hornem. ex Kuntze

In polar and equatorial views, pollen grains were observed to be small, tricolpate, and circular. The pollen was classified as Sub-prolate. It was observed that the polar and equatorial diameters were 19.6±0.37 µm and 15.1±0.23 µm, respectively. Colpi were measured at 6.3±0.33 µm and 4.6±0.43 µm in length and width, respectively. Calculated exine thickness was 12.0±0.48 µm. P/E ratio was noticed to be 1.29.

(47) *Rosa webbiana* Wall. ex Royle

In both polar and equatorial views, it was reported that pollen grains were small, tricolpate, and circular. The pollen was classified as Prolate in class. The diameters at the polar and the equatorial were measured to be 35.1±1.50 µm and 21.2±0.37 µm, respectively. Colpi were measured at 13.7±0.93 µm in length and 8.85±0.40 µm in width. The predicted exine thickness was 31.40.67 m. P/E ratio was observed to be 1.65.

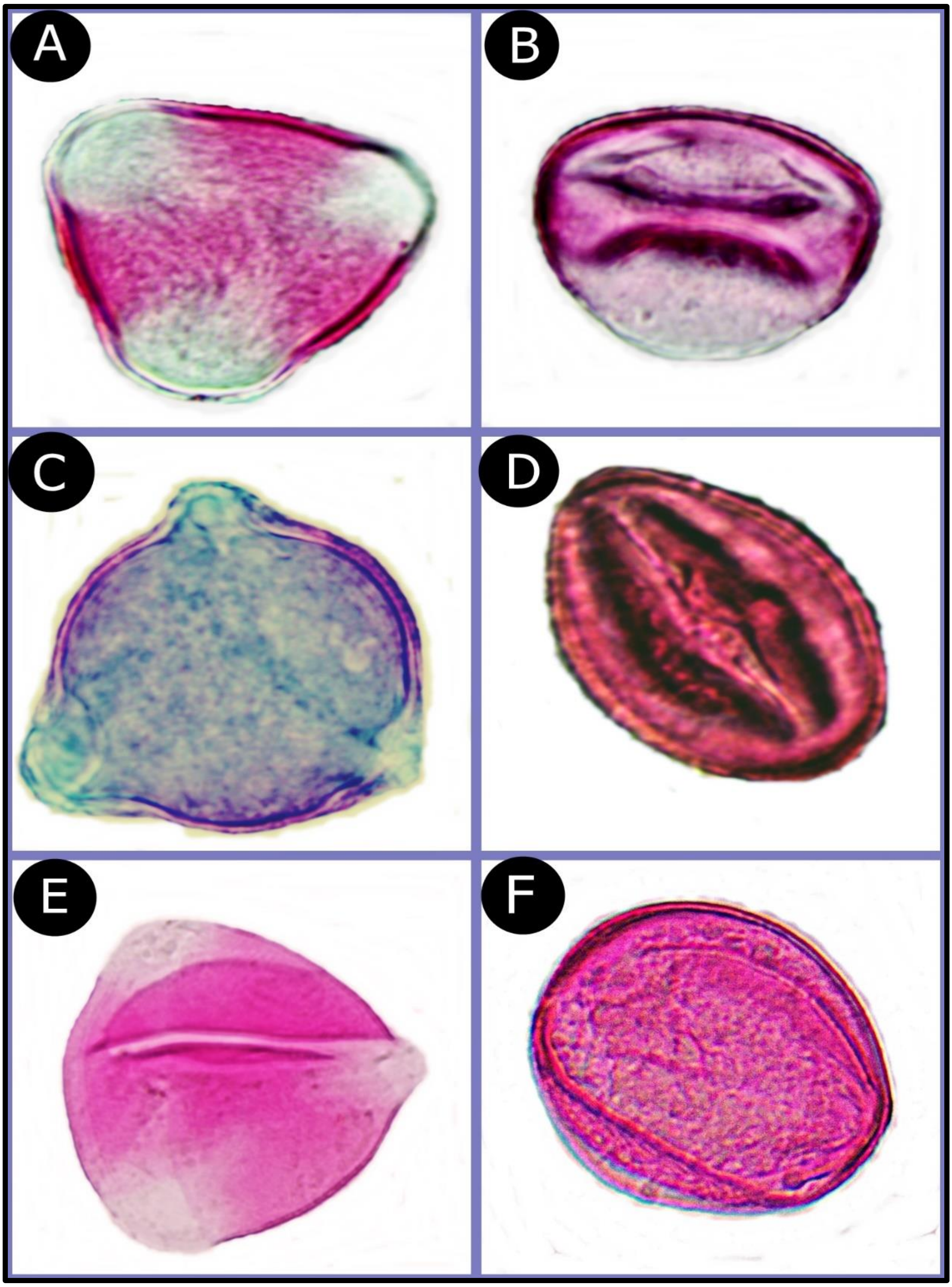


Plate 3.17: Light microscopic pollen photograph taken at 40X of *Pyrus pashia* (A) Polar view (B) Equatorial view, *Rosa indica* (C) Polar view (D) Equatorial view, *Prunus persica* (E) Polar view and (F) Equatorial view.

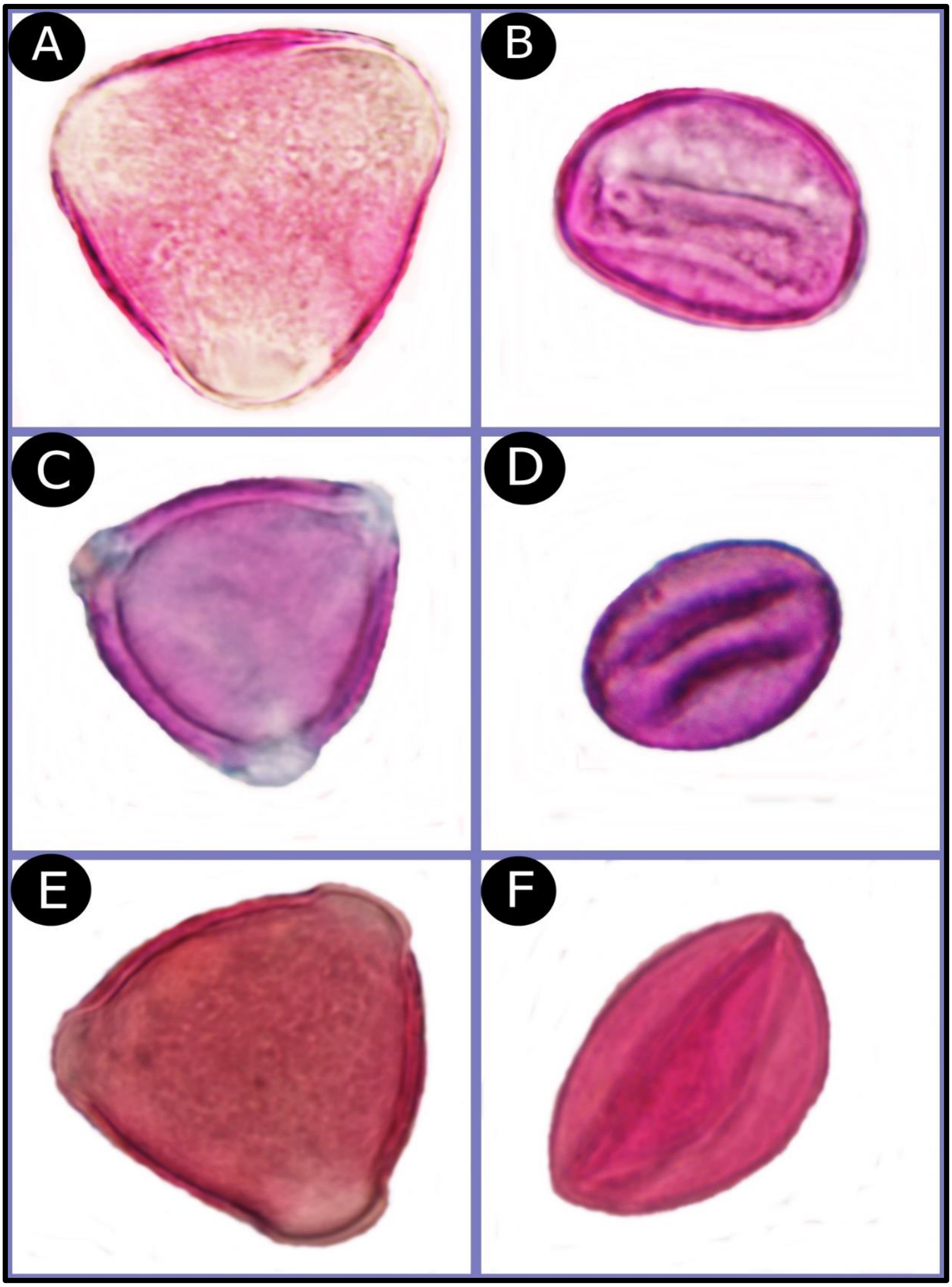


Plate 3.18: Light microscopic pollen photograph taken at 40X of *Cydonia oblonga* (A) Polar view (B) Equatorial view, *Prunus domestica* (C) Polar view (D) Equatorial view, *Prunus armeniaca* (E) Polar view and (F) Equatorial view.

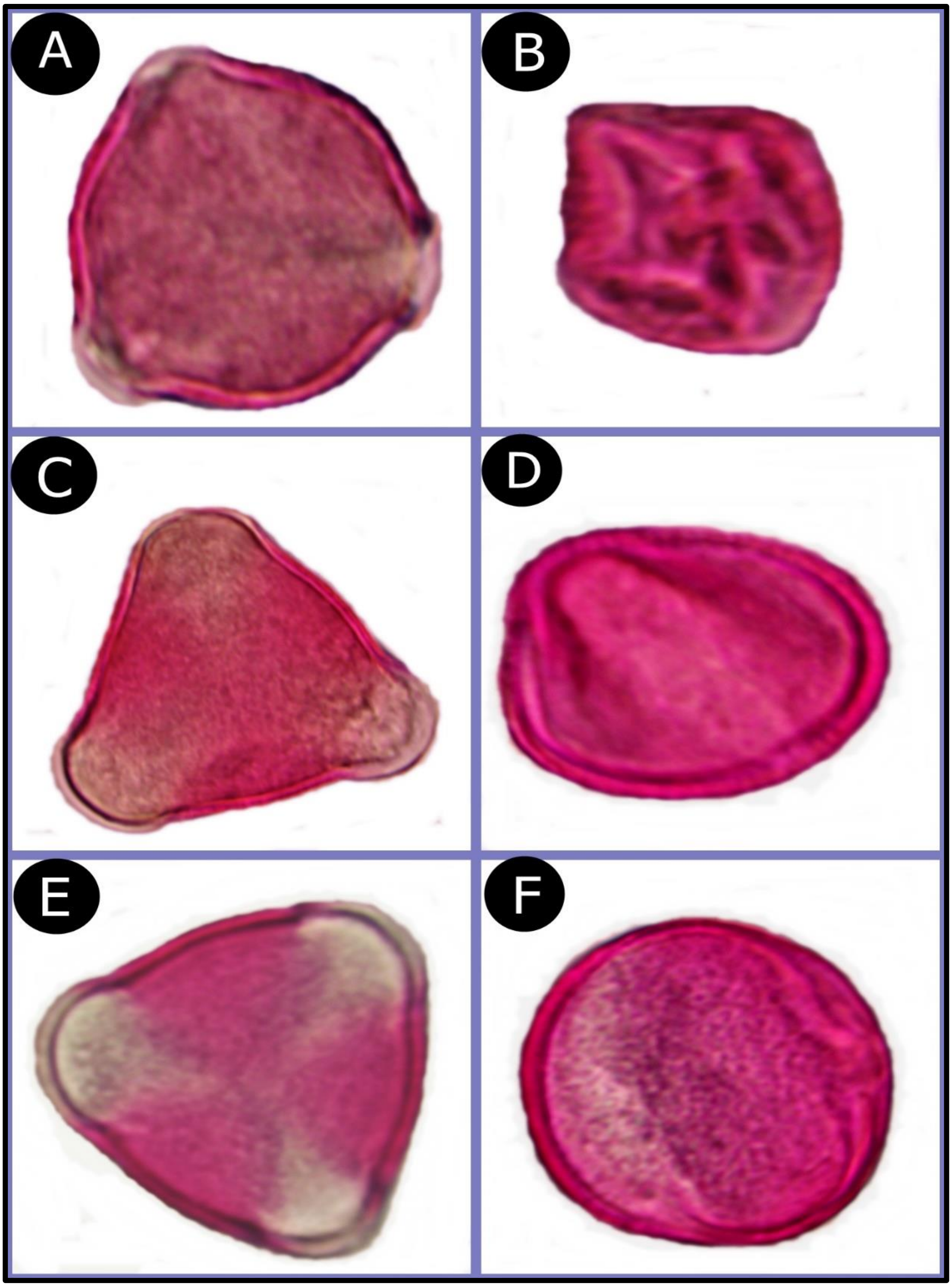


Plate 3.19: Light microscopic pollen photograph taken at 40X of *Rubus ellipticus* (A) Polar view (B) Equatorial view, *Duchesnea indica* (C) Polar view (D) Equatorial view, *Malus pumila* (E) Polar view and (F) Equatorial view.

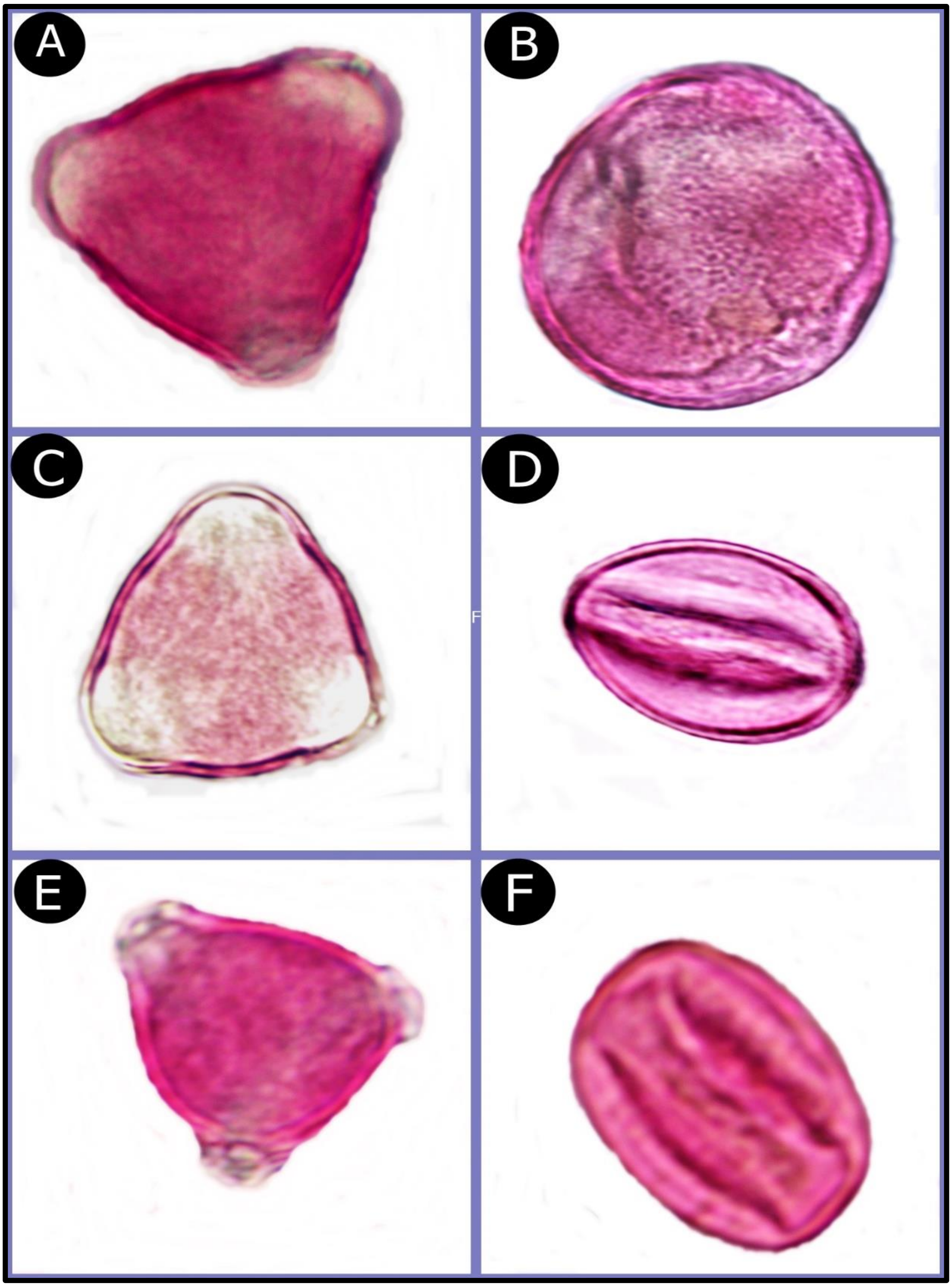


Plate 3.20: Light microscopic pollen photograph taken at 40X of *Prunus dulcis* (A) Polar view (B) Equatorial view, *Pyrus calleryana* (C) Polar view (D) Equatorial view, *Rosa banksiae* (E) Polar view and (F) Equatorial view.

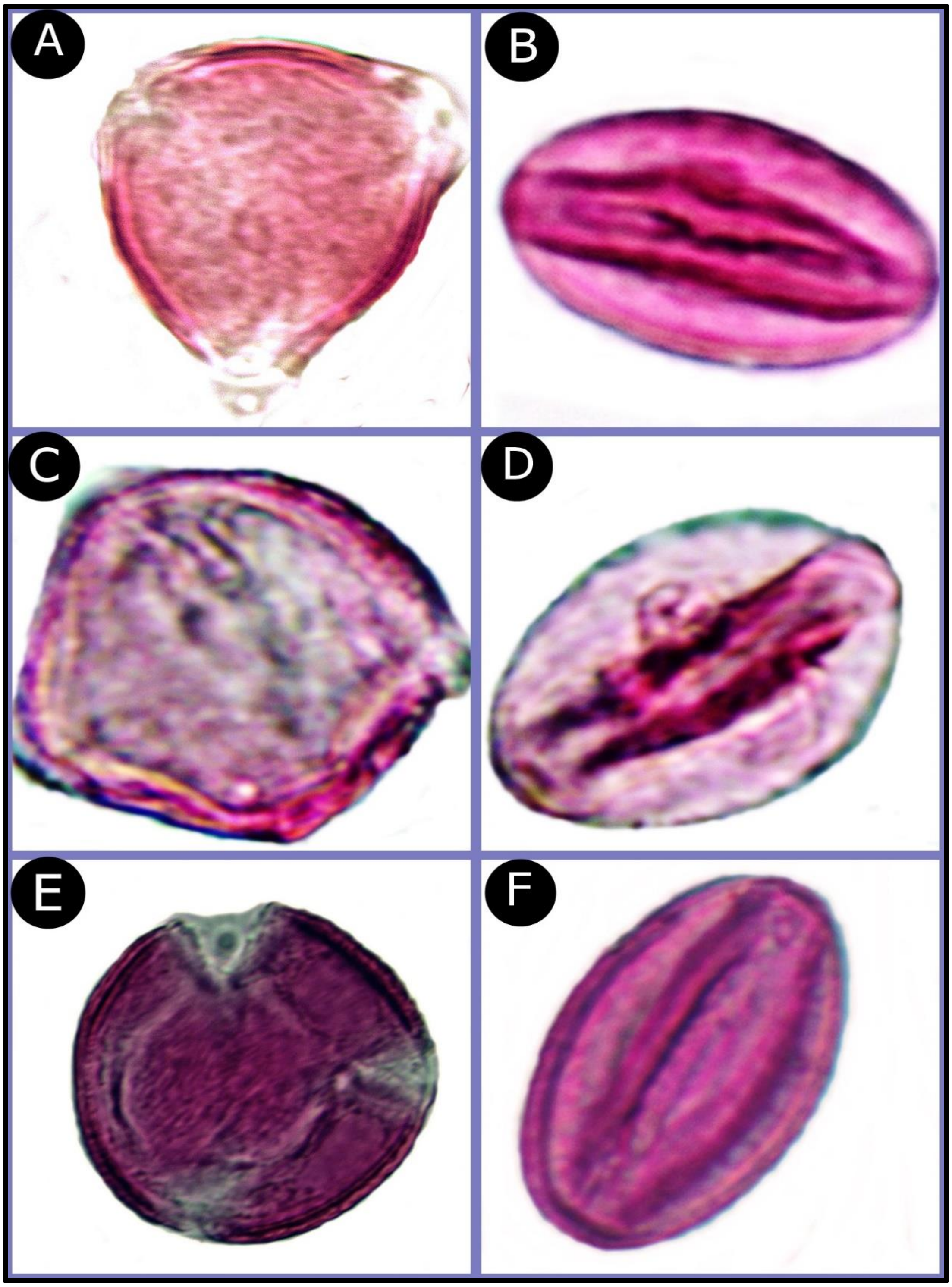


Plate 3.21: Light microscopic pollen photograph taken at 40X of *Rosa chinensis* (A) Polar view (B) Equatorial view, *Potentilla supina* (C) Polar view (D) Equatorial view, *Prunus cerasus* (E) Polar view and (F) Equatorial view.

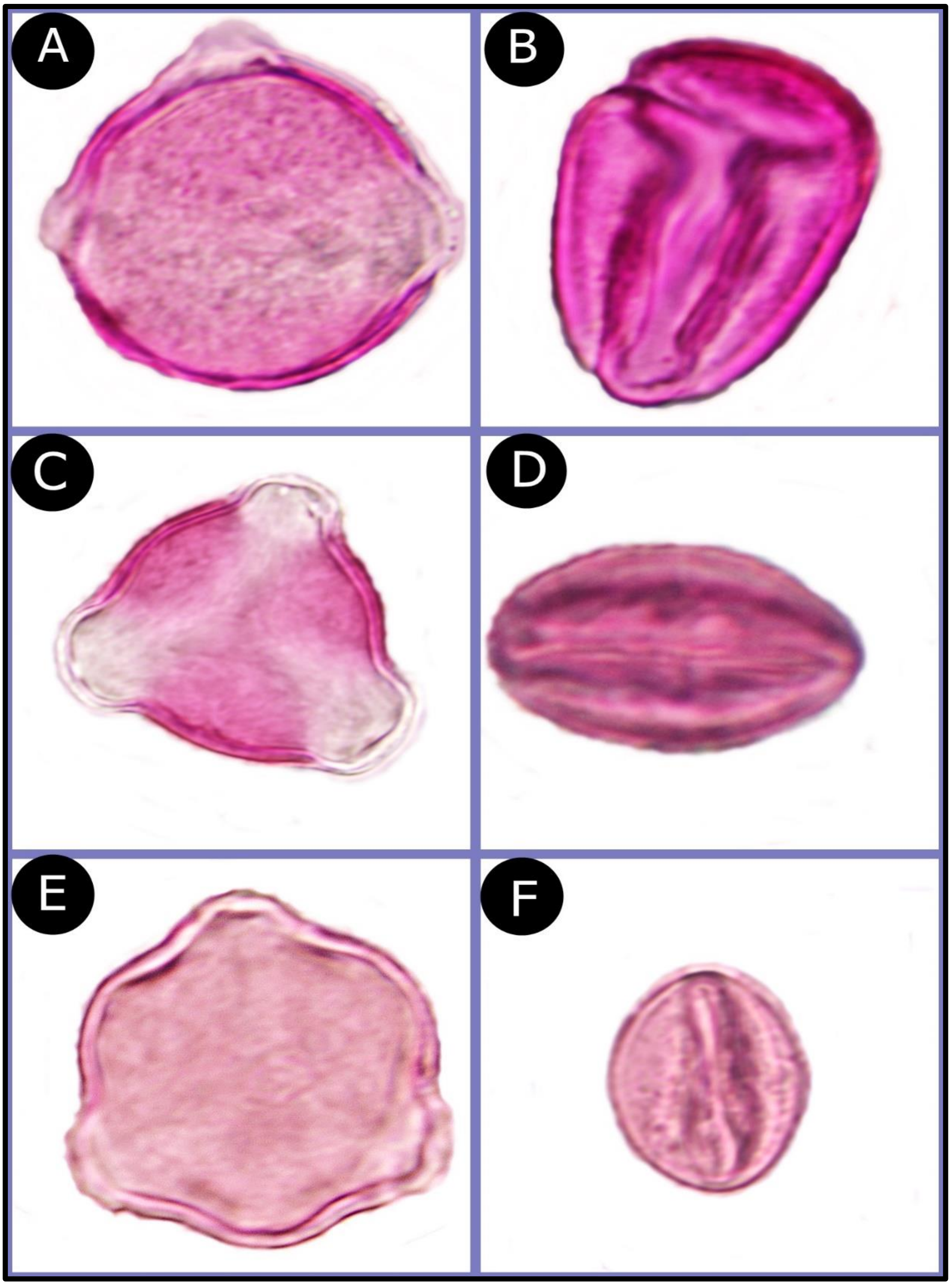


Plate 3.22: Light microscopic pollen photograph taken at 40X of *Pyrus communis* (A) Polar view (B) Equatorial view, *Pyrus bretschneideri* (C) Polar view (D) Equatorial view, *Rubus macilentus* (E) Polar view and (F) Equatorial view.

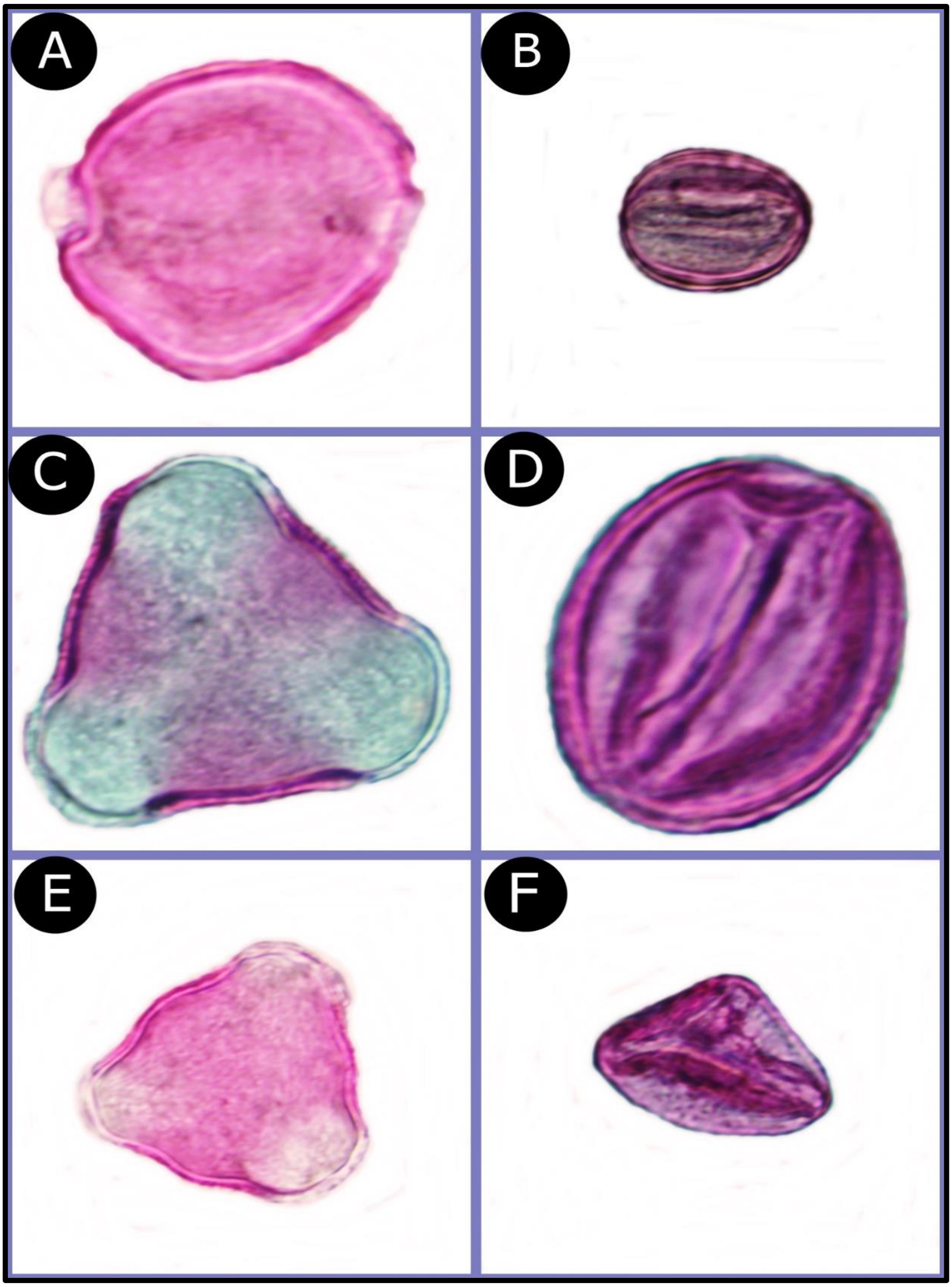


Plate 3.23*:* Light microscopic pollen photograph taken at 40X of *Pyrus pyrifolia* (A) Polar view (B) Equatorial view, *Prunus avium* (C) Polar view (D) Equatorial view, *Rubus vestitus* (E) Polar view and (F) Equatorial view.

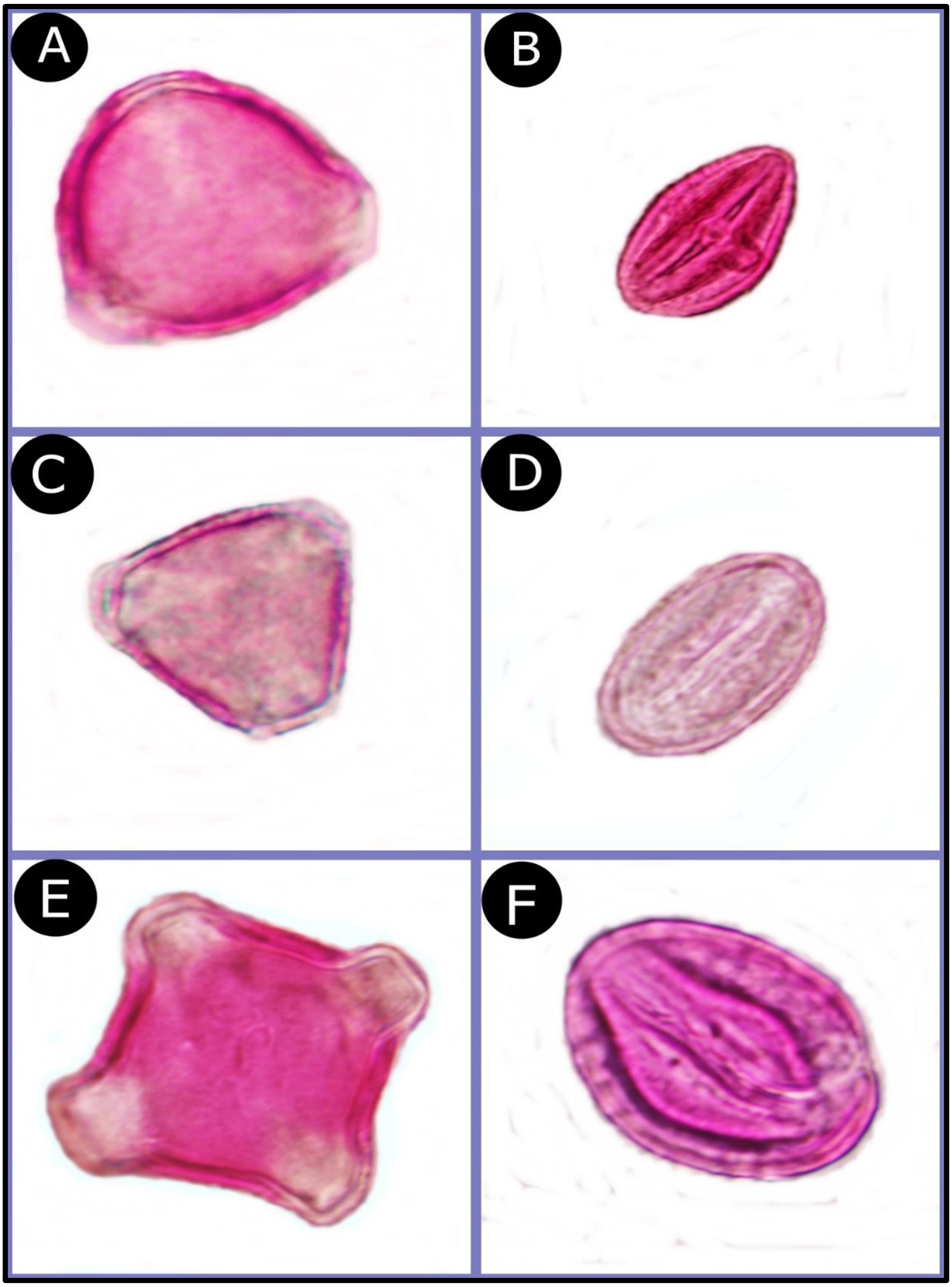


Plate 3.24: Light microscopic pollen photograph taken at 40X of *Rosa damascena* (A) Polar view (B) Equatorial view, *Fragaria nubicola* (C) Polar view (D) Equatorial view, *Cotoneaster nummularius* (E) Polar view and (F) Equatorial view.

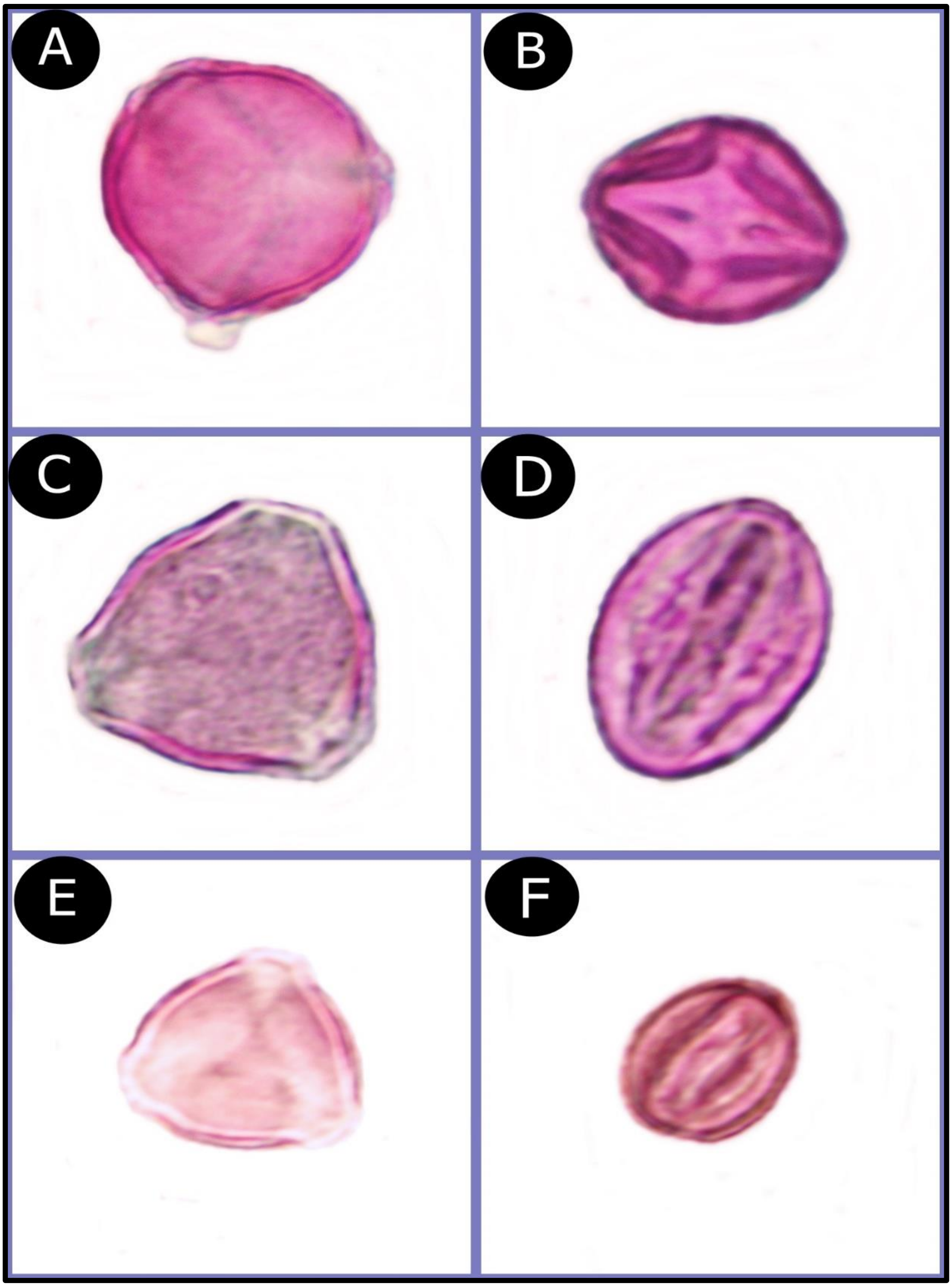


Plate 3.25: Light microscopic pollen photograph taken at 40X of *Rosa laevigata* (A) Polar view (B) Equatorial view, *Fragaria vesca* (C) Polar view (D) Equatorial view, *Spiraea prunifolia* (E) Polar view and (F) Equatorial view.

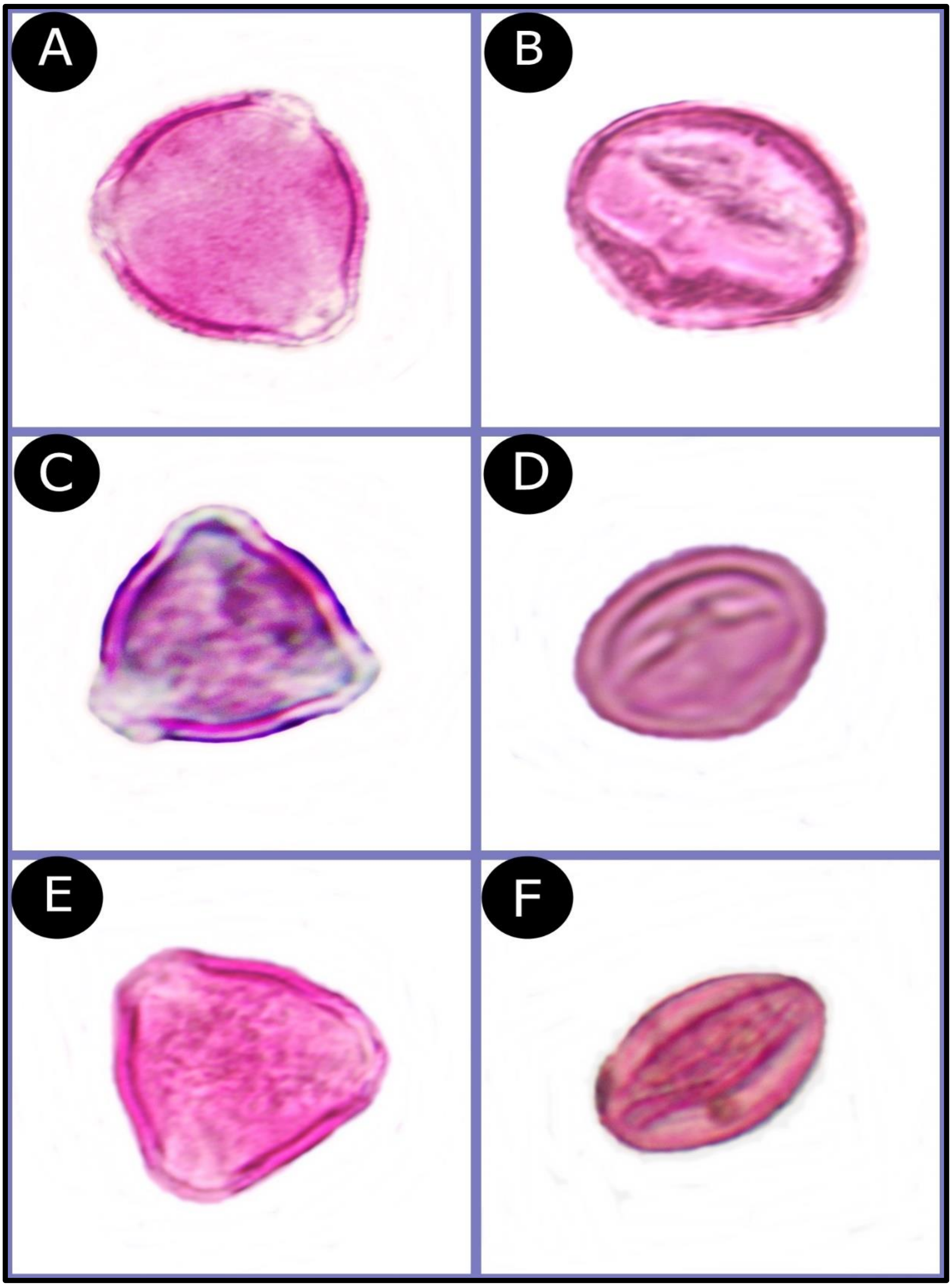


Plate 3.26: Light microscopic pollen photograph taken at 40X of *Rosa brunonii* (A) Polar view (B) Equatorial view, *Spiraea canescens* (C) Polar view (D) Equatorial view, *Potentilla recta* (E) Polar view and (F) Equatorial view.

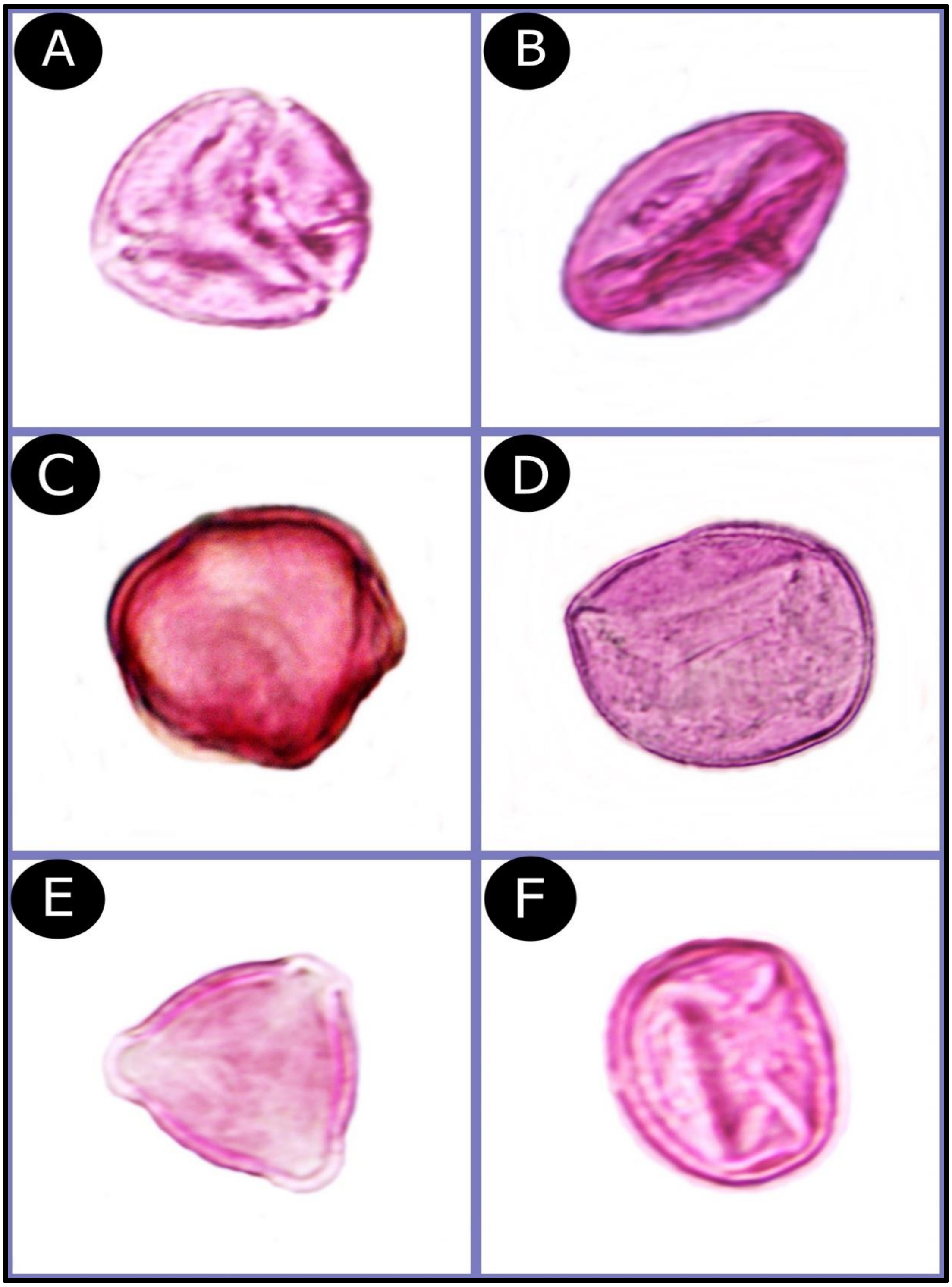


Plate 3.27: Light microscopic pollen photograph taken at 40X of *Rubus niveus* (A) Polar view (B) Equatorial view, *Cotoneaster affinis* (C) Polar view (D) Equatorial view, *Sorbaria tomentosa* (E) Polar view and (F) Equatorial view.

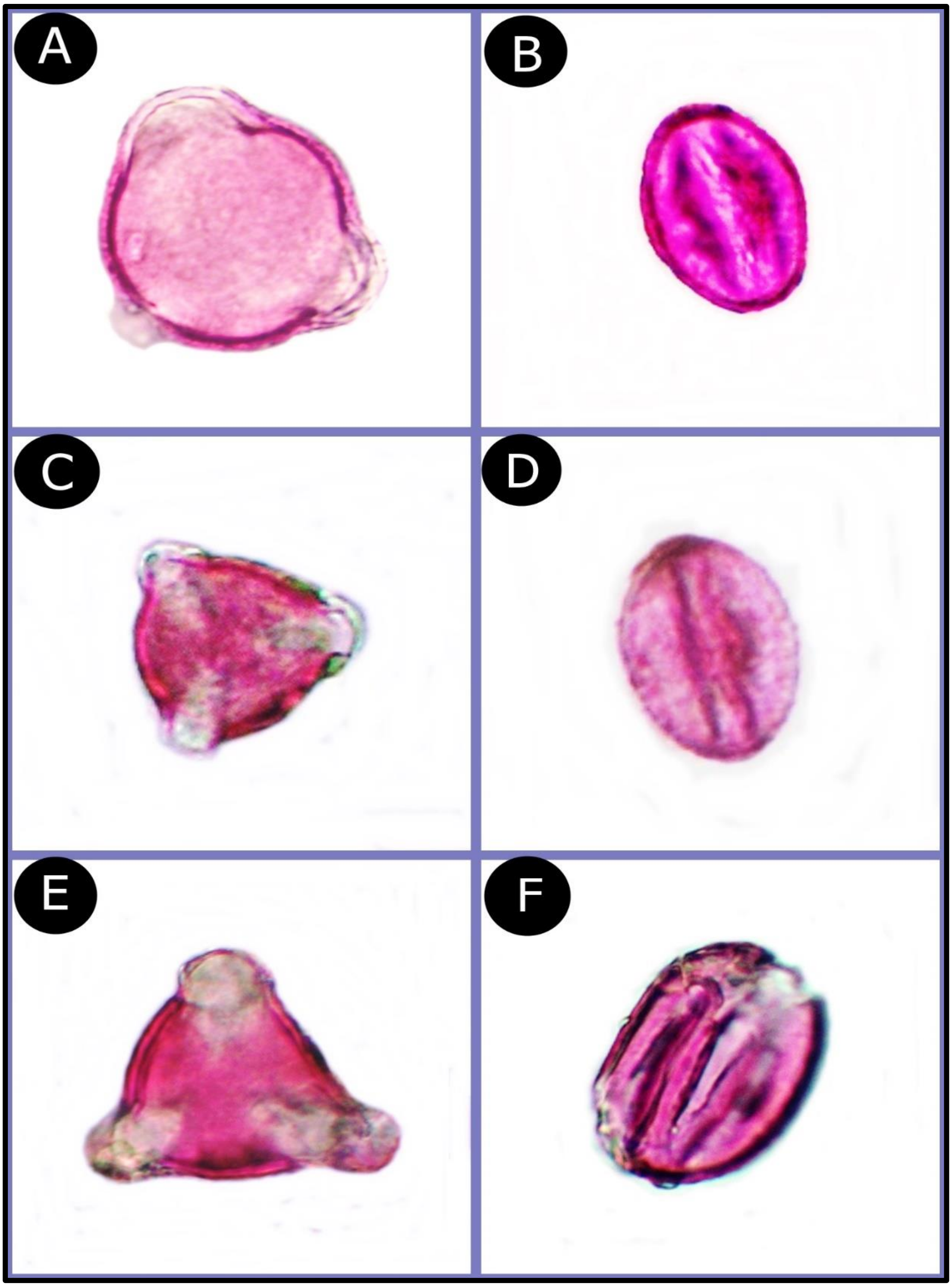


Plate 3.28: Light microscopic pollen photograph taken at 40X of *Rosa canina* (A) Polar view (B) Equatorial view, *Geum urbanum* (C) Polar view (D) Equatorial view, *Crataegus songarica* (E) Polar view and (F) Equatorial view.

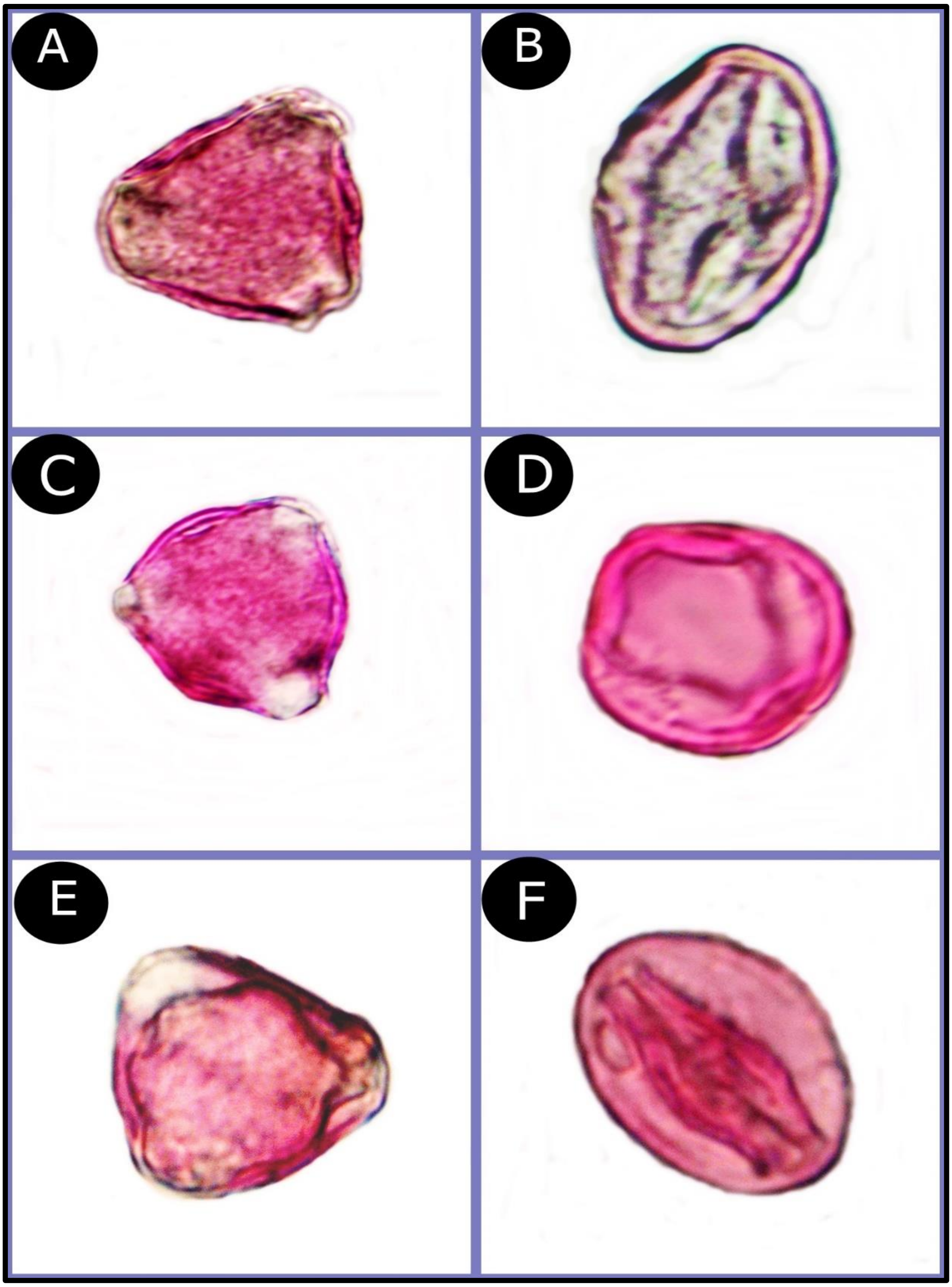


Plate 3.29: Light microscopic pollen photograph taken at 40X of *Potentilla reptans* (A) Polar view (B) Equatorial view, *Eriobotrya japonica* (C) Polar view (D) Equatorial view, *Rubus occidentalis* (E) Polar view and (F) Equatorial view.

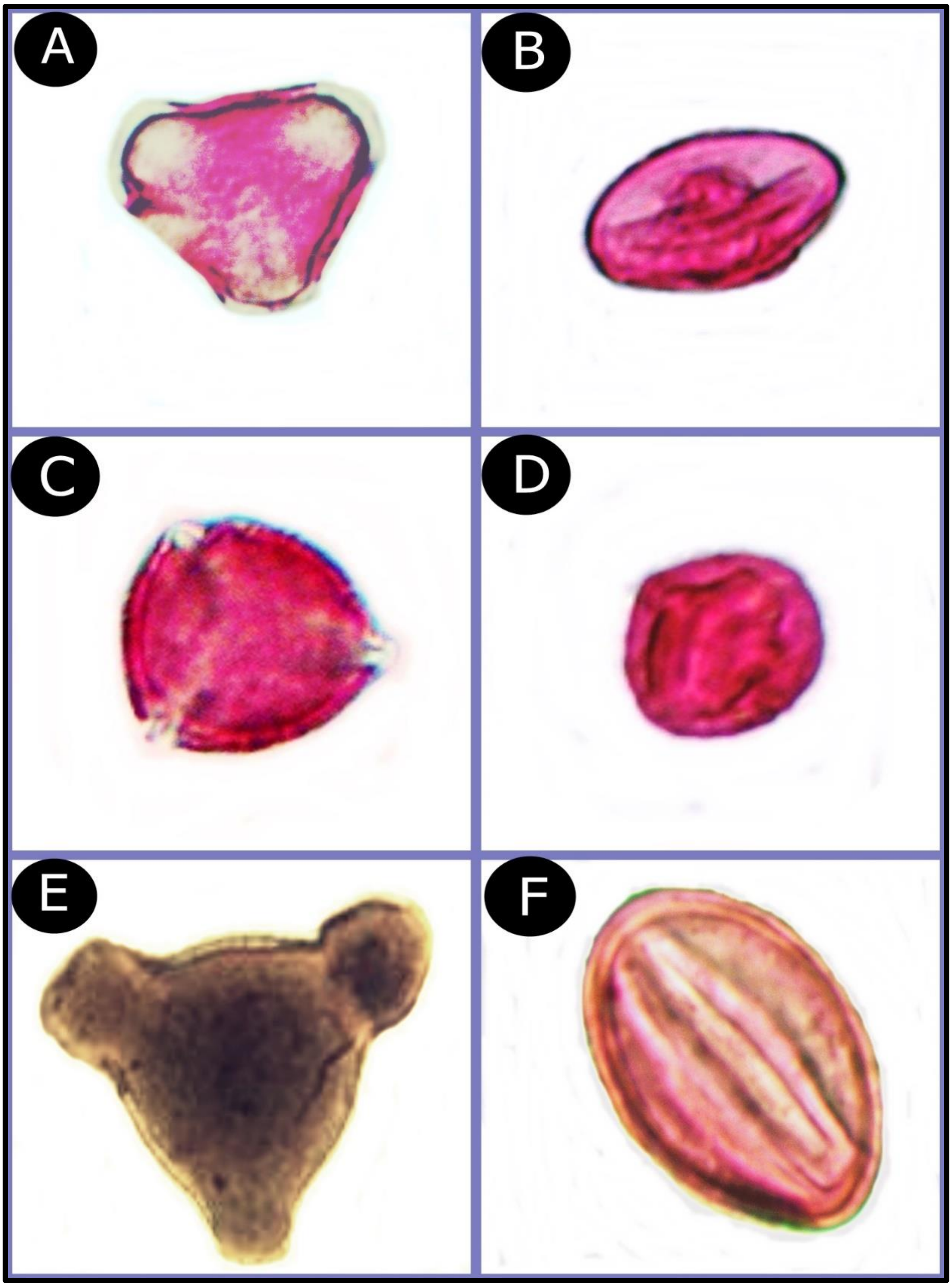


Plate 3.30: Light microscopic pollen photograph taken at 40X of *Potentilla nepalensis* (A) Polar view (B) Equatorial view, *Sibbaldia procumbens* (C) Polar view (D) Equatorial view, *Geum elatum* (E) Polar view and (F) Equatorial view.

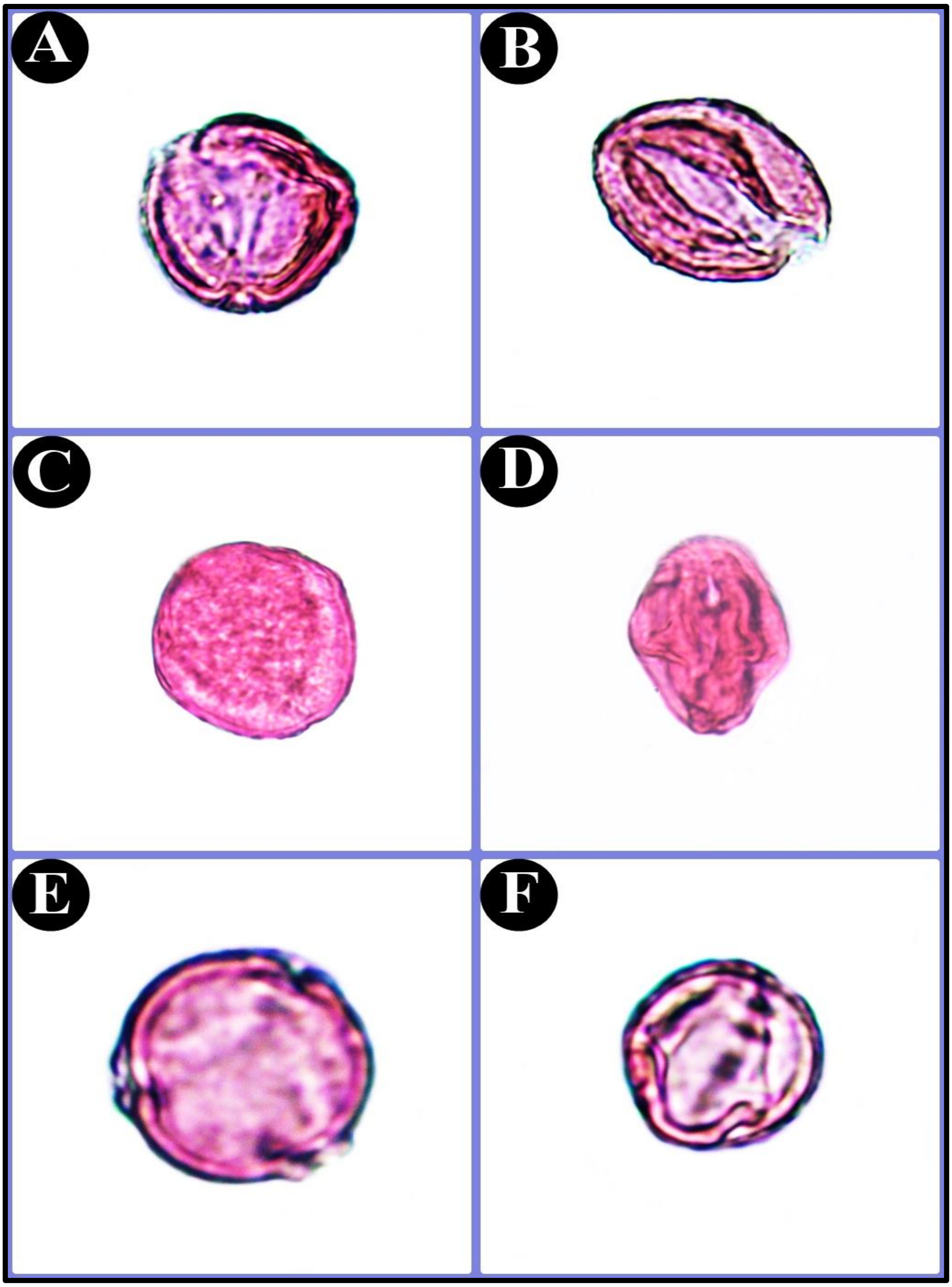


Plate 3.31: Light microscopic pollen photograph taken at 40X of *Potentilla atrosanguinea* (A) Polar view (B) Equatorial view, *Potentilla crantzii* (C) Polar view (D) Equatorial view, *Filipendula ulmaria* (E) Polar view and (F) Equatorial view.

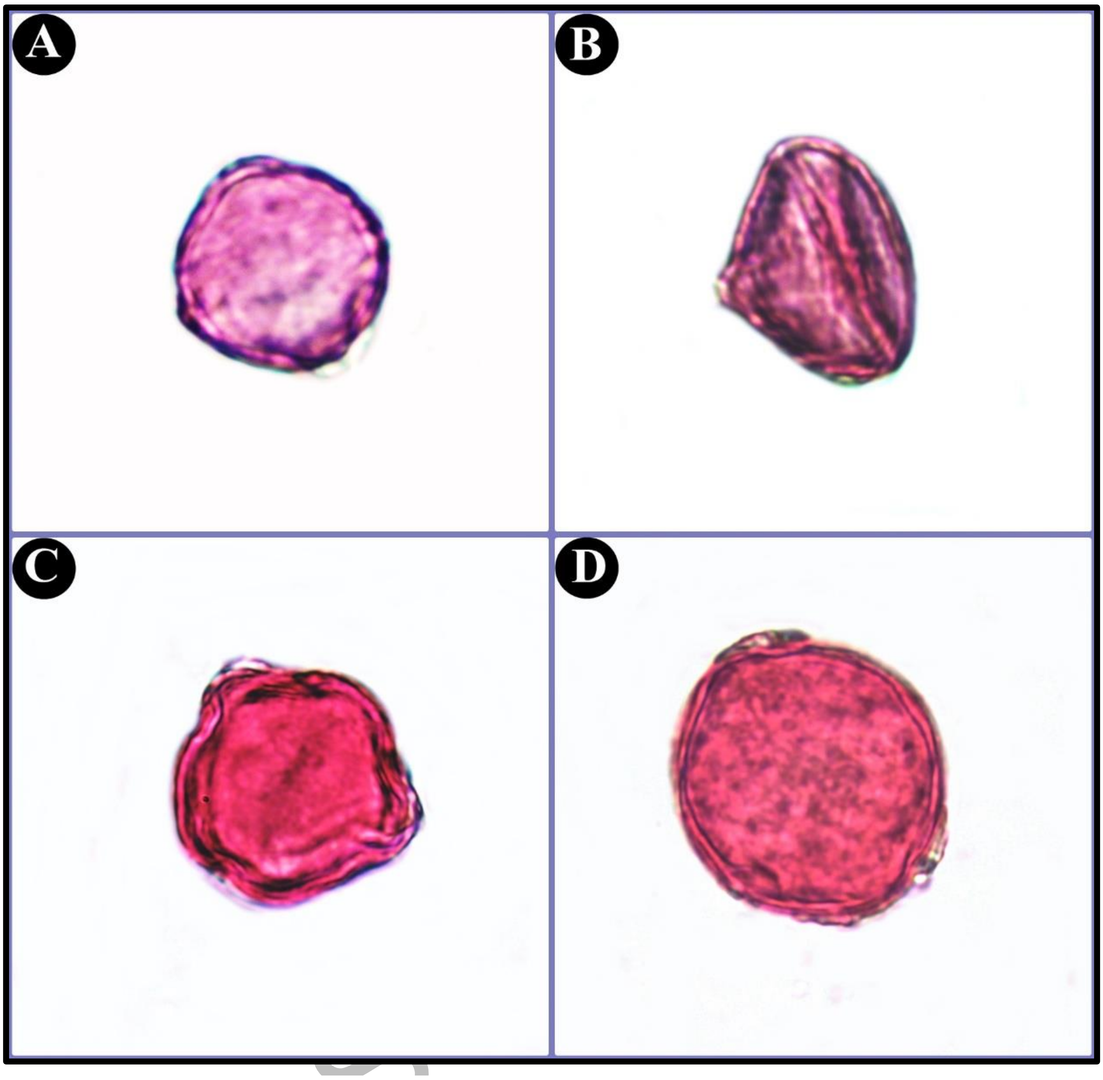


Plate 3.32: Light microscopic pollen photograph taken at 40X of *Sibbaldia cuneata* (A) Polar view (B) Equatorial view, *Rosa webbiana* (C) Polar view (D) Equatorial view.

3.4 PALYNOLOGICAL FINDINGS

The primary goal of the current research is to use a light microscope to highlight the diversity of pollen micro-morphology in 47 Rosaceous species. The pollen grains of the present study belong to 17 genera of family Rosaceae such as (*Cotoneaster*, *Cydonia*, *Duchesnea*, *Eriobotrya*, *Crataegus*, *Filipendula*, *Geum*, *Malus*, *Potentilla*, *Prunus*, *Sorbaria*, *Pyrus*, *Fragaria*, *Rosa*, *Rubus*, *Sibbaldia*, and *Spiraea)* with a numerous variation in both the qualitative and quantitative micro-morphological data. To show variations and diversity of Rosaceous pollen light micrographs were illustrated as shown in (figure 3.17-32).

3.4.1 Qualitative Characteristics

Qualitative micro-morphological features of Rosaceous pollen were pragmatic under light microscope (LM). In the current palynological findings a diverse variation has been observed in the profile of pollen grains in polar orientation. Most of the pollen shape in polar position was triangular however Quinquangular and circular shape of pollen in polar position was also noted in most Rosaceous species. Immense variations in types of pollen were not observed in family Rosaceae only three types of pollen among 47 pollens were observed that is Tricolpate, Tricolporate and tetracolporate. In the pollen type 29 out 47 Rosaceous taxa have Tricolpate pollen, while 26 out of 47 Rosaceous taxa have Tri-colporate pollen and only 1 plant *Cotoneaster nummularius* Tetracolpate pollen has been observed. Most of the pollen size in the current palynological study of family Rosaceae was noted smaller, however only in eight species large size pollen has also been reported. Diversity in the shape of equatorial view such as Oblate, Sub-oblate, Prolate, Sub-prolate and Circular in palynological data of family Rosaceae was also observed, only three species *Rosa chinensis, Potentilla supina,* and *Prunus cerasus* shape of the equatorial view was noted per-prolate.

Among 47 Rosaceous taxa 7 species that is *Pyrus pashia, Duchesnea indica, Rosa banksiae, Pyrus communis, Rosa brunonii, Eriobotrya japonica,* and *Potentilla nepalensis* class of the pollen on the bases of P/E ratio were Prolate spheroidal. Prolate class pollen were observed only in 11 species of the family including *Rosa indica, Prunus domestica, Pyrus calleryana, Rosa chinensis, Prunus cerasus, Prunus avium, Cotoneaster nummularius, Rosa canina, Potentilla atrosanguinea, Filipendula ulmaria* and *Rosa webbiana.* Subprolate class pollen shape has been observed in 28 species of the family while only 2 species *Cotoneaster affinis* class of the pollen was Spherical and in *Potentilla crantzii* pollen class was Per-prolate as shown in table 3.7.

3.4.2 Quantitative Characteristics

In the current bioinformatics data in quantitative features of Rosaceous palynology a diverse variation has been observed in Polar diameter, P/E ratio, Length of colpi, Length of pore, Equatorial thickness, Width of colpi, Width of pore, Mesocolpium and in Exine thickness. The minimum polar diameter was observed in the pollen of *Spiraea canescens* (10.4±0.93 µm) while maximum polar diameter was noted in *Prunus armeniaca* (44.2±0.72 µm) as shown in figure 3.16. Similarly minimum equatorial diameter was also noted in *Spiraea canescens* (7.95±0.48 µm) while maximum equatorial diameter was observed in *Prunus armeniaca* (38.3±0.87 µm) as demonstrated in figure 3.17. In *Cotoneaster affinis* (1.0 µm), the lowest P/E ratio in the most recent bioinformatic data of the Rosaceae family was demonstrated. while the highest P/E ratio was noted in *Potentilla crantzii* (2.11 µm) as displayed in figure 3.18.

The immense variations in the quantitative data in length and width of pollen Colpi were also found. The lowest possible length of Pollen Colpi was observed in *Rubus niveus* (3.30±0.14 µm) while largest length of Pollen Colpi was seen in *Rosa webbiana* (13.7±0.93 µm) as shown in figure 3.19. Similarly minimum width of pollen Colpi was noted in *Spiraea canescens* (3.5±0.25 µm) while maximum width of pollen Colpi was seen in *Rubus occidentalis* (11.7±0.35 µm) as displayed in figure 3.20. Eighteen species out of 47 have tri-colporate pollen so variations in quantitative data in the length along with width of pollen pore was also observed in some species of family Rosacae. The smallest length of pore was observed in *Rosa canina* (0.45±0.93 µm) while the largest length of pore was noted in *Rosa laevigata* (1.85±0.12 µm) as illustrated in figure 3.21. Similarly minimum width of pore was seen in *Rosa indica* (0.4±0.10 µm) while maximum width of pore was observed in *Pyrus pyrifolia* (1.85±0.16 µm) as shown in figure 3.21. A quantitative variation in Exine thickness was also noted in Rosaceous pollen, minimum exine thickness was calculated in *Spiraea canescens* (3.20±0.16 µm) while maximum was calculated in *Prunus armeniaca* (6.40±0.38 µm). Maximum fertile pollen was calculated in *Rosa banksiae* 97.9 % while minimum was calculated in *Potentilla crantzii* 65.6 % as shown in table 3.8.

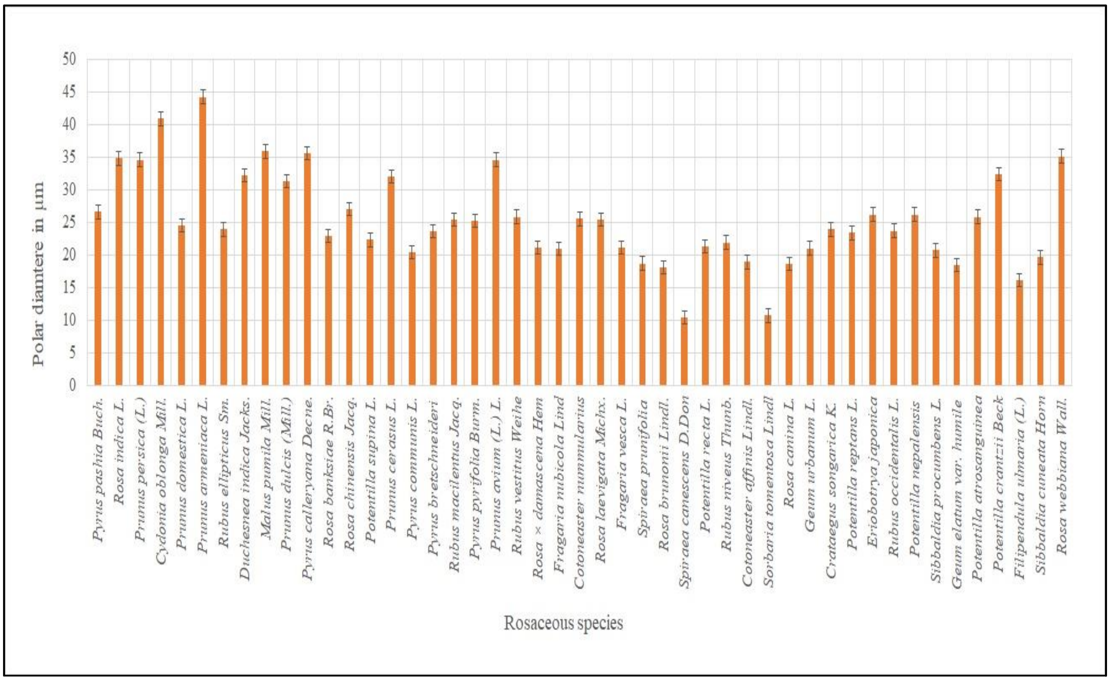


Fig 3.16: Graphical representation shows variation in polar diameter in pollen of Rosaceae.

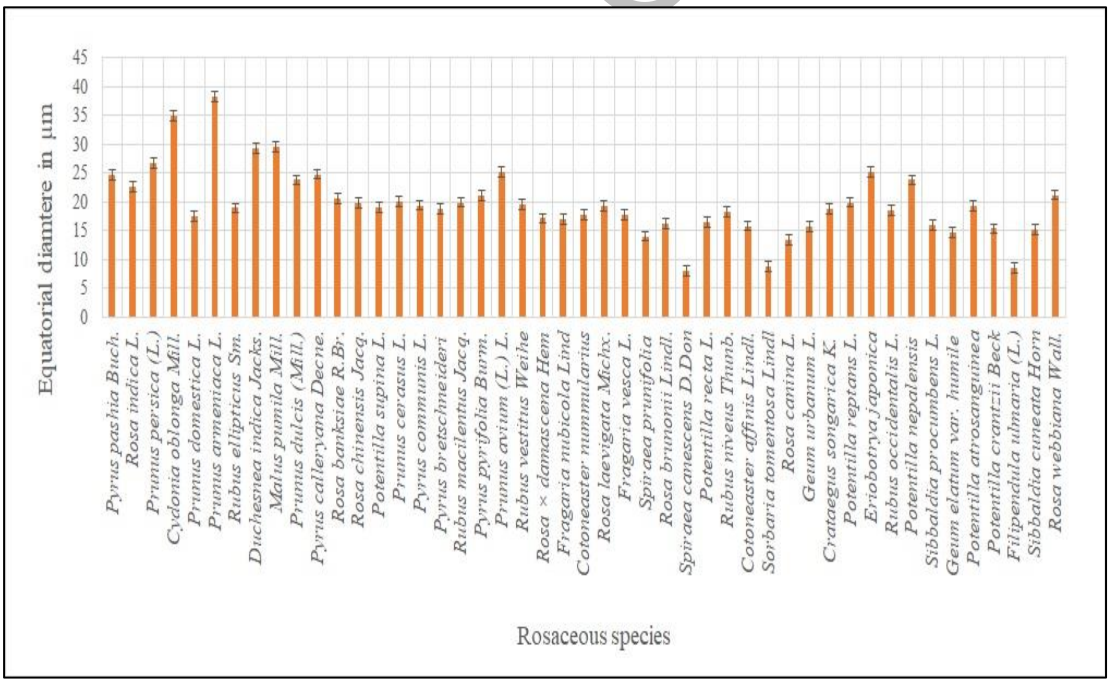


Fig 3.17: Graphical representation shows variation in equatorail diameter in pollen of Rosaceae.

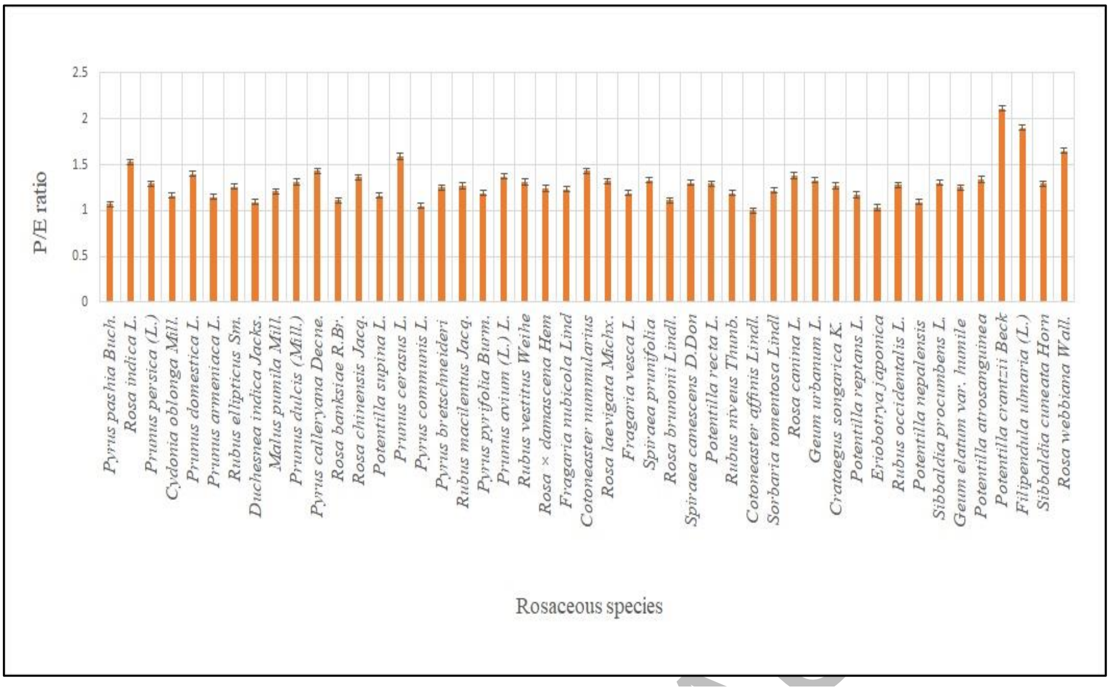


Fig 3.18: Graphical representation shows variation in P/E ratio in pollen of Rosaceae.

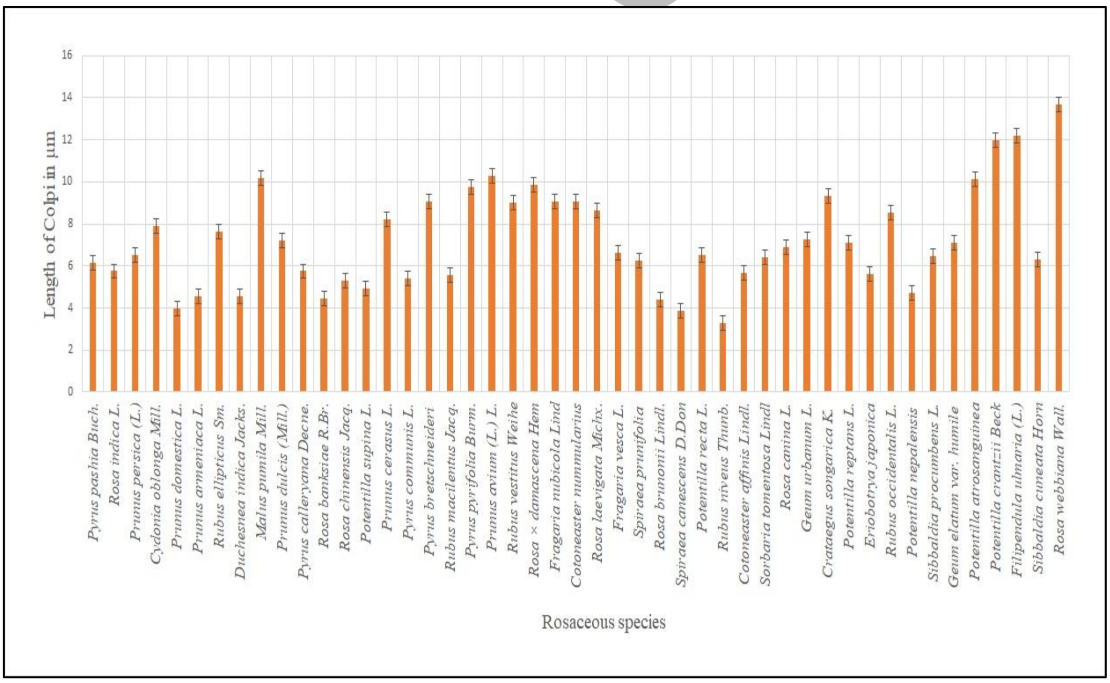


Fig 3.19: Graphical representation shows variation in Length of Colpi in pollen of Rosaceae.

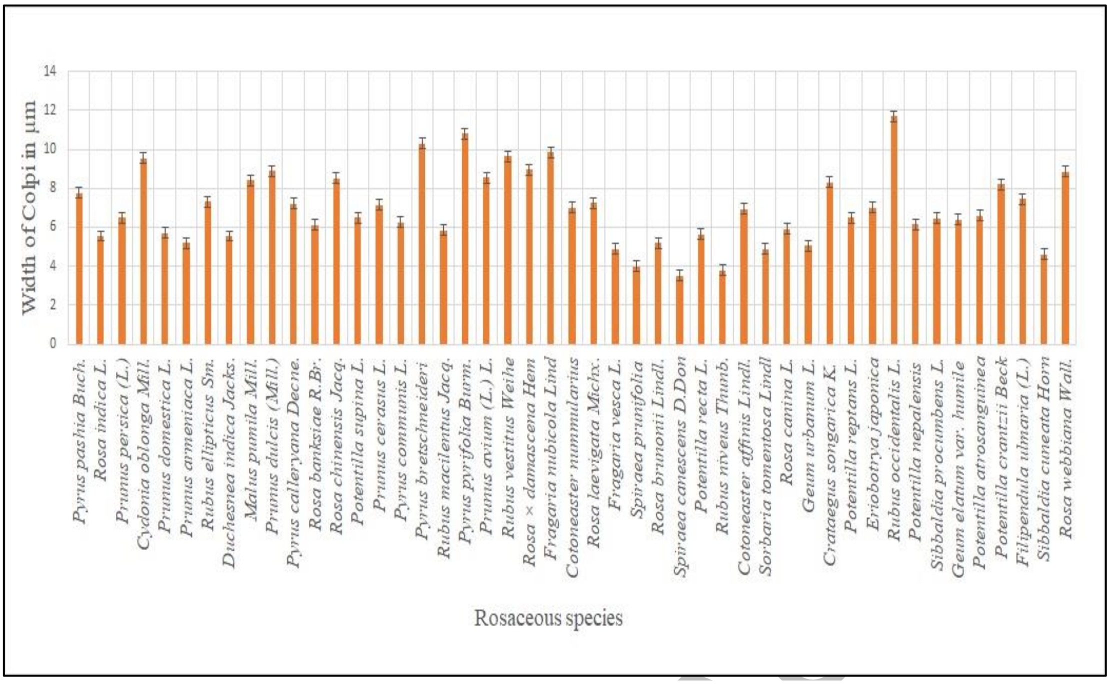


Fig 3.20: Graphical representation shows variation in Width of Colpi in pollen of Rosaceae.

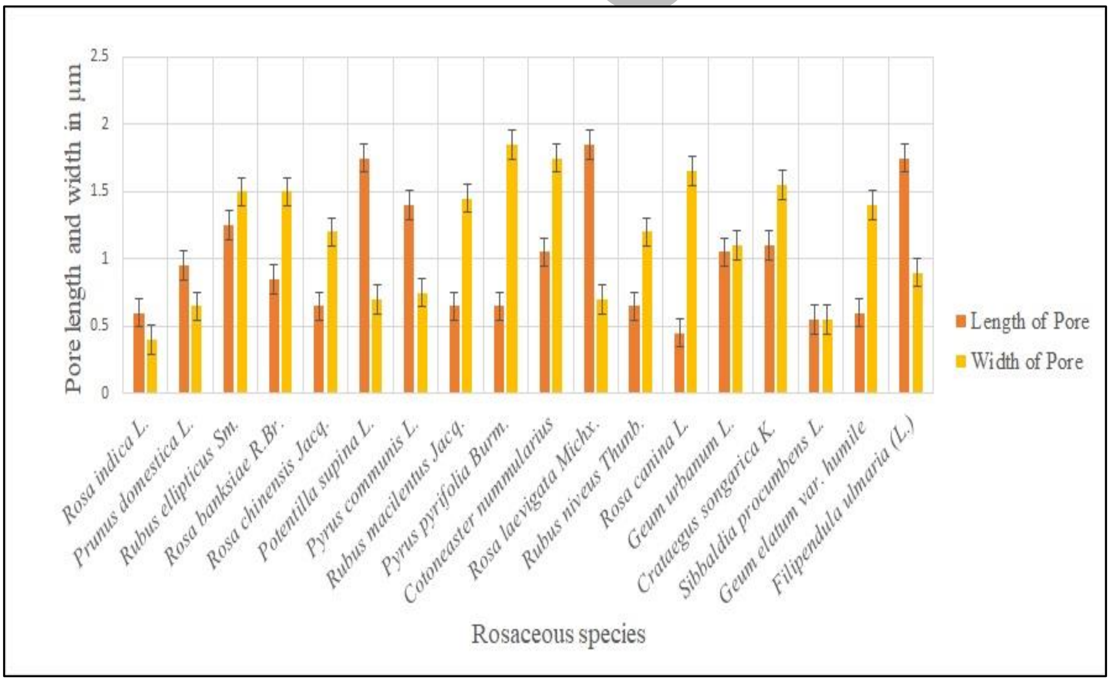


Fig 3.21: Graphical representation shows variation in Length and Width of Pore in pollen of Rosaceae.

Table 3.7: Qualitative palynological features of Rosaceous taxa.

Sr. No.	Rosaceous taxa	Size of pollen	Pollen type	Pollen class	Polar view	Equatorial view
1	*Pyrus pashia* Buch.	Medium	Tricolpate	Prolate spheroidal	Triangular	Suboblate
2	*Rosa indica* L.	Large	Tricolporate	Prolate	Slightly circular	Prolate
3	*Prunus persica* L.	Medium	Tricolpate	Subprolate	Slightly circular	Subprolate
4	*Cydonia oblonga* Mill.	Large	Tricolpate	Subprolate	Triangular	Suboblate
5	*Prunus domestica* L.	Small	Tricolporate	Prolate	Triangular	Oblate
6	*Prunus armeniaca* L.	Large	Tricolpate	Subprolate	Triangular	Prolate
7	*Rubus ellipticus* Sm.	Large	Tricolporate	Subprolate	Slightly circular	Subprolate
8	*Duchesnea indica* Jacks.	Medium	Tricolpate	Prolate spheroidal	Triangular	Subprolate
9	*Malus pumila* Mill.	Large	Tricolpate	Subprolate	Triangular	Circular
10	*Prunus dulcis* Mill.	Medium	Tricolpate	Subprolate	Triangular	Subprolate
11	*Pyrus calleryana* Decne.	Small	Tricolpate	Prolate	Triangular	Oblate
12	*Rosa banksiae* R.Br.	Small	Tricolporate	Prolate spheroidal	Triangular	Prolate
13	*Rosa chinensis* Jacq.	Large	Tricolporate	Prolate	Triangular	Perprolate
14	*Potentilla supina* L.	Small	Tricolporate	Subprolate	Quadrangular	Perprolate
15	*Prunus cerasus* L.	Medium	Tricolpate	Prolate	Circular	Perprolate
16	*Pyrus communis* L.	Small	Tricolporate	Prolate spheroidal	Circular	Subprolate
17	*Pyrus bretschneideri*	Medium	Tricolpate	Subprolate	Triangular	Oblate
18	*Rubus macilentus* Jacq.	Small	Tricolporate	Subprolate	Slightly circular	Subprolate
19	*Pyrus pyrifolia* Burm.	Small	Tricolporate	Subprolate	Circular	Suboblate

20	*Prunus avium* L.	Large	Tricolpate	Prolate	Triangular	Subprolate
21	*Rubus vestitus* Weihe	Small	Tricolpate	Subprolate	Triangular	Suboblate
22	*Rosa* × *damascena* Hem	Small	Tricolpate	Subprolate	Slightly circular	Prolate
23	*Fragaria nubicola* Lind	Small	Tricolpate	Subprolate	Triangular	Prolate
24	*Cotoneaster nummularius*	Medium	Tetracolpate	Prolate	Quadrangular	Suboblate
25	*Rosa laevigata* Michx.	Medium	Tricolporate	Subprolate	Circular	Circular
26	*Fragaria vesca* L.	Medium	Tricolpate	Subprolate	Slightly triangular	Prolate
27	*Spiraea prunifolia*	Small	Tricolpate	Subprolate	Slightly triangular	Subprolate
28	*Rosa brunonii* Lindl.	Medium	Tricolpate	Prolate spheroidal	Slightly circular	Suboblate
29	*Spiraea canescens* D.Don	Small	Tricolpate	Subprolate	Triangular	Suboblate
30	*Potentilla recta* L.	Small	Tricolpate	Subprolate	Triangular	Prolate
31	*Rubus niveus* Thunb.	Small	Tricolporate	Subprolate	Circular	Prolate
32	*Cotoneaster affinis* Lindl.	Medium	Tricolpate	Spherical	Quinquangular	Circular
33	*Sorbaria tomentosa* Lindl	Small	Tricolpate	Subprolate	Triangular	Subprolate
34	*Rosa canina* L.	Medium	Tricolporate	Prolate	Circular	Prolate
35	*Geum urbanum* L.	Small	Tricolporate	Subprolate	Triangular	Prolate
36	*Crataegus songarica* K.	Medium	Tricolporate	Subprolate	Triangular	Prolate
37	*Potentilla reptans* L.	Medium	Tricolpate	Subprolate	Triangular	Prolate
38	*Eriobotrya japonica*	Small	Tricolpate	Prolate spheroidal	Slightly circular	Circular
39	*Rubus occidentalis* L.	Medium	Tricolpate	Subprolate	Slightly triangular	Prolate
40	*Potentilla nepalensis*	Small	Tricolpate	Prolate spheroidal	Triangular	Prolate
41	*Sibbaldia procumbens* L.	Medium	Tricolporate	Subprolate	Circular	Circular
42	*Geum elatum* var. humile	Large	Tricolporate	Subprolate	Triangular	Prolate

43	*Potentilla atrosanguinea*	Small	Tricolpate	Prolate	Circular	Prolate
44	*Potentilla crantzii* Beck	Small	Tricolpate	Perprolate	Circular	Prolate
45	*Filipendula ulmaria* L.	Medium	Tricolporate	Prolate	Circular	Circular
46	*Sibbaldia cuneata* Horn	Small	Tricolpate	Subprolate	Circular	Subprolate
47	*Rosa webbiana* Wall.	Small	Tricolpate	Prolate	Circular	Circular

Table 3.8: Quantitative pollen morphological features of selected Rosaceous taxa.

S. No	Plants species	P.D (µm)	E.D (µm)	P/E ratio	L.C (µm)	W.C (µm)	L.P (µm)	W.P (µm)	M.C (µm)	E.T (µm)	Fr. (%)	St. (%)
		(Mean ± SE) µm										
1	*Pyrus pashia* Buch.	26.6±2.47	24.7±1.87	1.07	6.15±0.55	7.75±0.26	-	-	17.6±0.92	3.5± 0.25	82.0	17.9
2	*Rosa indica* L.	34.8±2.47	22.6±0.76	1.53	5.75±0.26	5.55±0.14	0.6±0.12	0.4±0.10	14.4±0.62	4.65±0.20	97.3	2.65
3	*Prunus persica* L.	34.6±2.17	26.7±2.13	1.29	6.50±0.39	6.50±0.35	-	-	17.5±1.14	4.55±0.64	96.0	3.96
4	*Cydonia oblonga* Mill.	40.9±0.95	35.0±0.75	1.16	7.90±0.64	9.55±0.46	-	-	17.4±0.44	4.50±0.11	95.2	4.8
5	*Prunus domestica* L.	24.5±2.18	17.4±0.20	1.40	3.95±0.21	5.70±0.42	0.95±0.18	0.65±0.16	13.1±0.12	5.40±0.10	94.9	5.04
6	*Prunus armeniaca* L.	44.2±0.72	38.3±0.87	1.15	4.55±0.93	5.2±0.53	-	-	15.3±0.66	6.40±0.38	94.4	5.55
7	*Rubus ellipticus* Sm.	23.9±1.40	18.9±0.71	1.26	7.65±0.30	7.3± 0.30	1.25±0.17	1.50±0.27	11.6±0.26	5.60±0.18	94.0	6.0
8	*Duchesnea indica* Jacks.	32.2±1.04	29.3±1.39	1.09	4.55±0.93	5.55±0.14	-	-	17.8± 0.63	4.95±0.31	93.6	6.30
9	*Malus pumila* Mill.	35.9±1.72	29.5±1.17	1.21	10.2±0.2	8.4±0.4	-	-	14.6±0.28	5.30±0.28	97.4	2.54
10	*Prunus dulcis* Mill.	31.3±1.42	23.8±0.50	1.31	7.2±0.30	8.9±0.33	-	-	14.0±0.62	5.25±0.36	94.1	5.88
11	*Pyrus calleryana* Decne.	35.6±1.14	24.8±1.27	1.43	5.75±0.26	7.2±0.50	-	-	12.6±0.26	4.5±0.32	97.6	2.32

12	*Rosa banksiae* R.Br.	22.9±0.43	20.6±0.45	1.11	4.45±0.33	6.1±0.38	0.85±0.25	1.5±0.25	10.7±0.35	4.05±0.40	97.9	2.04
13	*Rosa chinensis* Jacq.	27.0±2.35	19.8±0.43	1.36	5.30±0.20	8.5± 0.23	0.65±0.12	1.20±0.27	12.3±0.33	3.50±0.11	96.2	3.70
14	*Potentilla supina* L.	22.3±1.31	19.1±0.43	1.16	4.95±0.40	6.5±0.25	1.75±0.17	0.70±0.14	10.6±0.36	4.00±0.17	94.6	5.37
15	*Prunus cerasus* L.	32.0±1.66	20.0±0.49	1.59	8.20±0.33	7.15±0.43	-	-	12.1±0.42	3.80±0.21	92.9	7.05
16	*Pyrus communis* L.	20.4±0.37	19.4±0.55	1.05	5.40±0.24	6.25±0.35	1.4±0.18	0.75±0.17	11.5±0.32	3.9±0.31	87.5	12.5
17	*Pyrus bretschneideri*	23.6±0.70	18.8±0.70	1.25	9.05± 0.4	10.3±0.35	-	-	11.4±0.60	4.8±0.37	91.6	8.33
18	*Rubus macilentus* Jacq.	25.4±0.67	19.9±0.41	1.27	5.55±0.42	5.85±0.29	0.65±0.12	1.45±0.18	12.4±0.18	4.45±0.26	93.4	6.52
19	*Pyrus pyrifolia* Burm.	25.2±0.42	21.1±0.60	1.19	9.75±0.57	10.8±0.43	0.65±0.12	1.85±0.16	11.9±0.302	4.5±0.25	95.5	4.44
20	*Prunus avium* L.	34.6±1.20	25.2±0.96	1.37	10.3±0.39	8.55±0.42	-	-	10.9±0.60	5.40±0.18	94.2	5.76
21	*Rubus vestitus* Weihe	25.8±0.64	19.6±0.9	1.31	9.0±0.35	9.65±0.43	-	-	11.9±0.49	4.50±0.28	92.7	7.27
22	*Rosa* × *damascena* Hem	21.1±0.50	17.1±0.44	1.24	9.85±0.23	8.95±0.46	-	-	11.4±0.33	4.70±0.16	95.1	4.85
23	*Fragaria nubicola* Lind	20.9±0.18	16.9±0.30	1.23	9.05±0.31	9.85±0.23	-	-	10.3±0.29	5.70±0.61	93.5	6.48
24	*Cotoneaster nummularius*	25.5±0.52	17.8±0.66	1.43	9.05±0.31	7.0±0.48	1.05±0.09	1.75±0.13	12.5±0.45	3.80±0.45	91.1	8.82
25	*Rosa laevigata* Michx.	25.4±0.71	19.2±0.39	1.32	8.65±0.45	7.25±0.28	1.85±0.12	0.70±0.09	10.5±0.28	3.8±0.45	91.6	8.33
26	*Fragaria vesca* L.	21.1±0.34	17.7±0.35	1.19	6.65±0.53	4.9±0.26	-	-	11.1±0.43	4.85±0.23	95.1	4.80
27	*Spiraea prunifolia*	18.7±0.30	14.0±0.31	1.33	6.25±0.28	4.0±0.28	-	-	10.3±0.32	3.75±0.30	86.6	13.3
28	*Rosa brunonii* Lindl.	18.1±0.26	16.2±0.33	1.11	4.40±0.26	5.2±0.26	-	-	9.20±0.41	4.40±0.18	88.0	12.0
29	*Spiraea canescens* D.Don	10.4±0.93	7.95±0.48	1.30	3.85±0.30	3.5±0.25	-	-	8.05±0.14	3.20±0.16	94.2	5.71
30	*Potentilla recta* L.	21.3±0.55	16.4±0.28	1.29	6.50±0.35	5.65±0.30	-	-	13.2±0.53	3.65±0.12	93.0	7.0
31	*Rubus niveus* Thunb.	21.9±0.52	18.3±0.68	1.19	3.30±0.14	3.8±0.37	0.65±0.15	1.20±0.18	12.6±0.47	3.75±0.35	91.1	8.82
32	*Cotoneaster affinis* Lindl.	18.9±0.44	15.8±0.20	1.00	5.65±0.32	6.95±0.28	-	-	10.9±0.32	4.35±0.32	92.6	7.36
33	*Sorbaria tomentosa* Lindl	10.7±0.10	8.70±0.21	1.22	6.40±0.26	4.9±0.26	-	-	7.55±0.18	4.05±0.21	95.1	4.80
34	*Rosa canina* L.	18.6±0.34	13.4±0.46	1.38	6.9±0.29	5.9±0.29	0.45±0.93	1.65±0.23	12.4±0.21	3.90±0.15	86.7	13.2

35	*Geum urbanum* L.	21.0±0.60	15.7±0.42	1.33	7.25±0.30	5.05±0.21	1.05±0.09	1.10±0.12	11.0±0.34	3.60±0.12	85.9	14.0
36	*Crataegus songarica* K.	23.9±0.41	18.7±0.42	1.27	9.35±0.45	8.3±0.39	1.10±0.12	1.55±0.28	12.8±0.32	4.25±0.17	82.5	17.5
37	*Potentilla reptans* L.	23.4±0.51	19.9±0.39	1.17	7.1±0.35	6.5±0.79	-	-	12.2±0.78	4.35±0.16	79.5	19.5
38	*Eriobotrya japonica*	26.2±1.09	25.2±1.15	1.03	5.6±0.37	7.0±0.24	-	-	11.5±0.44	4.65±0.25	88.6	11.3
39	*Rubus occidentalis* L.	23.7±0.35	18.5±0.27	1.28	8.55±0.39	11.7±0.35	-	-	12.8±0.32	5.10±0.21	86.3	13.6
40	*Potentilla nepalensis*	26.2±0.25	23.8±0.35	1.09	4.7±0.16	6.15±0.16	-	-	12.2±0.32	3.40±0.39	76.3	23.6
41	*Sibbaldia procumbens* L.	20.7±0.82	15.9±0.59	1.30	6.45±0.40	6.45±0.33	0.55±0.07	0.55±0.93	12.7±0.39	3.65±0.23	82.1	17.8
42	*Geum elatum* var. humile	18.4±0.41	14.7±0.39	1.25	7.10±0.33	6.40±0.48	0.6±0.12	1.40±0.12	9.65±0.57	3.65±0.32	83.9	16.0
43	*Potentilla atrosanguinea*	25.8±0.43	19.2±1.75	1.34	10.1±0.23	6.60±0.26	-	-	19.9±0.26	4.15±0.23	80.6	19.3
44	*Potentilla crantzii* Beck	32.4±0.20	15.3±0.32	2.11	12.0±0.48	8.2±0.42	-	-	21.5±0.54	4.8±0.26	65.6	34.3
45	*Filipendula ulmaria* L.	16.1±0.35	8.45±0.21	1.90	12.2±0.28	7.45±0.54	1.75±0.17	0.9±0.16	9.4±0.38	4.45±0.28	80.7	19.2
46	*Sibbaldia cuneata* Horn	19.6±0.37	15.1±0.23	1.29	6.3±0.33	4.6±0.43	-	-	12.0±0.48	4.0±0.25	89.1	10.8
47	*Rosa webbiana* Wall.	35.1±1.50	21.2±0.37	1.65	13.7±0.93	8.85±0.40	-	-	31.4±0.67	4.0±0.26	84.9	15.0

3.5 DISCUSSION

3.5.1 Foliar Epidermal Anatomy

The present findings based on Light Microscopy (LM) stomatal and trichomes diversity were studied in Rosaceous taxa from district Swat, northern areas of Pakistan based on foliar epidermal anatomy. The Rosaceous taxa, which include 47 species across 19 genera, were examined. In the Rosaceae family, there are a total of 7 different types of stomatal complexes. 15 species have Stephanocytic type stomata, 14 species have Paracytic type stomata, 10 species have Laterocytic type stomata, 6 species have Anomocytic stomata, 5 species contain Tetracytic type stomata, 4 species have Actinocytic type stomata, while Staurocytic type stomata have been observed only in 3 species at the same time both glandular and non-glandular trichome was also studied.

Using Light Microscope (LM) detailed study of both qualitative and quantitative micro-anatomical features of the epidermal cell, shape, size, and types of Stomata and trichomes are regarded as the essential characteristics that offer the plant taxonomist considerable potential for correctly identifying the species. Based on Light Microscope (LM) **2** (two) different types of trichomes were detected in the family Rosaceae. Non-glandular trichomes were unicellular, uniseriate and mostly conical, stellate and cylindrical in shape. Glandular trichomes were Capitate, multicellular, uniseriate and found only in 13 species while only in *Geum urbanum* **3** different types of trichomes were observed **1** non-glandular and **2** Glandular trichomes with a different in qualitative appearance. Anatomical characteristics of Rosaceae family leaves under light microscope (LM) are crucial for accurate identification and delimitation. Previous studied records based on Light Microscope (LM) play a dynamic role in the investigation of a phylogenetic relationship with other taxonomic groups. Quantitative and qualitative data were found to be fruitful traits in taxonomic diagnosis of the family Rosacea. Genus *Potentilla* under light microscope exhibit great variations in glandular trichome (Capitate) size and morphology except *Potentilla crantzii* that lack Glandular trichome. Capitate trichomes in the family Rosaceae consist of 1-4 cells head with 2-4 cells basal stalk. The Rosaceous species collected from higher altitude (alpine) mostly exhibit Capitate glandular trichome. The present findings of the study revealed great variations in stomatal complexes and trichomes presence on both abaxial and adaxial exteriors of the family Rosaceae.

The current results of the study indicate specific information's with respect to species taxonomic identification of family Rosaceae. For the purpose of identifying and separating taxa within the Rosaceae family, the foliar epidermal traits examined in this study are crucial, their significance in identifying other plant taxonomic groups is also demonstrated by previous records (Ashfaq et al., 2019; along with Bahadur et al., 2019; and Munir et al., 2011; similarly Sufyan et al., 2018; and Ullah et al., 2018; Yousaf et al., 2008). According to various workers (Adedeji et al., 2007), trichomes can be beneficial at certain levels. (Metcalfe & Chalk, 1979) Different trichome types may sometime be very helpful to distinguish between species, genera, and even families. Formation of taxonomic key for correct identification of species mainly based on qualitative micro-morphological features that includes stomatal and trichomes diversity and their presence and absence on abaxial and adaxial surfaces in foliar anatomy (Khan et al., 2017; and Stenglein et al., 2003: as well as Ashfaq et al., 2019;).

According to (Shaheen et al., 2022) no stomata was observed on abaxial surface of *Eriobotrya japonica*, Paracytic type stomata was observed only on adaxial surface and no trichome was present, while current research findings is completely dissimilar as in *Eriobotrya japonica* stomata is Staurocytic and present only on abaxial surface, no stomata were observed on adaxial surface, Similarly abundant Cylindrical, unicellular, uniseriate trichome was also observed. In *Prunus persica* on abaxial surface Anomocytic stomata noted in the current findings show dissimilarity with the previous study done by (Munir et al., 2011; Shaheen et al., 2022), with a similarity only on polygonal shape of the epidermal cells. According to the previous work done by (Shaheen et al., 2022) *Fragaria vesca* have paracytic stomata, polygonal epidermal cell, cylindrical and capitate trichome present on adaxial surface while abaxial surface no stomata and trichomes were observed, however the current research findings in *Fragaria vesca* Laterocytic stomata was noted only on abaxial surface while cylindrical and capitate trichomes were also observed. Similarly, in *Potentilla supina* on adaxial surface in the previous work (Shaheen et al., 2022) Anomocytic stomata and only glandular trichome were mentioned, while in the present research on both abaxial and adaxail surface Laterocytic stomata and both Conical and glandular Capitate trichomes were detected.

Qualitative and quantitative variation in *Prunus dulcis* has also been detected by the previous work of (Shaheen et al., 2022), stomata was absent and stellate trichome was present on abaxial surface, while in present findings Tetracytic stomata was noted only on abaxial surface and no trichome was detected on both surfaces. According to the previous work by (Shaheen et al., 2022) *Prunus armeniaca* has no trichome and paracytic stomata present only on adaxial surface while the current observation revealed that Anomocytic stomata and conical trichome present on abaxial surface. Dissimilarity within the current and previous study of the family Rosaceae was also found in *Prunus cerasus.* Paracytic stomata on adaxial surface with completely absence of trichome was mentioned by the previous research, while current research revealed the presence of Tetracytic stomata only on abaxial surface with the presence of cylindrical non-glandular trichome in *Prunus cerasus.* Similarly, by the same authors mentioned in their previous findings that *Prunus domestica* abaxial surface have no stomata and trichome, only adaxial surface exhibit Paracytic stomata which is completely dissimilar from the current findings of the study. *Prunus domestica* in the current findings shows the presence of Anomocytic stomata only on abaxial surface with the prescence of unicelluar cylindrical trichome in the same plant.

Both qualitative and quantitative detections were also noted in *Malus pumila* in the previous and current findings. According to (Shaheen et al., 2022) Anomocytic stomata in *Malus pumila* was observed only on adaxial surface with completely absence of trichome, while the current findings shows that Paracytic stomata is only present on abaxial surface, unicellular cylindrical trichome was also found in the same plant. In the current research findings *Pyrus pyrifolia* have Anomocytic stomata only on abaxial surface while the previous study of (Shaheen et al., 2022) Paracytic stomata was noted only on adaxial surface. Contradiction within qualitative and quantitative observations in *Rosa banksiae* was also notified. Paracytic stomata only on adaxial surface was noted with complete absence of trichome in the previous study (Shaheen et al., 2022), however in present research Actinocytic stomata only on abaxial stomata was found with the presence of cylindrical trichome. Variations in micro-anatomical features in *Rosa indica* were also exists between present and previous research findings of (Shaheen et al., 2022). Diacytic stomata was found only on adaxial surface with no trichomes, while in present research work Paraytic stomata was noted only on abaxial surface, unicellular cylindrical trichome was also present in *Rosa indica*.

Diacytic stomata was not found in family Rosaceare. Foliar micro-anatomical research was also carried out by the family Lamiaceae, most common stomata types of

Lamiaceae were anomocytic, anisocytic, and diacytic (Gul et al., 2019). *Rosmarinus officinalis* (Rosemary) belong to family Lamiaceae were considered the member of family Rosaceae having Diacytic stomata and stellate trichome on adaxaial surface by (Shaheen et al., 2022). The same foliar micro-anatomical features of the family convolvulaceae were also studied previously, mostly Paracytic and rarely Anomocytic stomata with capitate glandular trichomes were observed (Ashfaq et al., 2019). In gymnosperm stomatal complex is usually found to be sunken (Khan et al., 2019) while in rosaceous taxa a very less number of stomata was observed. According to the previous bioinformatics data of (Majeed et al., 2022) glandular trichome was observed only in 6 species out of 14 Amaranthaceous taxa, glandular trichome was having a broad base with a narrow-pointed tip while in the current bioinformatics data of Rosaceae taxa glandular trichomes is having cylindrical stalk with glandular broad cap at the tip. 12 species from two genera of Dryopteridaceae (Dryopteris and Polystichum) were studied preciously, only 2 types of stomata were observed Staurocytic stomata was found in Polystichum which is similar to the current research findings while Polocytic stomata which is not found in Rosaceae was present in the genus Dryopteris by (Shah et al., 2018). Subfamily Caryophylloideae had been investigated (Ullah et al., 2018) in which Diacytic stomata was dominant found in 12 species out of 14 while in family Rosaceae no Diacytic stomata was observed.

The main objective of the recent study was investigation of foliar micro-anatomical features of the family Rosaceae with special prominence on stomatal and trichome diversity via using light Microscope (LM). Taxonomic study via using light Microscope (LM) for the correct identification and delimitation of any group of taxa thus play a vibrant role in the field of taxonomy and provide the taxonomist valuable potential to distinguish any taxonomic group or level up to certain extent using foliar epidermal features.

3.5.2 Pollen morphology

The present palynological findings of the data are mainly based on light microscopy (LM). The main objective of the palynological findings was to find out variations and diversity of pollen among Rosaceous taxa collected from different geographical locality from District Swat, the northern areas of Pakistan. The current palynological study used a total of 47 distinct species from 17 different genera of the Rosaceae family to examine pollen diversity. A total of 3 main different types of pollen were studied among Rosaceous taxa. 29 Rosaceous taxa exhibit Tricolpate pollen, 26 Rosaceous taxa are represented by Tri-colporate pollen and only one specie *Cotoneaster nummularius* exhibit a single Tetracolpate pollen, beyond these results in pollen type no dynamic variations in Rosaceous taxa were found.

Rosaceous taxa showed considerable diversity with respect to qualitative and quantitative pollen micro-morphological data, however all studied species shared similar physical surface outlines such as striate sculpturing. Under light microscope a detailed account of pollen micro-morphology including both qualitative and quantitative observations of Rosaceous pollen were studied. The qualitative characters used in the present study include size of the pollen, Pollen type, Pollen class, Polar and equatorial view of the pollen. On the other hand, the quantitative parameters which is used to find out the quantitative features of the pollen include Polar diameter, Equatorial diameter, Ratio between the polar and equatorial value, Length of colpi, width of colpi, Length of pollen pore, width of pollen pore, Mesocolpium, Exine thickness and percentage of Fertile and sterile pollen. The current account of palynological study in Rosaceae a diverse variation was noted on both the quality and quantity in the pollen morphology. The basic criteria to correctly identified species is mainly the qualitative and quantitative data that's include shape of the pollen, polar and equatorial diameter, length, and width of colpi etc, (Eide, 1981; Hebda & Chinnappa, 1994; Shinwari, 2004).

More diversity in palynological variations were observed in the studied taxa, except the number of apertures in the form of Colpi and pore. Although Rosaceous taxa is mainly represented by tricolporate pollen (Eide, 1981; Hebda & Chinnappa, 1990, 1994; Zhou et al., 1999), tetra as well as hexacolporate pollen were also found in Rosaceous taxa (Chung et al., 2010; and Lee et al., 2011)**.** In this study tricolporate pollens in the family Rosaceae are consistent with the observations of Lee et al and Chunsg**.** In this study, we determined the Tetracolpate, Prolate type of pollen in *Cotoneaster nummularius* with 91.1 % rate of fertility, while according to (Niaki et al., 2020) pollen grain of *Cotoneaster nummularius* had tetracolporate, prolate-spheroidal pollen with 98 % fertility rate. Thus, the aperture type and shape of pollen in *Cotoneaster nummularius* remains controversial with the present data. Similarly consistent similarities in the current study have not been observed in both quantitative and qualitative data of *Fillipendula ulmaria* with the previous data of (Lee et al., 2009). Dissimilarity in *Cotoneaster affinis* pollen micro-morphological appearance in both qualitative and quantitative were also observed in current and previous literature of (Anjum & Muhammad, 2014). In this study pollen of *Cotoneaster affinis* was observed Spherical and tricolpate while according to Parveen et all pollen of *Cotoneaster affinis* was Prolate-spheroidal with tricolporate, thus shows a diverse variation in pollen class. The diversity and variations in pollen data has also been observed in *Fragaria nubicola,* according to Parveen et all the pollen of *Fragaria nubicola* had tricolporate with a P/E ratio 1.25 µm, while in this study the pollen of *Fragaria nubicola* was noted Tricolpate with a P/E ratio 1.23 µm. The only similarity was noted with the previous data in *Fragaria nubicola* is in the class of pollen that was Subprolate.

Controversial data has also been observed with previous records in *Cydonia oblonga.* The pollen grain of *Cydonia* was larger in size, tricolpate, Sub-prolate with a P/E ratio 1.16 µm, while the previous palynological data of *Cydonia oblonga* by (Radovic et al., 2016) is completely dissimilar with the current data. Similarity in the present qualitative and quantitative pollen micro-morphological data with respect to previous literature in *Malus pumila* by (Nazeri, 2008; Perveen & Qaiser, 2014) have been observed. The pollen of *Malus pumila* was Tricolpate type with Sub-prolate in pollen class. According to (Ullah et al., 2019) pollen grain in the subfamily of *Alsinoideae* was mostly subs-pheroidal or prolate and have two types of ornamentations microechinate-punctate and perforate with a pollen type pantaporate, while in family Rosaceae pantaporate and echinate type pollen was not observed. Family *Lamiaceae* exhibit monad, tricolpate, and oblate class pollen which is the similar characters with respect to the current palynological study of pollen found in family Rosaceae (Gul et al., 2021). The results of this investigations are quite different with the previous palynological micro-morphology of the genus *Rosa,* a clear variations in the bioinformatics data between the polar and equatorial diameter of pollen were observed with the previous study of (Wrońska-Pilarek et al., 2015). The controversial bioinformatics data in the micro-morphological study in the genus *Rubus* were also found between this study and study done by the previous authors of (Lechowicz et al., 2021; Wronska-Pilarek et al.,2006; and Wrońska-Pilarek et al., 2012).

The primary goal of the current study was to investigate the Pollen micro-morphological features in the family Rosaceae under light microscope (LM), with a special emphasis on diversity and variations with Rosaceous pollen. Taxonomic study using a light microscope (LM) for accurate taxonomic group identification and delimitation thus plays a crucial role in the field of taxonomy and offers the taxonomist valuable potential to distinguish and segregate any taxonomic group or level up to a certain extent using palynological micro-morphological features.

3.6 CONCLUSION

Based on the current analysis of the pollen morphology and leaf epidermal anatomy the results obtained are more are less consistent with those of other palynologists, but the most discriminating characters was the polar and equatorial axis of the pollen grain along with the class of pollen shape determination. While the current study leaf epidermal micro-anatomical features were mostly not consistent with those of other taxonomists data. This is foremost detailed study that deals with the leaf micro-morphology and palynology of selected Rosaceous species growing in northern areas of Pakistan from temperate to alpine regions. The current findings reveal that foliar anatomical features, including the diversity of pollen morphology, epidermal cells, trichome morphology, and variation of stomatal types, are potentially useful to delimit the taxa at a specific level. Rosaceous species can easily be differentiated on account of their epidermal cell shape. The size of epidermal cells, their shape, and the stomata type of these species were considerably variable and different from each other. The diversity in the pollen morphology, foliar epidermal cell, stomatal types, and morphology of trichomes at species level also served as a useful taxonomic tool. Each trait has its own systematic importance in the delimitation of taxa. Furthermore, it is concluded that palynological and microanatomical characters provide accurate identification and taxonomic key description of Rosaceous species proved to be significant in classification.

3.7 RECOMMENDATIONS.

Future recommendations for further study on family Rosaceae would be investigation of pollen and leaf epidermal characters of other Rosaceous genera and its species for better understanding and defining natural taxonomic lineages in the family Rosaceae, As more investigating the other species of the genera it may be possible to observe more characters. Finally, pollen morphology and leaf epidermal anatomy will have to be correlated with other characteristics such as Morphometric, DNA barcoding’s etc, to establish more clearly relationship and identification of the taxonomic group within the family Rosaceae.

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(Map of District Swat Showing Damaged Areas and Sampling Points | Download Scientific Diagram, n.d.)

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