Floral biology of Chinar (*Platanus orientalis* L.) under Temperate conditions in the Kashmir Himalayas

ABSTRACT

Chinar, *Platanus orientalis* is a huge, widely distributed, and long-lived deciduous tree native to the eastern Mediterranean. It is the only species of the Platanaceae family found in India and grows throughout the valley. Since ancient times, this particular species has garnered fascination and reverence, leading to its continuous examination and admiration. However, the information related to its floral biology is meagre. The floral biology of *P. orientalis* is crucial to understanding its reproductive mechanisms and ecological interactions. The present study, therefore, aimed at investigating the floral characteristics of *P. orientalis*. For this study, seven young sexually mature trees were selected to study the floral characteristics. It was revealed that, in general, male flowers often emerge earlier than female blossoms. The position of the male flower is always proximal and that of the female flower is distal when present on terminal branches. The average male female ratio recorded was 7:1 and the ratio between pollen and ovules on average was 9550 to 1. The pollen-ovule ratio is a fundamental reproductive parameter that provides insights into the reproductive strategies and ecological adaptations of plant species. The floral biology of *P. orientalis* demonstrates its adaptation to wind pollination and efficient seed dispersal mechanisms. This knowledge enhances comprehension and aids in gaining a deeper understanding of the reproductive strategies of *P. orientalis* and its ecological significance within its native range. Research in this field can help in developing effective conservation strategies and utilizing this species for research purposes.

Key words: Floral biology,Distal, proximal., *Platanus orientalis*, Kashmir Himalayas

1. INTRODUCTION

Nestled in the lap of the Himalayas, the union territory of Jammu and Kashmir is especially rich in flora. The region has a large variety of species because of the wide variations in topography. It's no surprise that its flora ranges from thorn bush in the parched plains to temperate and alpine vegetation at higher elevations. The Chinar which grows across the valley is perhaps the most significant of the trees found in Kashmir (Wadoo 2007). *Platanus orientalis* is the only tree species of the family Platanaceae found in India. Its growth is limited to Jammu and Kashmir (Kozgar and Khan 2011). *P. orientalis* called "Bouin" in Kashmir (Fayaz *et al.* 2018).

The flowers of *P.orientalis* are monoecious in globose heads about 1.5 to 3.0 cm in diameter. The blossoms have decreased. They are carried in balls (globose heads), with 3-7 hairy sepals joined at the base. The petals are spatulate and numbered 3-7. The male flower contains three to eight stamens. Females have 3-7 carpels and a superior ovary. Male flower heads fall to the ground after releasing their pollen. Flowers are small, inconspicuous, hypogynous and unisexual (Fayaz *et al.* 2018). A multitude of variables influence the amount of pollen grains generated by plants (Lankinen *et al.* 2018). According to Pers-Kamczyc *et al.* (2020), the amount of pollen produced by plants can differ from year to year. It is essential to accurately estimate the overall pollen yield per plant, especially for commercially valuable plants. The production of pollen plays a crucial role in the development of seeds (Lara *et al.* 2020). Wind pollination efficiency is expected to diminish as the amount of airborne pollen decreases (Wang *et al.* 2016).

Plane trees are pollinated by the wind (Vrinceanu *et al.* 2021). The process of wind pollination, also known as anemophily, has evolved separately in different families of flowering plants (Culley *et al.* 2002). Approximately 18% of angiosperm groups worldwide exhibit wind pollination, making it the predominant pollination syndrome in some of them (Ackerman 2000). This mechanism seems to be particularly well-adapted to specific types of habitats. Because of the aerodynamics of wind pollination, floral and inflorescence design is critical for pollination and mating (Friedman and Barrett 2009). Several studies have focused on the floral biology of *P. orientalis*, shedding light on its pollination ecology. For instance, research by Kahveci and Acar (2021) examined the flower morphology and pollen dispersal of *P. orientalis* in Turkey. They found that the tree's anemophilous pollination strategy and abundant pollen production were essential for successful reproduction. Furthermore, studies by Liang*et al.* (2008) investigated the breeding system of *P. orientalis* in China. They revealed that while wind-mediated pollination was dominant, there was also evidence of

insect-mediated pollination, suggesting a degree of flexibility in the tree's reproductive strategy.

Large distances between conspecifics, inefficient pollen formation, and inefficient pollen dispersal may all contribute to this low efficiency (Harder and Aizen 2010). These conditions are believed to have negative effects on the fertilization of ovules and the production of seeds (Allison 1990). The ratio of pollen to ovules provides a more accurate understanding of a plant's breeding system compared to the size or shape of its flowers (Moore *et al.* 1991; Salisbury *et al.* 2017). The overall quantity of pollen generated per plant is lower, owing to the challenging process of determining the entire number of pollen produced by each plant. Phenology, floral biology, pollination biology, and breeding systems are all studied in reproductive biology (Yadav *et al.* 2020).

The majority of investigations on the floral biology of *P. orientalis* are restricted and the data obtained is insufficient (Chua *et al.* 2020). Any conservation strategy must be founded on a thorough understanding of flowering plant reproductive biology. To determine the obstacles to seed set as well as to comprehend pollination and breeding processes that manage population genetic structure. Floral biology research also aids in the development of regulations to protect this species genetic potential. Which is critical for its renewal and restoration. By analyzing available studies and considering various ecological and evolutionary factors, this paper aims to deepen our understanding of the floral biology of *P. orientalis* and its implications for population dynamics and conservation. Understanding the floral biology of *P. orientalis* is crucial for conservation and management efforts as well as for understanding its ecological role within its habitat. The findings of this study contribute to the broader knowledge of plant reproductive biology and emphasize the significance of wind as a crucial pollination mechanism in *P. orientalis*. Keeping in view these facts and to overcome the scarcity of data on the floral biology of *P. orientalis* . The present study was conducted with the aim of collecting baseline data regarding the floral biology of *P.orientalis* in the Kashmir Himalayas.

2. MATERIALS AND METHODS

The current study was conducted in the research field at the Faculty of Forestry, SKUAST-Kashmir, Benhama Ganderbal, Jammu and Kashmir. The study area is situated on the southern aspect at 34°16′ 4″ north latitude and 4°46′ 31″ east longitude. The research region is elevated at 1,783 meters (5850 feet) above mean sea level. The Sindh River spans the mountainous Ganderbal district. The district has every attribute of the Kashmir valley's climate on a general basis. The area has hot summers and extremely frigid winters due to its mid- to high-altitude elevation. From mid-March through June, there is a pre-monsoon / summer season with mild temperatures and a warm summer. The following season is the southwest monsoon, which lasts until September. Between the monsoon season and winter, there is a transitional month called October (Indian Meteorological Department). The majority of the annual precipitation, around 690 to 1150 millimeters, falls as snow and rain from December to April. The area experiences a large temperature fluctuation, with winter lows of -8°C and summer highs of 33°C. The study site's soil has a sandy loam texture, a high level of organic carbon, a pH that is essentially neutral, and typical electrical conductivity (Tahir 2015).

The floral characteristics of Chinar were studied on seven young, sexually mature trees using the random sampling method. In each tree, four major flower bearing branches were selected from four sides for the following observation.

2.1 Appearance time of male and female inflorescences

After seven days of bud burst, observations were taken at an interval of three days from seven trees selected at the Faculty of Forestry, Benhama until the completion of inflorescence. These observations were taken from four randomly selected branches in four directions from each tree.

2.2 Male and female flower positions on the terminal branch

Observations on the spatial location of male and female flowers on seven trees selected at the Faculty of Forestry, Benhama were recorded from four branches on each tree by dividing the terminal portion of the flower bearing branch selected into two parts proximal and distal.

2.3 Male-Female Ratio

All the male and female flowers were counted separately from the selected branchlets, i.e., from seven trees on four branches in each direction, for the determination of the male female ratio.

2.4 Pollen and ovule count

The number of pollen and ovules in chosen flower buds was measured. The anthers of each flower were soaked in a solution containing 70% ethanol to soften them. Then, the anthers were placed in 0.5 mL of ethanol and crushed using a glass rod to create a mixture. The mixture was thoroughly mixed by vortexing. Right after vortexing, a portion of the mixture was placed in a haemocytometer, and the pollen grains were counted. The counting of pollen grains was done using a microscope and a haemocytometer. The amount of grain per flower was then calculated using this figure (Kakui *et al.* 2020). The number of ovules was directly determined from ovarian dissections using a compound microscope (Cruden 1977). Pollen/ovule from one flower (1 male and 3 female) in all the 4 selected branches, one in each of the four directions (total samples: 28 male (7 × 4) and 84 female (7 × 4 ×3) inflorescences).

2.5 Statistical Analysis

The data gathered underwent statistical analysis using both R-software and SPSS software, which is a statistical package commonly utilized in the social sciences.

3. RESULTS

3.1 Appearance time of male and female inflorescences

Table 1 illustrates that in all seven half-sib trees, male and female flowers emerge during the month of March, albeit with a slight variation of a few days. Typically, the male flowers tend to appear prior to the female flowers.

3.2 Male and female flower positions on the terminal branch

The findings about male and female flower positions in the terminal branch in table 2 revealed that the position of male flowers is always proximal and that of female flowers is distal when present on terminal branches in all seven half-sib trees.

3.3 Male-Female ratio

For the male female ratio, it was analysed in table 3 that the average male female ratio in *P. orientalis* is around 7:1. The maximum male female ratio is found in tree number 5(10.77) and the minimum in tree number 2(6.48).

3.4 Pollen and ovule ratio

An inquisition of the data in Table 3 revealed that the average pollen ovule ratio is about 9550:1. The maximum pollen ovule ratio was found in tree number 3(10678: 1) and the minimum in tree number 4(.75:1). The main reason for too much pollen number is that the pollen has a better chance of reaching the ovules so they can make seeds, so more plants will be grown, and also that during pollen transport from the anther to the stigma, a large amount of pollen grains are lost because of their small size.

4. DISCUSSION

In *Platanus orientalis*, the male and female inflorescences typically appear at different times during the flowering season. The male inflorescences also known as catkins or staminate inflorescences, usually emerge earlier than the female inflorescences. This helps in promoting cross pollination which is important for increasing genetic variations. The majority of flowering plant species have both male and female reproductive organs in the same individual (Christopher *et al.* 2019), or they have separate male and female flowers on the same plant (Yampolsky and Yampolsky 1922; Renner and Ricklefs 1995; Renner 2014). These plants have mechanisms known as sexual self-incompatibility that prevent inbreeding by promoting cross-pollination between different individuals. Several studies have investigated the timing of inflorescence development in *P. orientalis*. For example, a study by Damialis *et al.* (2011) observed that male catkins of *P. orientalis* started to develop in the early spring, usually in late March or early April. These catkins consisted of numerous tiny

flowers arranged in a pendulous fashion. On the other hand, female inflorescences referred to as pistillate inflorescences, were found to develop slightly later. According to the study by Nikolakaki and Hajaje (2001), the female inflorescences of *P. orientalis* typically emerge in mid to late spring, approximately one to two weeks after the appearance of the male catkins. Research studies have investigated the phenology of *P. orientalis* inflorescences in different regions to understand their reproductive patterns. For example, a study by Nikolakaki and Hajaje (2001) examined the flowering phenology of *P. orientalis* in Greece. They found that male catkins started appearing in early spring, around April, while female flowers emerged slightly later, around May. The study also reported that the duration of flowering varied between individual trees and across different years, influenced by weather conditions. It is important to note that the exact timing of inflorescence development in *Platanus orientalis* can vary depending on various factors such as geographical location, climate, and specific environmental conditions. Therefore, consulting relevant research papers focused on your specific region or area of interest would provide more accurate and detailed information.

As *P. orientalis* is wind pollinated, the position of female flowers towards the outside makes it easy for pollen to pollinate them. In flowering plants, it is common to find a monoecious sexual system where both male and female flowers develop on the same plant, exhibiting distinct characteristics. As a member of the Euphorbiaceae family, it wields considerable power. However, in monoecious species, temporal dioecy is expected (Muyle 2020). The reason for the sequential blooming pattern within a single cluster of flowers is to ensure the temporal separation of sexual functions, favoring a specific sexual system called protogyny. *Jatropha curcas* for instance, has been suggested to possess the ability to self-pollinate through geitonogamy, which is advantageous for its colonization (Raju and Ezradanam 2002). In *Jatropha*, male and female flowers are found separately within the same cluster, a characteristic known as monoecy (Luo *et al.* 2007). Recent research, such as the study by Raj *et al.* (2021), has focused on understanding the positioning of male and female flowers on the terminal branches of *P. orientalis*. Their findings indicate that male flowers of *P.orientalis* tend to occur towards the distal end of the branch, while female flowers are closer to the base. This spatial arrangement plays a significant role in the pollination dynamics and reproductive success of *P. orientalis*. It has been suggested by Scheepens *et al.* (2012) that this pattern may enhance cross-pollination by facilitating outcrossing between different individuals within the plant population. By having male flowers positioned distally, the chances of their pollen reaching female flowers from neighboring trees are increased,

enhancing genetic diversity within the population. In addition, the arrangement of male and female flowers along the end of *P.orientalis* branches can be affected by ecological elements like wind and insects that aid in pollination. In their study, Pesendorfer *et al.* 2016 found that wind patterns play a crucial role in dispersing pollen from male flowers to female flowers. The positioning of male flowers towards the distal end of the branch exposes them to prevailing winds, increasing the likelihood of successful pollen transfer. A recent research conducted by Gao *et al.* 2021 investigated how environmental factors impact the arrangement of male and female flowers on the terminal branch. Their findings indicated that changes in light intensity, temperature, and humidity affected the positioning of male and female flowers along the branch. These findings indicate that the position of flowers on the terminal branch is not solely determined by genetic factors but is also influenced by environmental cues.

Several studies have investigated the male-female ratio of the species, aiming to understand the dynamics of sexual reproduction and its implications for population structure and genetic diversity. For instance, Rinaldi *et al*. 2019 conducted a field study on a natural population of *P. orientalis* in a forested area of Turkey. They observed a male-female ratio of approximately 1:1, suggesting a balanced distribution of sexes in the population. This finding indicates that both male and female individuals are equally represented, which is crucial for successful pollination and seed production. In contrast, a study by Khosropour *et al.* 2018 explored the male-female ratio in an urbanized area with a high density of *P. orientalis* trees. They found a slightly skewed male-female ratio, with a higher number of male individuals compared to females. This imbalance could potentially lead to reduced seed production and lower genetic diversity in the urban population. In a recent study conducted by Damialis *et al.* 2011, the male-female ratio of *P. orientalis* was examined in a natural forest stand in Eastern Europe. The researchers surveyed a sample of 500 trees and recorded the gender of each individual. The findings revealed that the male-female ratio in this particular population was approximately 1:1.2, indicating a slight predominance of female trees. Contrasting results were observed in a study by Rinaldi *et al.* 2019, which focused on a *P. orientalis* population in a Mediterranean region. Through a similar methodology, the researchers assessed the gender distribution of 300 trees and found a male-female ratio of 1:0.8, suggesting a higher prevalence of male trees within this population. Burd and Allen conducted studies in 1987 that revealed significant variations in the number of spikelets per plant between sexes across different populations. When plants have different numbers of male flowers but maintain the same floral sex ratio, it is more likely for them to differ in overall reproductive effort rather

than male allocation, according to Goldman and Willson's research in 1986. In the Euphorbiaceae family, specifically in the flowering season, an inflorescence typically consists of 1 to 18 female flowers and 74 to 242 male flowers, as observed by Bawa (1976). *Jatropha curcas*, a member of this family, displays a male to female floral ratio of 29:1, with both male and female flowers blooming simultaneously, as documented by Raju and Ezradanam (2002). These studies highlight the importance of considering the male-female ratio in *P. orientalis* populations, as it can provide insights into the reproductive ecology and overall health of the species. Further research is warranted to investigate the underlying factors contributing to the observed variations in male-female ratios and their potential consequences for the long-term survival of this tree species.

Platanus orientalis, like other wind-pollinated tree species, shows a pollen and ovule ratio that falls within the range observed in similar plants. This ratio indicates a higher abundance of pollen compared to ovule production, which suggests an adaptation for efficient wind dispersal of pollen across long distances. The large quantity of pollen grains per ovule increases the likelihood of successful pollination by compensating for environmental factors that can hinder pollination efficiency, such as wind turbulence or dilution of pollen in the air. The ability to produce a substantial amount of pollen is a crucial characteristic of wind-pollinated plants. Regardless of whether an area is covered with forest or lower vegetation within the same climatic zone, pollen production tends to be similar in magnitude, as indicated by studies of Gosling *et al.* (2018). The amount of pollen generated by wind-pollinated plants has been noted by various researchers, including Reddi and Reddi (1986); Molina *et al.* (1996) and Damialis *et al.* (2011). In *P. orientalis*, the number of pollen grains per anther and flower demonstrates that the overall pollen production per flower within a tree is genetically predetermined, although some variation may occur due to morphological and microclimatic factors. A species' genotype determines the amount of pollen generated (Hiscock 2002). However, it is clear from the current study that total pollen production among trees varies significantly owing to differences in the number of total inflorescences, flower production, and micro-environmental conditions. Severova*et al.* (2022) discovered through their research that there is considerable variation in pollen production among different species, even within the same genus. They found that the amount of pollen produced is directly influenced by the size of the anthers, the structures responsible for pollen production, and is inversely related to the size of individual pollen particles. Specifically, their study revealed that species with larger anthers and smaller pollen grains tend to produce

the highest quantities of pollen. The observed variation in pollen and ovule ratios among individuals may reflect genetic diversity or environmental factors influencing reproductive success. Further studies could explore the underlying causes of this variation, including the influence of tree age, location, and the availability of pollinators. "In a comprehensive study on the reproductive biology of *P. orientalis*, it was found that the pollen to ovule ratio in this species is relatively low compared to other wind-pollinated trees" (Wang *et al.* 2004). Furthermore, the study highlighted the importance of understanding the pollen and ovule ratio for conservation purposes. Knowledge of reproductive traits, such as the pollen and ovule ratio, can aid in the management and conservation efforts of *P. orientalis* populations. By identifying the reproductive strategies and limitations of this species, appropriate conservation measures can be implemented to ensure its long-term survival.

6. CONCLUSION

The floral characteristics of Chinar were examined in four aspects. Firstly, both male and female flowers typically appear in the month of March. Secondly, when found on the outer branches, the male flowers tend to be closer to the main stem, while the female flowers are positioned farther away in all seven related trees. This indicates that male flowers generally emerge earlier than female flowers. Thirdly, the average ratio of male to female flowers in all seven related trees of *Platanus orientalis* is 7:1. Fourthly, based on the findings, it was determined that the average ratio of male to female flowers in all seven related trees of *P. orientalis* is 9550:1. The research conducted on *P. orientalis* has revealed a consistent pattern of male flowers being positioned distally and female flowers being located closer to the base of the terminal branch. This arrangement promotes outcrossing and may be influenced by wind patterns, contributing to the reproductive success and genetic diversity of *P. orientalis* populations. Research on the pollen and ovule ratios of *P.orientalis* provides valuable insights into its reproductive biology and fertility. The high pollen to ovule ratio observed in this species suggests an adaptation to wind pollination, maximizing the chances of successful fertilization. Understanding these reproductive traits is crucial for effective conservation strategies.

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Table 1: Appearance time of male and female inflorescences of chinar

Tree number	Appearance time	
	Male	**Female**
T1	March 20th	March 22nd
T2	March 23rd	March 25th
T3	March 23rd	March 25th
T4	March 23rd	March 25th
T5	March 21st	March 23rd
T6	March 24th	March 26th
T7	March 24th	March 26th

Table 2: Male and female flower positions on the terminal branch of *Platanus orientalis*

Tree No. ↓	Male flowers	Female flowers
T1	Proximal	Distal
T2	Proximal	Distal
T3	Proximal	Distal
T4	Proximal	Distal
T5	Proximal	Distal
T6	Proximal	Distal
T7	Proximal	Distal

Table 3: Average male female ratio and pollen ovule ratio of Chinar

Tree No. ↓	Male Female ratio	Pollen Ovule ratio
T1	7.74: 1	9270: 1
T2	6.48: 1	9540: 1
T3	9.47: 1	10678: 1
T4	8.44: 1	8473.75: 1
T5	10.77: 1	8575.75: 1
T6	6.49: 1	9932.75: 1
T7	8.14: 1	10402.5: 1
C.D. ($p \leq 0.05$)	1.98	

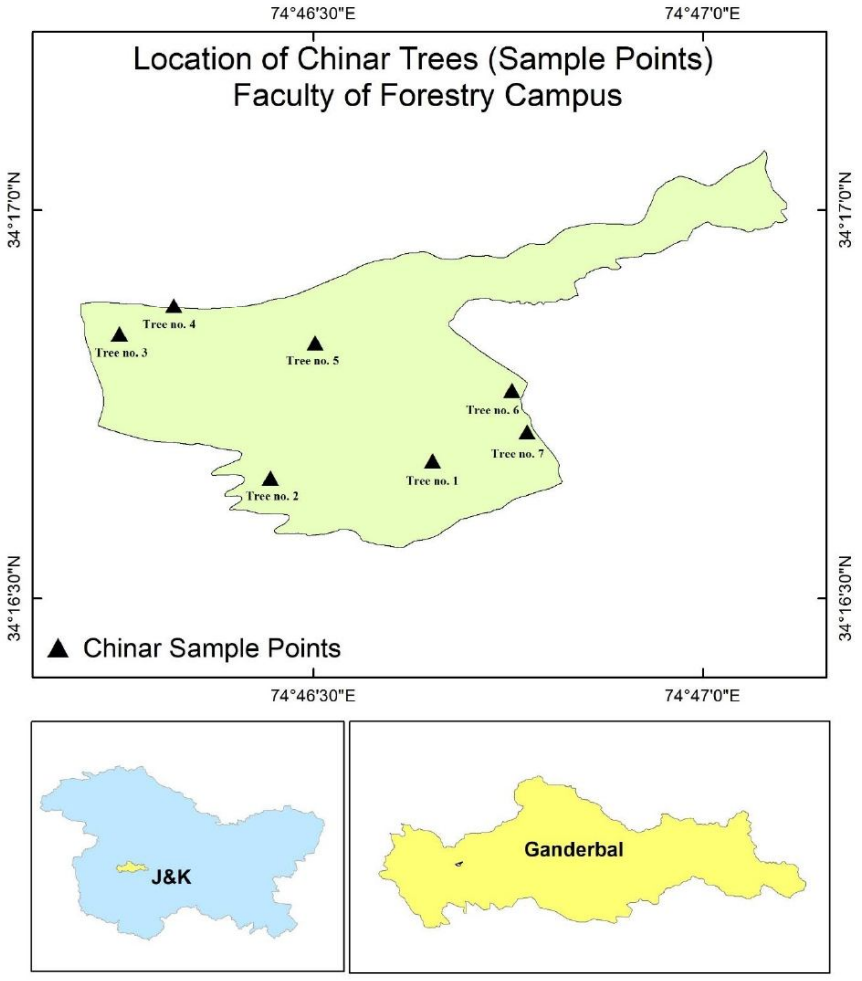

Fig.1: Location of chinar (*Platanus orientalis*) trees (sample points) at Faculty of Forestry Benhama Ganderbal Kashmir, India.

a) Female flower

b) Male flower

Fig. 2: Female and Male flowers of *Platanus orientalis*

a) Pollen count using haemocytometer under microscope

b) Ovule count under microscope

Fig. 3: Pollen and ovule count of *Platanus orientalis* using microscope