

Research Article

Phenodynamics of *Ginkgo biloba* L. - A Living Fossil under threat under temperate conditions of Kashmir Himalayas, India

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Abstract

The present investigation entitled “Phenodynamics of *Ginkgo biloba* L. – A living fossil under threat” was carried out at Faculty of Forestry, Benihama, Ganderbal. Phenological events of *Ginkgo biloba* were studied at 15 days interval and described in different phases of growth throughout the seasons (2016-2017). The study revealed that the phenophases of *Ginkgo biloba* viz., Bud set and bud burst started earlier in male than in female trees. Catkin initiation started from 1st April and lasts till 15th April. The catkins begin to fall from 10th to 25th of May. Leaf initiation started from 5th to 25th April, while fruit formation from 1st to 15th June. In *Ginkgo biloba* leaf fall started from 25th November to 10th December in male and from 20th November to 5th December in female. The fruit begin to fall from 25th November to 10th December.

Keywords: *Ginkgo biloba*, Phenodynamics, Living fossil, Kashmir, catkin

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Introduction

The state of Jammu and Kashmir lies in Western Himalayas which has been recognized as floristically under explored by the Botanical Survey of India [1]. Jammu and Kashmir is a hilly state with an area of 2,22,236 Km² [2]. Biogeographically, it comprises of three district provinces: the subtropical Jammu, the predominantly temperate Kashmir, and the cold-arid Ladakh. About 2/3rd of the state's total area is recorded under forest and substantial part of this is non-conducive for the growth, being under permanent snow, glaciers and cold deserts [2]. *Ginkgo biloba* L. the sole survivor of the ancient family of Ginkgoaceae is the world's oldest tree. Also known as Maidenhair tree, Ginkgo is a monotypic genus native to China [3, 4]. *Ginkgo biloba* was admitted as a living fossil of Jurassic period that emphasizes its relic position [5]. *Ginkgo biloba*, which is not closely related to any other living plant, is generally classified in its own division the Ginkgophyta. Ginkgo is a hardy tree, tolerating a variety of climate and soil types. It can grow well in climates with a mean annual temperature from 8 to 20°C and can tolerate a minimum temperature of -20°C and annual rainfall ranging from 840 to 1400mm. The tree can survive for a short period at seasonal extreme temperature of 40°C and -30°C in China [6, 7]. The Ginkgo tree is grown in many regions of the world, now cultivated extensively in Asia, Europe, North America, New Zealand and Argentina. The species is cultivated commercially for obtaining leaves which are known to contain a wide variety of medicinally active chemicals, most notably terpenoids and flavonoids [8, 9]. Ginkgo leaf extracts are used for many pharmaceutical purposes. The leaves of this species are extensively used in the form of a concentrated standardized *Ginkgo biloba* Extract (GBE) in different countries of the world (particularly in China, Europe, France and Germany) as a source of herbal medicine.

Ginkgo biloba L. was listed as a rare species in the IUCN 1997 red list of threatened plants and listed in the red list of endangered plant species. Because of its high medicinal value the species has been exploited by pharmaceutical industries all over the world. The demand for *Ginkgo biloba* in the world is increasing from 26-36% every year. So, there is urgent need to cultivate *Ginkgo biloba* at large scale [10]. Phenology is a periodic phenomenon in plants that is tied to periodic environmental changes. This type of study investigates the relationship between climate and growing periods of plants of an area. The studies are essential for planning, regeneration, forestation, and conservation in rangeland and forestry. Further, the study of phenophases is yet to be taken up for this species to elucidate the exact stage and time of seed maturity, which is essential for collection of abundant quality of fully ripe, viable and vigorous seeds [11, 12].

Keeping in view the importance of this species and its least exploration, a study entitled “Phenodynamics of *Ginkgo biloba* L. - A Living Fossil under threat” was carried out with the objective to study different phenophases of *Ginkgo biloba* under temperate conditions of Kashmir Himalayas.

Materials and Methods

The present study was conducted in the Faculty of Forestry, SKUAST-Kashmir, Benhama, Ganderbal, Jammu and Kashmir. The site lies on the southern aspect at 34°16'44"N and 74°46'31"E. The study area is located at an elevation of 1783m (5850 feet) above the mean sea level. The study area has temperate climate experiencing four distinct seasons: a severe winter (December to February), a cold spring (March to May), a mild summer (June to August) and a pleasant autumn (September to November). The site falls in a mid to high altitude characterized by hot summer and very cold winters. The average precipitation is 690 mm most of which is received from December to April in the form of snow and rains

The phenological events of *Ginkgo biloba* were studied at 15 days interval in famous Shalimar and Harwan Mughal gardens of Srinagar, J&K. These events were described in different phases of growth throughout the seasons and following parameters were studied:

Bud set, Bud burst, Flowering, Leaf initiation, Fruit formation, Leaf tint, Leaf fall, Fruit fall and Seed characteristics

Results and Discussion

The data presented in **Table 1** summarizes Pheno-phases and reproductive behaviour of *Ginkgo biloba* in the selected sites at the Srinagar. The results envisage that the phenological events of the species overlap with each other. The bud set in the male tree started from 15th March to 1st April followed by bud burst from 20th March to 5th April, catkin initiation started from 1st to 15th April, catkin fall from 10th to 25th May, leaf initiation from 5th to 20th April, leaf tint from 25th October to 10th November. The leaf fall started from 25th of November and prolonged to 10th December.

The vegetative and reproductive phases of female *Ginkgo biloba* were observed to be delayed by some days as compared to male *Ginkgo biloba*. The bud set in female tree started from 20th March to 5th April followed by bud burst from 1st to 15th April, ovule formation from 15th April to 1st May, leaf initiation from 10th to 25th April, fruit formation from 1st to 15th June, leaf tint from 20th October to 5th November. The leaf fall started from 20th November to 5th December. Fruit fall from 25th November to 10th December (**Figure 1**). Seed characteristics of *Ginkgo biloba* are like this seed length 18.67mm, seed diameter 14.29 mm, seed weight 2.28 gm/seed.

Table 1 Pheno-phases of *Ginkgo biloba* trees in Srinagar Kashmir

S. No.	Reproductive and vegetative phases	<i>Ginkgo biloba</i>	
		Male	Female
1.	Bud set	15 th March-1 st April	20 th March-5 th April
2.	Bud burst	20 th March-5 th April	1 st April -15 th April
3.	Flowering	1 st April -15 th April	-
	a) Catkin initiation		
	b) Catkin fall	10 th May-25 th May	-
	c) Ovule formation	-	15 th April-1 st May
4.	Leaf initiation	5 th April-20 th April	10 th April- 25 th April
5.	Fruit formation	-	1 st June- 15 th June
6.	Leaf tint	25 th Oct-10 th Nov	20 th Oct- 5 th Nov
7.	Leaf fall	25 th Nov- 10 th Dec	20 th Nov-5 th Dec
8.	Fruit fall	-	25 th Nov- 10 th Dec
9.	Seed characteristics	-	18.67
	a) Seed length(mm)		
	b) Seed diameter(mm)	-	14.29
	c) Seed weight(g/seed)	-	2.28

Phenology is generally described as “The art of observing life cycle phases or activities of plants and animals in their temporal occurrence throughout the year” [13]. It is a part of reproductive biology that deals with the study of different life events of plants such as seed germination, bud break, leaf expansion, leaf color change, leaf fall, flowering and fruiting. [14] Reported phenology of gymnosperms including *Ginkgo biloba* in Nanital, kumaun Himalaya, India and recorded various phenological parameters like leaf emergence, seed germination, cones or seeds formation, catkin formation, fruit formation, leaf fall etc. The results of the present study revealed that phenology of *Ginkgo biloba* is strongly influenced by the climatic hostilities in the temperate zone. The spring phenophases are particularly sensitive to the temperature during late winter and early spring, which are also considered as accurate predictors of pheno-phase timing [15, 16].



Bud Set Stage



Bud Burst Stage



Catkin in male tree



Ovule in female tree



Fruit Set



Leaf fall



Fruit fall

Figure 1

Referring to the data represented in Table 1, our results reveals that annual life cycle for the *Ginkgo biloba* during the study period started from 2nd week of March for male and from 3rd week of March for female trees. The bud set initiated from 15th to 30th March for male and five days later for female from 20th March to 5th April with the corresponding phenophases following almost the similar trend. Bud burst started from the 20th of March to 5th April for male and for female tree progressing through 1st to 15th April. The time from initiation of bud swelling to bud break is longer when the average temperature prior to bud break is below 3°C, and shorter when the average temperature exceeds 5°C. It has been advocated that early melting of snow had a negative effect on phenology of the species [17]. Further as the temperature is low due the presence of snow, the phenological trends are largely affected by extremity in the mean temperature at higher elevations. This extremity in the ambient temperature results in delaying increase in soil temperature at high altitudes [18] This delay could explain the increase in thermal sum if phenological phases, especially the early ones (budburst) are influenced more by temperatures fluctuations. The phenomenon is known for sub-alpine and alpine plants which can start their development only when the snow has melted away. It is also reported that phenological events are constrained at high altitudes by the short growing season being delimited by cold temperatures and snow cover [19]. The time of snowmelt appears to have an almost universal effect on high-altitude phenology, the variations which can usually be linked to variations in climatic conditions [20]. A detailed phenological studies in Japan over a fifty year period by [21] have determined the spring bud break in Ginkgo occurs 40 days earlier in the extreme south of the country (30° N latitude) than it does in the far north (43° N latitude) and that autumnal leaf drop happens about 40 days later, making for an effective vegetative growing season range of 170 to 260 days across 13° of latitude. It's thus no wonder that Ginkgo is touted as a paragon of environment adaptability. The results of our study revealed that leaf initiation in male starts from 5th to 20th April and in the female from 10th to 25th April, which could be attributed to the increasing temperature and on set of rains observed in the month of April-May. Leaf emergence occurs early in summer, when light conditions were more favorable for photosynthesis at the start of the growing season. Thus, it is probably more favorable for plants to grow and expand their leaves earlier in spring rather than to prolong the photosynthetic season in autumn [22]. The Flowering dehiscence includes Catkin initiation and Catkin fall in male and Ovule formation in the female. Catkin initiated from 1st to 15th April with their dehiscence and starting from 10th to 25th May. The male catkins emerge before the leaves and fall off immediately after shedding their pollen. Flowering in female (ovule formation) started from 15th April and extended up to 1st May. According to [23] the onset of flowering is crucial to the reproductive success of flowering plants and in late flowering species the entire seed production is often lost in summers which are colder or shorter than the average. Pollination occurs from early April in the areas with mild winters to late May in areas with severe winters [24]. Fruit formation started from 1st June and continued up to 15th June. The seeds mature in November and length of embryo at this time may range from less than 1 millimeter to 5 millimeters (0.04 to 0.2 inch) at the time of seed drop. Once the seeds fall to ground, the embryo continues to develop until the arrival of cold temperature (below 10°C [50°F]), at which point elongation stops [25].

Leaf tint started from 25th October to 10th November in male where as in female from 20th October to 5th November approximately with little difference in timing. Whereas in female leaf fall started from 20th November to 5th December and subsequently fruit fall started from 25th November to 10th December. However, leaf fall in the male started from 25th November to 10th December. Ginkgo seeds are not protected by ovary wall and can as such be morphologically considered a gymnosperm. The apricot like structure produced by female Ginkgo trees are technically not fruits, but are seeds that have a shell which consists of a soft and fleshy section (the sarcotesta), and a hard section (the sclerotesta). Mature Ginkgo seeds are moderately abundant on trees and generally about 1 to 2 cm in length [26]. The seed encompasses an embryo surrounded by a thick seed coat. The seed coat consists of a soft, fleshy outer layer, a hard, stony middle layer and a thin membranous inner layer. The seeds change color in response to seasons with green during fall while they are growing and, as the temperature gets colder they turn to a yellow color [24]. The seeds usually fall from the trees they have a faint odor but, after they have laid on the ground for a few days, the fleshy outer covering of the seed coat start to decompose and, they start to develop an unpleasant rancid odor. After the fleshy outer layer has decomposes a hard-shelled nut is left. The results summarized in Table 1 reveal that seed dimensions of Ginkgo ranged from 18.67 millimeter to 14.29 millimeter. Similar results were reported by [27] that the seed, devoid of the famously smelly sarcotesta generally referred to as “nut” ranges in size from 19 to 30 millimeters.

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Publication History

Received	01 st Mar 2018
Revised	16 th Apr 2018
Accepted	04 th May 2018
Online	30 th May 2018

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