

Phenological Observation and Conservation of *Sophora mollis* Royle (Papilionaceae) an Endangered Multi-purpose Legume of North West Himalaya

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ABSTRACT: Phenological observation and Conservation of *Sophora mollis* Royle (Papilionaceae) is discussed. This species is a multipurpose legume distributed in the plains and foothills of N.W. Himalaya to Nepal Himalaya and is facing high risk of extinction due to habitat loss and indiscriminate exploitation by local people for its fuel and fodder values. Phenological observation on ex-situ plants has revealed poor and low percentage of fruit and seed sett. The influence of biotic factors coupled with poor seed setting has badly affected the regeneration and its population in the wild.

KEY WORDS: *Sophora mollis*, Phenological Observation, Conservation.

INTRODUCTION

Leguminosae are the third largest family of flowering plants. In India, leguminous plants are found throughout the country but the greater variety grows in the tropical and subtropical regions. Leguminosae include some of the most glorious of flowering plants and having great diversity in their method of acquiring the essentials of growth and in their modes of reproduction (Polhill & Raven, 1981). Although the family is distributed all terrestrial habitats, from the equator to the dry and cold desert, it has much of its diversity centered in the Himalayas.

The growing human population and enhanced pace of socio-economic development has enormously increased pressure on biological resources and on their natural habitats. This has led to the degradation of parts of earth biosphere and has resulted in loss of several plant species (Khoshoo, 1996). *Sophora mollis* Royle is one of such species whose habitat and natural populations are extensively reduced to critical level and facing high risk of extinction.

Sophora mollis is a multipurpose legume of great economic and conservation value. Originally it was commonly distributed in the plains and foothills of North-West Himalaya to Nepal Himalaya (Royle, 1835; Hooker, 1878; Collett, 1921; Nair, 1977), on exposed or shady situations and was used extensively by the local people for its high fodder and fuel values. The young twigs and leaves are used as a traditional fodder and the whole stems are used to meet their fuel requirements.

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This plant is on the verge of extinction due to loss, destruction and shrinkage of its habitat. The indiscriminate exploitation and destruction of its natural habitat by road construction and extensive mining, particularly in its type locality have resulted in large scale depletion of its populations and the species is facing high a risk of extinction. Therefore there is an urgent need to conserve this species.

MATERIALS AND METHODS

Four seedlings of *Sophora mollis* Royle were collected from its type locality in 1993 for its ex-situ conservation in the botanic garden. After successful transplanting and acclimatization of the seedlings, the plants flowered in 1997, after about four years of its transplanting.

For study of its phenology observations were made ex-situ on different phenophases i.e. (1) flowering and anthesis; (2) fruit setting, development and retention; and (3) fruit and leaf drop. During 1997 the phenological observations included the formation of first floral bud, its withering till development of fruits and seed set.

RESULTS

Phenological observations

The study on phenology started from the very beginning of the bud stage to full bloom. The twigs were marked for counting various floral stages at different time intervals (Opler, 1980; Semalty *et al.*, 1996). Flowering was recorded by counting the average floral stages on different twigs (Sharma, 1984). The formation of first floral bud was considered as floral initiation. There was simultaneous appearance of floral buds in the month of January 1997. The first floral bud was observed in the second week of January and anthesis (complete opening of flower) was observed from Feb, 17, 1997 on twig I. Anthesis was observed to be very slow and a mature buds takes 4-5 days for complete opening. Sufficient gap of time i.e. 7-10 days was absorbed for anthesis in different twigs.

The opening of the flower started with a slit at the top of the bud with the opening of the standard on outward direction. Subsequently wings get separated with a slit from the top, in two direction, finally keel starts opening and bend downwards. Complete opening of flower takes two to three days. Maximum anthesis of flowers was observed between 12 noon to 2 p.m. when more than 35% - 40% flowers were open. The evening and morning hours of the day were not very congenial of the anthesis. The temperature range between 12°C to 28°C and relative humidity 32% to 50% have been recorded during bud initiation and anthesis. 50% of flowering was recorded on first week of March and full bloom (90% flowering) is also observed at the end of the same week. (Table 1). The total period of flowering was 49 days. Fruit setting was recorded on March first week after 20 days of pollination. Interestingly no leaf sprouting was observed during this entire period (flowering and fruit setting).

Table 1. Anthesis in *Sophora mollis* statement of five days as well as specific period within a day.

Date	Twig No.	No. of floral buds observed	Percentage of flowers opened at						Temperature Max.	Temperature Min.	Relative humidity (R. H.)
			8 a.m.	10 a.m.	12 noon	2 p.m.	4 p.m.	6 p.m.			
26. 2. 97	I	40	20	35	35.5	40.6	40.6	40.6	26°C	12°C	47%
	II	22	-	4.5	4.5	9	9	9			
	III	25	-	12	12	20	20	20			
	IV	22	-	-	-	-	-	-			
	V	25	5.5	8	8	25	25	25			
27. 2. 97	I	40	-	47.5	47.5	48	48	48	28°C	10°C	43%
	II	22	10	14	14	17	17	16			
	III	25	15	24	24	26	26	26			
	IV	22	-	-	-	-	-	-			
	V	25	5	8	8	12	12	12			
28. 2. 97	I	40	-	57	57.5	62.5	65	65	23°C	12°C	45%
	II	22	18	18.2	18.2	27.3	27.3	27.3			
	III	25	-	32	32	34	34.5	34.5			
	IV	22	-	-	-	-	-	-			
	V	25	15	16	16	17	17	17			
1. 3. 97	I	40	-	75	76	78	78	78	28°C	10°C	39%
	II	22	30	32	32	36	36	36			
	III	25	-	32	33	34	34	34			
	IV	22	-	-	-	-	-	-			
	V	25	-	20	20	23	23	23			
2. 3. 97	I	40	-	95	95	95.5	95.5	95.5	29°C	12°C	53%
	II	22	-	63.7	63.7	64.5	64.5	64.5			
	III	25	-	60	60	64	64	64			
	IV	22	30	36	38	38	38	38			
	V	25	-	68	68.5	69.5	69.5	60			

Fruit setting, development and retention

The activity of fruit setting, fruit maturing and retention was observed to be a longer phenophase in *Sophora mollis*. All the already marked twigs were observed for the fruit setting observation. The marked branches were observed for the fruit setting behaviour after 30 days and 50 days of pollination subsequently. The fruit setting started in the first week of March and a maximum 88% fruit setting occurred in twig number-5, after 30 days of pollination. After 50 days of pollination the percentage of fruit retention have been observed to be declined enormously in all branches and a maximum retention of only 32% occurred in the same twig (Twig 5). Thus an average fruit setting after 30 days of pollination was 56.66% where as fruit retention after 50 days of pollination has gone down tremendously with an average to 21.4% this year (Table 2).

Table 2. Fruit setting percentage in *Sophora mollis* under open pollination in ex-situ during the year 1997.

Twig No. (Branch)	Year 1997 After 30 days of pollination	Year 1997 After 50 days of pollination
I	40%	18%
II	54.5%	23%
III	28%	20%
IV	72.8%	14%
V	88%	32%
Average	56.66%	21.4%

The fruit of *Sophora mollis* is a winged pod, 5-5.5 cm long and 0.6-0.8 cm broad. Each pod consists of 1-2 seed in ex-situ, however, 4-6 seeds are observed in in-situ. The pod is monoliform with an average weight 0.063g. Seeds are rounded, oval shaped whitish or blackish brown with an average weight 0.030g.

Leaf and fruit abscission

In the second week of April abscission of leaves started initially with abscission of leaflets first and simultaneously followed by entire leaf fall. The leaf fall was followed by the quick formation of many young branches and subsequent sprouting of many juvenile leaves in the same week of April. In the same week a vast majority of the fruits start getting dry with change in colour from green to yellowish brown. Fruit drop started from the third week of April which is almost complete by the last week of April. By the end of April complete leaf drop has been observed. During this period the branches remained leafless for about a week which is quickly followed by sprouting of juvenile leaves and young twigs. Interestingly no sprouting of juvenile leaves and twigs was observed during the flowering and anthesis.

Interestingly flowering and fruit set and development were delayed by about 25 days under in-situ. Flowering and anthesis were complete in ex-situ whereas bud formation, maturation, flowering and anthesis were continued during the same period (13-14. 3. 97) in the in-situ which is considered to be affected due to the diverse climatic conditions of two sites. The physical properties of soil in both (in-situ and ex-situ) do not appear to be much different indicating clearly that they do not have any direct bearing on the temporal differentiation of phenophases. Therefore, it is concluded that physiological activities in *Sophora mollis* Royle are largely governed by atmospheric temperature. The gradual increase in temperature in early summer induces the growth which is followed by anthesis whereas the decline in temperature in winters terminated the growth and subsequently the anthesis.

Floral biology

Flowers of *Sophora mollis* begin forming after the initiation of flowering bud in the last week of January. Gradually there is transformation of flowering buds into the mature buds and finally the appearance of complete flower. Flower developed first in copious short

ascending racemes which is about 4-5 cm long; pedicel is about equalling the calyx. Leaves don't appear at the time of flower formation but start appearing with the formation of fruits. The flowers are yellow in axils of leaves on dense axillary racemes. Each raceme comprises 6-12 flowers arranged in alternate or subopposite fashion and emerges from the base of leaves or on the apical or lateral branches of the stem. Flowers are hermaphrodite, zygomorphic, calyx 0.5-0.7 cm long, gamosepalous, silky, 5 toothed, cup shaped or campanulate, greenish yellow, corolla 2.3-2.5 cm long, arranged in 1+2+2 fashion; standard 1, 2.4-2.5 x 1-1.2 cm, somewhat oblong; wings 2, 1.9-2 x 0.5-0.6 cm, keel 1, 1.7-1.8 x 1.6-1.7 cm, hooked. Stamens 10, 1.5-2 cm long, all perfect in two series; anthers dark yellowish-brown, filament whitish green; ovary 1.5-1.6 cm long, superior; style simple 0.5-0.7 cm long. Fruits are winged pod 5-5.5 cm long, 0.6-0.8 cm broad in ex-situ (7.5-12.5 cm long in the in-situ), more or less distinctly constricted between the seeds, 4-winged.

DISCUSSION

Sophora mollis is a shrub with clump of long slender stems from the base. The average height and thickness of the branches slightly higher in ex-situ than the plants growing in natural habitats. Usually branches are many, 10-20 ft. high, pendulous. Leaves imparipinnate with 20-25 pairs of leaflets both in ex-situ and in-situ, leaflets opposite or alternate, elliptic, ovate or oblong, obtuse, entire, whitish below, yellowish green when young to dark green at maturity, finely downy. The flowers are bright yellow and the plant looks quite attractive when in full bloom, appearing before the leaves in axillary racemes. Fruits 4-6 seeded under in-situ whereas 1-2 seeded in ex-situ.

Sophora mollis, an endangered plant species whose populations are reduced to a critical level due to habitat loss and indiscriminate exploitation by local inhabitants. The destruction of its natural habitat coupled with poor seed set threatens its survival as it moves towards extinction.

The influence of biotic factors specially human beings on the natural populations of this species is of much concern and cannot be underestimated. Being traditional fodder and fuel crop, the young twigs and branches are cut for fodder which reduce the chances of the species to flower and subsequently the seed setting is affected tremendously (Babu, 1977; Hajra, 1983). Quite often the whole bunch of the stem is cut few centimeter above the ground for fuel which leaves no chance for the species to reproduce sexually and the possibility of seed setting is completely wiped out. Therefore the regeneration and recolonisation of the existing wild population is affected. Besides the developmental activities such as road construction and extensive mining alongwith deforestation and forest fire in its natural habitat have also reduced its capability or recolonisation and increased risk of its extinction.

The fragmented and isolated nature of its populations has also affected the cross pollination in different populations of this taxon, resulting in the loss of its genetic diversity. It is also expected that this taxon with a severely fragmented population with a very few individuals (often 2-4 individuals within one population) is facing a strong genetic drift. Therefore, there is an urgent need to conserve this taxon.

It is of utmost significance to understand the biology of *Sophora mollis* to initiate a proper conservation strategy for its survival and management under in situ and ex-situ. Studies on its reproductive biology are needed to be done in understanding if there is any malfunctioning or failure in its reproductive behaviour resulting in large scale decline of its natural populations. Phenological studies this year under ex-situ conditions have indicated very poor percentage of fruit and seed setting.

Besides a traditional fuel and fodder plant, it is also exploited for its great medicinal value. The burnt roots are styptic, cure disease of liver and kidney, promot the growth of hair and give it dark colour. The flowers are sweetish, useful in the troubles of the kidney, lumbago, gleet and urinary discharges. The decoction is emetic. The seeds are good in disease of eye (Kritikar & Basu, 1918).

During the field study an interesting phenomenon was observed in *Sophora mollis* i.e. it produces young shoots directly from the underground parent rootstocks. Every year about 3-4 such shoots are produced in the month of July to September or even later. Every young shoot is either developed into an independent plant or forms part of the parent plant making it more thick clum (shrub). We have established few such plants in the botanic garden which are now developed into healthy plants.

As regards distribution and evaluation of populations of *Sophora mollis* there is need to take an extensive search, survey and monitoring programme to establish its population size in its entire range of distribution. The population in its type locality (Shastradhara, Dehra Dun) is highly critical with about 15-20 fragmented and isolated populations. In other parts of the Himalaya particularly in Garhwal and Kumaon the plant is of rare occurrence and highly fragmented (Gupta, 1967). The sharp decline in its natural populations is either due to lack, of specific pollinators leading insufficient pollination or due to other biotic factors operating upon the species in its whole distributional area needs further investigation.

Ex-situ conservation

Keeping in mind the urgency of conserving this taxon an effort has been made to conserve this taxon ex-situ in our botanic garden. Efforts are continued to multiply this taxon after simulating the required habitat condition. Seedlings and seeds collected from the natural habitats are grown in the garden and are maintained in the plant house. Some of the seedlings are planted in the ground which are now grown into mature plants. Flowering and seed setting occurred this year in one plant. The seeds grown in ex-situ are collected and will be sown in due course to multiply this plant and to maintain its genetic diversity in ex-situ. During our studies an effort was also made to propagate this plant by stem cutting and air layering technique under normal conditions, which did not meet any success indicating incapability of vegetative propagation in *Sophora mollis* under normal conditions.

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LITERATURE CITED

- Babu, C. R. 1977. Herbarium Flora of Dehra Dun, CSIR, New Delhi.
- Collett, H., 1921. Flora Simlensis, Thacker, Spink and Co. London.
- Gupta, R. K. 1967. Flora Nainitalensis, Navayug Traders, New Delhi.
- Hajra, P. K. 1983. An Assessment of Threatened Plant of India (ed. Jain, S.K. and R.R. Rao) Botanical Survey of India, Howrah. pp. 35-36.
- Hooker, J. D. 1879. The Flora of British India, Vol. 2. 251. L. Reeve and Co., London.
- Khoshoo, T. N. 1966. India needs a National Biodiversity Conservation Board. *Curr. Sci.* **71**: 506-513.
- Kirtikar, K. R. and B. D. Basu, 1918. Indian Medicinal Plants. Vol.1: 837. Prabasi Press of Calcutta. India.
- Nair, N. C. 1977. Flora of Bashahr Himalayas, International Bioscience Publisher, Hissar.
- Opler, P. A., C. A. Frankie and H. G. Baker. 1980. Comparative phenological studies of tree layer and shrub species in tropical wet and dry forest in the low lands of Costa Rica. *Jour. Ecol.*, **68**: 167-188.
- Polhill, R. M. and P. H. Raven. 1981. Advances in Legume Systematics (Ed.) Part I, pp. 1-464. International Legume Conference Kew Proceedings. Ministry Agriculture, Fisheries and Food England.
- Royle, J. F. 1835. Illustration of Botany of Himalayan Mountain. 196.
- Semalty, R. K. and C. M. Sharma. 1996. Phenology and Floral Biology of *Acer Caesium* Wall. *Ind. For.* **96**: 170-176.
- Sharma, C. M. 1984. Flowering and fruiting behaviour in-vitro germination and viability of pollen grains of some commercial peach cultivars. *Ind. Jour. Hort.* **41**: 225-229.

蝶形花科毛槐的物候觀察及保育瀕臨滅絕危機之
喜馬拉雅西北部多用途豆科植物

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摘 要

討論蝶形花科毛槐的物候現象觀察及保育。本種分佈於喜馬拉雅西北部到尼布魯喜馬拉雅山且具多用途目標之豆科植物，面臨當地居民做為糧食及燃料，致使過度開發及損失生育地的瀕臨高度滅絕之危機。栽培植物觀察物候現象後發現結實的情況很差及低比率。生物現象影響低結實量致使野生族群更新不佳。

關鍵詞：毛槐、物候觀察、保育。

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