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Impact of environmental changes on the reproductive biology in *Pyrostegia venusta* Presl

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Abstract: *Local environment (temperature and relative humidity) affects reproductive biology in Pyrostegia venusta (Bignoniaceae) growing at Agra and Mysore. At Agra, the species flowers profusely during December to March, but fails to bear fruits. At Mysore, on the other hand it flowers during November to February and produces well developed fruits with winged seeds. This species, growing at two places, exhibited differences in their pollen fertility and in vivo pollen germination. Pollen fertility at Agra and Mysore was 27.55 and 80-90%, respectively. The in vivo pollen germination on stigmatic surface was only 3-4% at Agra, but 85-95% at Mysore. The flowers at Agra also exhibited heterostyly and increased number of stamens and stigmatic lobes. The significantly low and wide ranged temperature (4.5-33.8°C) and between 23-98% RH during the flowering period at Agra could be the cause for reduced in pollen fertility, floral polymorphism and inhibition of pollen germination on the stigmatic surface and fruitlessness. At Mysore, where temperature ranges between 20.2-33.5°C and RH varies from 33-75% profuse fruiting takes place. The study shows a direct control of environment over the process of reproduction.*

Key words: *Environment, Pollen fertility, Incompatibility, Relative humidity, Pyrostegia venusta*
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Introduction

Environment affects reproductive success of organism (Sedgley and Griffin, 1989). Individuals, well adapted to their current environmental conditions, are likely to pass on relatively more of their genes to the next generation than those not so well adapted (Shivanna, 2003). The process by which the environment-organism interaction is translated into changes in the underlying genetic structure of the population is called natural selection (Raghvan, 2000; Dutkuner *et al.*, 2008). The physiology of reproduction in most of the flowering plants is markedly influenced by environmental factors (Taiz and Zeiger, 2003). Environment exerts considerable influence on flowering, pollen fertility, *in vitro* pollen germination and fruiting in plants (Shivanna, 2003). Factors like soil nutrients, atmospheric conditions such as light and temperature, affect the formation of fruits to a great extent (Shivanna and Johri, 1985). Perennial trees interact with environmental conditions all round the year, and flowering and fruiting are closely related to seasonal climatic changes (Sedgley and Griffin, 1989). Extensive studies have been made on the effect of various environmental factors on floral development, pollen fertility, female sterility, flower and fruit abscission including diseases on the development of fruit in the plants (Shivanna, 2003).

Pyrostegia venusta Presl. (Family Bignoniaceae) is a large, tendril bearing evergreen climber distributed in tropical and sub-tropical zones. It is cultivated in gardens as an ornamental climber. Despite normal flowering it remains fruitless at Agra. On the contrary, in Mysore, it flowers profusely and bears well-developed fruits with winged seeds. The two cities differ in their climatic set up. The present study investigates the impact of local environment on the reproductive biology of *Pyrostegia venusta* Presl growing at Agra and Mysore.

Materials and Methods

Present investigation was carried on *Pyrostegia venusta* plants growing at 10 selected sites of Agra (Civil lines, Lawer's colony con NH2, Circuit house, Taj Gardens Khane-Alam Nursery, Mall Road, Rizwan Nursery, Shahganj, Vijay Nagar Colony, Elora Enclave, Dayalbagh, Smt. Bhagirathi Devi, Marg and Indrapuram) and 5 at Mysore (Mysore Zoo, Das Prakesh Hotel, Mysore University, Vrindaban Gardens and Chamundi Hills). Flowering phenology was observed at plant and inflorescence level with reference to day-to-day flowering pattern in one marked plant at each site. Randomly selected 200 inflorescence were tagged at the time of initiation of flowering. These inflorescence were followed daily and the number of open flowers were recorded. The open inflorescences were then removed to avoid recounting the next day. One hundred flowers/plant were sampled to record the floral morphology and pollen characters. Anthesis, anther dehiscence and stigma receptivity were studied using various methods as described by Shivanna and Rangaswamy (1992). Number of pollen grains/anther/flower was determined from 100 flowers/plant following the method of Cruden (1977). Pollen size was measured with an ocular micrometer under light microscope following the procedure of Mckone and Webb (1988). The number of pollen grains and the number of ovules per flower were recorded to get the pollen-ovule ratio. Pollen viability was assessed by fluorescence-FCR method outlined by Shivanna and Rangaswamy (1992). *In vivo*, pollen germination was checked by aniline blue fluorescence microscopic method as described by Shivanna and Rangaswamy

(1992). Breeding behaviour (autogamy, geitonogamy and xenogamy) was tested using controlled pollination studies in emasculated and bagged flowers. In order to find out incompatibility factor, if any, mature floral buds were opened carefully, causing minimal disturbance to the floral parts and all the anthers were removed with forceps. The emasculated buds were bagged with butter paper bags. Self and cross– pollination experiments were performed by dusting pollen obtained from freshly dehisced anthers on the receptive stigma. The pollinated flowers were re-bagged and observed periodically for fruit formation (Shivanna and Rangaswamy, 1992). Foraging behavior of insects and birds was recorded using binoculars. Pollination efficiency of different insects was checked by observing pollen load on their body parts under a microscope according to the procedure given by Kearns and Inouye (1993). Data on daily maximum and minimum temperature and relative humidity during the entire flowering period at Agra and Mysore was collected from their respective Meteorological Department.

Results and Discussion

Pyrostegia venusta Presl. (Bignoniaceae) is an ornamental perennial, evergreen climber. At Agra, flowering starts in the last week of December and continues till mid of March with optimum flowering during January to February. On the other hand, at Mysore it blossoms during November to February and bears a large numbers of straps shaped fruits with several wing seeds.

The reproductive biology of this species growing at both the places of study is more or less similar. There are 5-7 inflorescence on each branch and the total number of inflorescence/plant is 630-650 (Table 2). Golden-orange flowers are arranged in dichasial cyme and usually there are 8 to 10 flowers in each cyme. Flowers are complete, pentamerous, zygomorphic, bisexual and hypogynous. Calyx is gamosepalous with five green sepals arranged in valvate aestivation. Corolla is tubular and gamopetelous with five golden-orange petals. Stamens are four, epipetalous, didyanamous with a posterior staminode. There are 7519+0.89 pollen per anther and 30076 + 0.27 pollen per flower. The pollen grains are oval and spherical in shape and 40-75 mm in diameter. Gynoecium is bicarpellary, with bilocular ovary and axile placentation. The style is long terminal; with bifid and wet stigma bearing medium sized unicellular papillae. Opening of stigmatic lobes and presence of hyaline exudates mark the receptivity of stigma. Nectaries are present on calyx, corolla, and base of staminal filament and on the ovarian surface (Chauhan *et al.*, 2007).

At Agra, the climber exhibited higher rates of abscission of young floral buds, corolla with epipetalous stamens and unfertilized pistils. Pre-mature abscission of flowers or their parts results in fruitlessness in a large number of members of the family Bignoniaceae growing at Agra. According to Chauhan (1995) this is closely associated with the climatic conditions particularly temperature and RH. At Agra, the minimum and maximum temperature during the entire flowering period ranges between 4.5-33.8°C and RH between 23-98%. On the other hand, at Mysore, the extent of floral abscission was low and the temperature ranges between 20.2 -33.5°C and RH between 33 -75%.

Table - 1: Comparative view of environmental and reproductive biological parameters in *Pyrostegia venusta* growing at Agra and Mysore

Parameters	Agra	Mysore
Temperature (°C)	4.5 - 33.80	20.20 - 33.5
Relative humidity (%)	23.00 - 98.00	33.00 - 75.00
Flowering months	Dec. - Mar.	Nov. - Feb.
Inflorescence each branch	5 - 7	5 - 7
Inflorescence/ plant	630 - 650	630 - 650
Pollen fertility (%)	27.55 - 55.00	80.00 - 90.00
In vivo germination (%)	3 - 4	85 - 95
Polymorphism (December-March)	Present	Absent
a. Heterostylous flowers/plant (%)	2 - 90 (%)	-
b. No. of lobes/stigma	3 - 4	-
c. No. of stamens/flower	5 - 6	-

Pollen fertility of plants growing at Agra ranged between 27.55-55 and 80-90% at Mysore (Table 2). This difference in pollen fertility is closely associated with the environmental conditions mainly temperature and relative humidity. Low temperature also results in lowering of pollen viability up to various levels in several plants (Shivanna, 2003). According to Stanley and Kirby (1973), both low and high temperatures are critical for pollen development. During critical stages of anther development, low or high temperatures may result in partial (25-75%) or complete (100%) pollen sterility.

The flowers of *Pyrostegia venusta* at Agra exhibited various polymorphic features *e.g.* increase in the number of stamens and stigmatic lobes. Stigma position below the level of stamens, at the level of stamens, and above the level of stamens was recorded during the entire flowering period. With the initiation of flowering (December-March), the stigma was observed below the level of stamens in only 2-11% flowers and the presence of stigma at the level of stamens was seen in 7-37% flowers in these months. Presence of stigma above the level of stamens was recorded in 52-90% flowers during entire flowering period. The percentage of such flowers was only 52-70% in December-January (2.8-24.4°C) and 90% in March (13.4-33.8°C). Interestingly, during this month, an increase in the number of stigmatic lobes was also recorded and there were 40% flowers with 3-4 stigmatic lobes. This clearly indicates that with the rise in temperature, the number of trifid and tetrafid stigmas increase. Thus, increasing the receptive surface for cross-pollination. Shu-Xiang *et al*. (2004) have detected permanent closure of stigmatic lobes after self-pollination and it is also controlled by environmental changes. On the other hand, an increase in the number stamens/flower (5-6) was recorded only during the months of December-January (2.8-24.4°C). It is important to note that pollen fertility in the initial flowering period was 27.55%, which increased slightly and reached up to 55% in the month of March. Similiar polymorphic features, closure of stigmatic lobes and reduction in pollen fertility have also been reported by Singh and Chauhan (1994). They have also observed floral polymorphism

in *Tecoma stans* (Bignoniaceae), exhibiting seasonal transient sterility. Interestingly, this ornamental species flower round the year, but is sterile in summers and fertile in winters. They have recorded an increase in the number of stamens, stigmatic lobes and heterostyly in *Tecoma stans* in winters during which the plant produces a large number of fruits. According to them, increase in the number of functional stamens in winters enhances the chances of higher fruit-set in cross-pollinated flowers. Similarly, trifid and tetrafid stigmas increase the receptive surface for effective cross-pollination.

The pollen grains in seedless plants of Agra in spite of landing on the stigmatic surface exhibited only 3-4% *in vivo* pollen germination. The tubes were too small to penetrate through the thick walled compactly arranged stigmatic papillae and the ovule remained unfertilized and finally degenerated and unfertilized pistils abscised. On the other hand, in this ornamental climber at Mysore exhibited 85-95% *in vivo* pollen germination. The long pollen tubes thus developed grow through the stylar tissue, enter the ovary and fertilize the ovules to produced seeds and as a result large number of fruits developed. *In vivo* pollen germination and tube growth is also highly sensitive to climatic factors, particularly, temperature and relative humidity (Shivanna and Johri, 1985; Raghvan, 2000; Chauhan *et al*., 2001; Shivanna, 2003; Rana, 2005). Thus, present findings clearly indicate that reduction in pollen fertility and failure of *in vivo* pollen germination and tube growth on the stigmatic surface at Agra is largely due to low temperature and RH and this seems to be main cause of fruitlessness in this beautiful climber.

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