

## Flexistylly – a structural and functional contrivance for successful pollination in *Lathyrus aphaca* L.

Roohi Sharma\* and Veenu Kaul

Department of Botany, University of Jammu, Jammu 180 006, India

Angiospermic plants are known to follow a wide range of breeding systems from obligate inbreeding to complete outbreeding. Legumes among these exhibit inbreeding as the predominant mode, which they achieve by self pollination. The sexual apparatus of *Lathyrus aphaca* L. seems to favour out-crossing both structurally and functionally. However, an interesting mechanism known as ‘Flexistylly’ facilitates and ensures fruit production through autogamy. A part of style bears trichomes known as ‘pollen brush’ which undergoes curvature, exhibits movements and deflects towards the dehisced anther to catch hold of maximum pollen for its reproductive assurance. The present communication elaborates this fascinating mechanism.

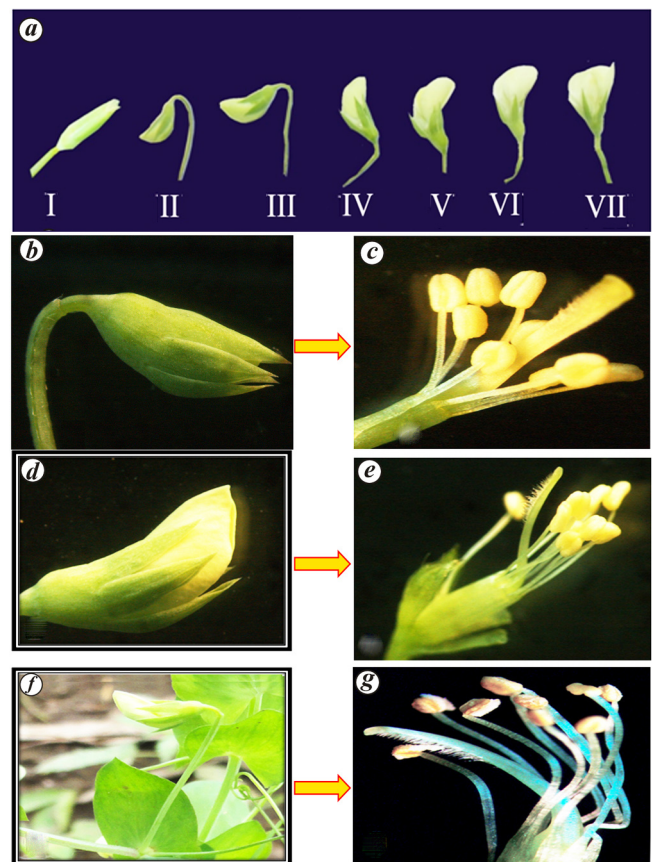
**Keywords:** Flexistylly, pollen brush, reproductive assurance, trichomes.

*LATHYRUS APHACA* L. is an annual herbaceous weed growing luxuriantly in waste and productive lands of Jammu and Kashmir (J&K), India. With a lifespan extending from 4 to 5 months, the plants are known to reduce the yields of wheat and saffron<sup>1,2</sup>. Flowers are papilionoid, small, creamish-white, perfect, odourless and nectarless. These features are characteristic of the family Fabaceae to which this species belongs<sup>3–7</sup>. A member of tribe Viciae, this plant is characterized by pollen brush<sup>8</sup>.

The present study is an endeavour to unravel the role of pollen brush in the reproduction of this species. For this, floral buds ( $n = 60$ ) of different ages were randomly selected and carefully dissected out to excise the sexual apparatus, measure the components of sexual function and photograph them. A protractor was used to measure the angles of deflection of style at different stages till floral buds transform into fruits, and calibrated ocular and stage micrometres were used to measure their dimensions. This study was carried out from 2014 to 2016 on *L. aphaca* plants growing naturally in the campus of University of Jammu and those raised in experimental beds of the Botanical Garden therein. The life cycle of this plant starts with germination of seeds in December. After a vegetative phase of two months, the plants remain in the reproductive phase from February to March, after which fruit formation begins.

The flowers of *L. aphaca* L. are creamish-white and characterized by papilionaceous corolla. Sexual apparatus

consists of 10 stamens in diadelphous (9 + 1) condition and a monocarpellary gynoecium. Nine stamens are joined along their filaments into a staminal tube that measures 8.53 mm, while the tenth free stamen at 7.11 mm is shorter. The 9.39 mm long pistil is distinguished into an elongated ovary, style and slightly bifid stigma. The style bears an aggregation of trichomes on its distal side, which is not continuous throughout its entire length. Also known as stylar or pollen brush, the trichomes spread over a small portion of the style immediately below the stigma. While analysing the sexual apparatus of the flowers at different ages, we noted a striking feature exhibited by the style. It undergoes movements and thereby curves and changes its orientation with respect to the free and fused stamens. It takes 5–6 days for a bud to transform into an open flower. Flowers are protandrous, i.e. anthers dehiscence prior to anthesis and stigma receptivity. Flower opening is characterized by a number of dynamic and coordinated structural and positional changes. The transition from floral bud to open flower has been categorized into seven stages, labelled as I–VII (Figure 1 a and Table 1). Initially at stage I, the style is erect in the 0.7 cm × 0.3 cm bud



**Figure 1.** (a) Flowers at varying stages of development from bud (stage I) to open flower (stage VII). (b–g) external morphology of buds at these stages (b, d, f) and stereomicrophotographs of sexual organs (c–g).

\*For correspondence. (e-mail: ruhaniruhi@gmail.com)

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**Table 1.** Dynamics of floral organs vis-à-vis their phenological events

Stage no.	Size of the bud (length × breadth; cm)	Average duration (h or days)	Average angle of deflection (°) of style with respect to ovary	Average pollen load	Mean % pollen germination	Phenology
I	0.7 × 0.3	8.00 a.m. (first day)	170–180	Nil	Nil	Small floral bud enclosed by calyx
II	0.8 × 0.3	5.00 a.m. (9 h after stage I)	140	Nil	Nil	Corolla starts emerging above calyx
III	0.9 × 0.4	8.00 a.m. (12 h after stage I)	110	575.4 (472–692)	Nil	Loosening of calyx teeth marks the onset of anther dehiscence
IV	0.9 × 0.5	9.30 a.m. (second day)	126	638.6 (590–690)	6.89 (2–10)	Anther dehiscence
V	0.9 × 0.5	1.00–2.00 p.m. (second day)	110	646.4 (608–714)	8.35 (3–9)	Stigma receptivity initiated
VI	0.9 × 0.6	5:30–6:00 p.m. (second day)	60	744.1 (690–808)	10.31 (8–12)	Standard and wings are adpressed and all anthers have been emptied
VII	1.1 × 0.8	8.00 a.m. (third day)	106	804 (720–842)	16.54 (7–18)	Flower opens with the expansion of standard

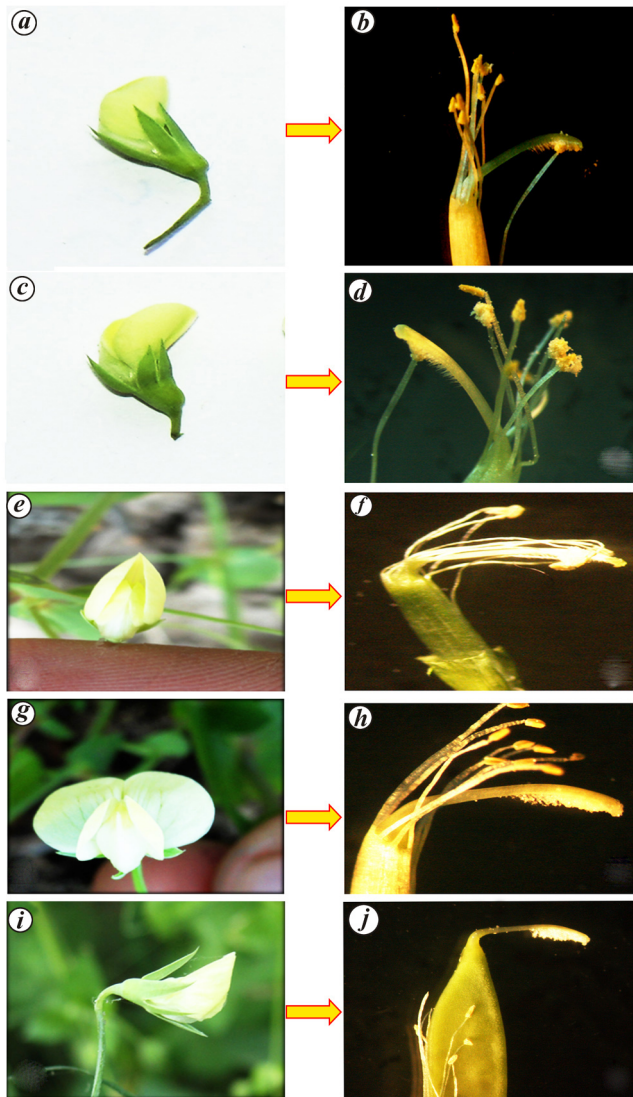
\*All the above-mentioned stages are shown in Figures 1 and 2.

which is tightly enclosed by the calyx (Figure 1 *b*). The sexual apparatus has a pistil with erect style, surrounded by one free and nine fused stamens (Figure 1 *c*). The latter are marginally longer than the free stamen by about 0.4 mm. During stage II, the corolla exceeds the 0.8 cm long calyx by 0.2 cm (Figure 1 *d*). The style at an angle of 140° with the ovary is aligned towards the tenth anther only. All the anthers of the fused and free stamens have not dehisced yet (Figure 1 *e*). Anther dehiscence is initiated at stage III, and is marked by the loosening of calyx (Figure 1 *f*). It is asynchronous occurring first in the anthers of fused stamens followed by that in the tenth stamen (Figure 1 *g*). The bud attains a size of 0.9 cm × 0.5 cm (Figure 2 *a*) at stage IV on the second day. The pollen brush of the style bent at an angle of 126° in close association with the tenth anther (Figure 2 *b*). Stage V reached 3–4 h later is characterized by an increase in pistil length (9.39 mm) with no corresponding change in flower size (Figure 2 *c* and *d*). The pistil makes an angle of 110° with the ovary and is marked by a receptive stigma. At stage VI, the standard and wings are slightly adpressed and the flower (0.9 cm × 0.6 cm) is considered as partially opened (Figure 2 *e*). The style is inclined at an angle of 60° with the ovary. The anthers take almost 22 h to empty their contents (Figure 2 *f*). The flower is fully opened on the third day at stage VII, which is characterized by the expansion of standard (Figure 2 *g*). The stamens move away from the pollen brush of the style, which makes an angle of 106° with the ovary (Figure 2 *h*). One day after anthesis, the flowers close in the same manner as they had unfolded (Figure 2 *i*). Finally, the corolla falls off and the fertilized ovary registers an increase in its length ( $\bar{X}$  = 13.3 ± 0.9 mm). Along with the persistent calyx, it transforms into a mature fruit (Figure 2 *j*). The style shows a striking feature by deflect-

ing itself only towards the tenth free anther. These movements bring the pollen brush in close proximity to the dehiscing anther. This close association of the style with the tenth dehiscing anther is maintained till stage VI. On account of this association, pollen grains adhere to trichomes of the pollen brush. Movement of the style at this point helps in sweeping the pollen grains to the surface of the stigma.

Flexistylly in genus *Lathyrus* has not been reported earlier. *L. aphaca* L. is, therefore, the first species of this genus to exhibit this fascinating movement of style. Flowers are papilionaceous concealing the sexual apparatus inside. This architectural constraint imposed by the floral design is accentuated by the flowers being protandrous and herkogamous. To overcome these barriers to self-pollination, the species has evolved structural and functional innovations in the form of stylar movements or flexistylly. These movements bring the pollen brush in close contact with the dehisced anther. While doing so it acts as a pollen-sweeping organ, and assists in collecting and delivering the pollen grains to the surface of the stigma for successful pollination.

Flexistylly, as a mechanism, promotes self- as well as cross-pollination. It was reported first in *Amomum tsao-ko* Crevost @ Lemarie and documented in 24 species of Zingiberaceae, including *Alpinia*, *Etilingera* and *Plagios-tachys*. The style in these taxa changes its position and thereby separates the two sexes in space<sup>9–13</sup>. During this process, the maturation times also drift apart. In *Alpinia*, two flexistylous phenotypes/morphs exist. Referred to as cataflexistylous and hyperflexistylous depending upon the placement of sex organs, movement of style and time of pollen release during anthesis, they exhibit stylar movements which prevent self-pollination and promote intercrossing between the morphs<sup>10,13,14</sup>.



**Figure 2.** External features (*a, c, e, g*) of floral buds and their respective internal dynamics (*b, d, f, h*). A pollinated flower (*i*) external (calyx and corolla intact) and (*j*) internal (calyx and corolla removed) features.

This type of stylar behaviour in *L. aphaca* has purportedly evolved in response to lack of pollinator visits/mate availability. Further insight into flexistylous and the role of fused stamens is required. Studies in this direction are underway.

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