Though there is a substantial increase in the number of students who appeared in all the subjects during 2005–2013, the relative proportion of SC/ST candidates in chemical sciences and life sciences was in the range of 13–16% during the period. In earth sciences, the relative proportion of SC/ST candidates ranged between 22% and 25%, whereas in mathematical sciences and physical sciences, it ranged between 7% and 12% (Table 3). Relative proportion of SC/ST candidates in engineering sciences was 15% (Table 3). The relative proportion of SC/ST candidates who were awarded JRF through NET in chemical sciences was in the range of 11–16% during 2005–2013. In earth sciences, the relative proportion of SC/ST candidates ranged between 24% and 43%, whereas in life sciences, it ranged between 13% and 25%. The relative proportion of SC/ST candidates in mathematical sciences and physical sciences ranged between 6% and 16% and in engineering sciences, it ranged between 15% and 17% (Table 4).

The overall relative percentage of SC/ST students who appeared in CSIR–UGC NET during 2005–2013 in chemical sciences, earth sciences, life sciences, mathematical sciences, physical sciences and engineering sciences was 15, 22, 15, 11, 12 and 15 respectively (Table 3). The overall relative percentage of SC/ST candidates in terms of the number of fellowships awarded in these subjects was 13, 31, 19, 10, 13 and 16 respectively (Table 4). The results indicated a parity in relative proportion of SC/ST candidates in selected and appeared candidates in the area of chemical, mathematical, physical and engineering sciences. In the area of earth and life sciences the relative proportion of selected candidates from SC/ST category was, however, higher in comparison to those who appeared in these two subjects.

Growth profile of SC/ST candidates, selected for JRF through CSIR–UGC NET during the period 2005–2013, indicates that the concerted efforts by the Government for the socio-economic development of under privileged through its various scholarship/fellowship schemes are bearing fruits, particularly in providing opportunities to SC/ST candidates to do doctoral research and thus to opt science and technology as a career.

1. http://tribal.nic.in
2. http://socialjustice.nic.in
3. http://ambedkarfoundation.nic.in
4. www.ugc.ac.in
5. http://www.dbtindia.nic.in
6. www.icmr.res.in
7. Hasan, S. A. and Luthra, R., *Curr. Sci.*, 2013, **104**, 430–434.
8. Inderpal, Sharat Chetri, Saini, A. K. and Luthra, R., *Curr. Sci.*, 2009, **97**, 490–499.

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A mechanism of self-pollination in *Ajuga bracteosa* Wallich ex Benth

The movement of floral parts, including the pistil (style), stamen (filament, anther) and corolla has been observed in many angiosperms to affect successful pollination and mating. Various hypotheses have been proposed to explain the adaptive significance of floral movements[1–4]. It has been reported that styles exhibit curvature movements either to promote outcrossing[5,6], or to affect selfing, or to achieve delayed selfing[7–9]. In most of the cases the stigma, as the uppermost portion of pistil, is the seat of pollen reception[10]. Here, we describe a mechanism of self-pollination in *Ajuga bracteosa* Wallich ex Benth, (Lamiaceae), in which the bisexual flower bends its stigmas in such a way so as to come in contact with dehisced anthers without the aid of any external agency to ensure self-pollination.

The species is a perennial herb up to 15–40 cm long, stoloniferous; stems branched from base, grey villous or lanate-villous, especially on young parts; basal petioles 1–1.5 cm; basal leaf blade spatulate to oblanceolate, 2–4 × 0.7–1.2 cm; stem blades sessile or sub-sessile, obovate to subcircular, 1–1.5 × 0.6–1 cm, pilose or strigose, base cuneate–decurrent, margin inconspicuously to irregularly undulate–crenate, ciliate, apex obtuse to sub-rounded; basal verticillasters widely spaced, apical verticillasters in dense spikes; basal floral leaves densely lanate-villous, incised, ciliate; calyx campanulate, 4.5–6 mm, villous especially on teeth; teeth subulate–triangular, regular, 1/2 or more as long as calyx, apically acute, margin villous–ciliate; corolla purple or purplish with dark purple spots, tubular, slightly exerted, puberulent, yellowish glandular, villous annulate inside; upper lip straight, apex emarginate; middle lobe of lower lip obcordate, lateral lobes oblong (Figure 1 *a*).

The species produce pale blue to whitish flowers borne on crowded whorls; calyx with five nearly equal lobes, densely haired; corolla tube nearly twice as long as calyx, densely pubescent from outside, two-lipped with upper lip very short, two-lobed and lower lip three-lobed; stamens four, epipetalous, arranged in two rows (didynamous), upper row opposite to lower lip of corolla and lower row opposite to upper lip of corolla, filaments white and shining, anthers are dark brown, dehiscence longitudinal; carpels two, ovary superior, style gynobasic, stigma bifid (Figure 1 *b*).

A. bracteosa grows as wild in Afghanistan, Bhutan, China and Japan. The present study was carried out in Kashmir Himalaya, India, which represents the main valley of Kashmir together with the side valleys of Tilel, Guraiz, Keran and Karnah. The region falls within the biogeographic zone of the Northwestern Himalaya in India and lies between 33°20′–34°54′N lat. and 73°55′–75°35′E long., covering an area of 15,948 sq. km. The selected sites and their geo-coordinates are given in Table 1. The species grows in sloppy and landslide-prone areas with low moisture content in temperate to sub-alpine zones at an altitudinal gradient of 1620–2900 m asl.

In the bud stage of the flower, the style is short and stigma is close to anthers. As

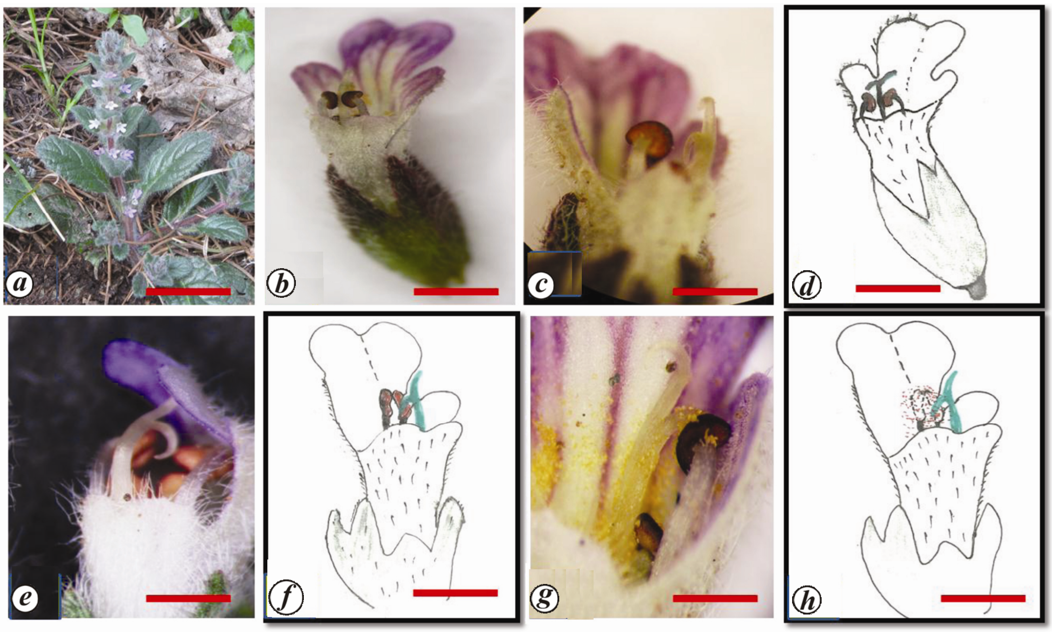

Figure 1. ***a***, Individual plant (scale = 0.33 cm); ***b***, Flower (scale = 4.2 cm); ***c***, ***d***, Bent stigma (scale 9 cm for (***c***) and 0.35 cm for (***d***)); ***e***, ***f***, Stigma lying between two anthers (scale 7 cm for (***e***) and 5 cm for (***f***)); ***g***, ***h***, Stigma entering the dehisced anthers (scale 10 cm for (***g***) and 5 cm for (***h***)).

Table 1. Geo-coordinates of the selected sites

Collection site	Latitude (N)	Longitude (L)	Altitude (m asl)
Handwara	34°23′51″	74°16′59″	1610
Bandipora	34°25′24″	74°38′32″	1691
Drang	34°04′14″	74°24′33″	2266
Yousmarg	33°49′59″	75°16′12″	2437
Doodhpathri	33°56′48″	74°35′15″	2216
Naranag	34°21′10″	74°06′24″	2216
Kangan	34°16′59″	74°54′18″	1860
Dachigam	34°07′56″	75°01′04″	2537
Khrew	34°02′50″	74°58′51″	1800
Aharbal	33°39′01″	74°48′43″	2750
Shopian	33°42′02″	74°49′02″	2115
Aru	34°05′31″	75°15′48″	2567
Chandanwari	34°04′43″	75°25′07″	2888
Pahalgam	34°02′59″	75°20′50″	2335
Daksum	33°37′50″	75°27′12″	2650
Pandobal	33°34′48″	75°22′29″	2970
Jawahar Tunnel	33°30′29″	75°12′31″	2875

the flower opens, the style elongates and bifid stigma becomes incurved and one of the branches bends at an angle of 20–30° with respect to the style and comes to lie between the two dark brown-coloured anthers (Figure 1 *c* and *d*). At the time of anthesis the stigma becomes receptive and anthers dehisce; the bent stigmatic lobe comes in contact with dehisced anthers and gets fully loaded with pollen grains (Figure 1 *e* and *f*). When such stigmas were observed under microscope, considerable number of germinating pollen grains were seen. The experimental studies revealed that the stigma receptivity lasts up to one day. The number of deposited pollen grains as well as the percentage of germinated pollen were highest on the first day after anthesis. Thereafter, the receptivity of stigmas decreased and was completely lost on the second day after anthesis; the stigma dried up and lost its shine, marking the end of receptivity. The simultaneous anther dehiscence and stigma receptivity depict that the species exhibits autogamy. Pollen load and germinating pollen grains were observed only on the curved branch of stigma (Figure 2 *a* and *b*), which comes in contact with dehisced anthers. This observation also supports the argument that self-pollination is operative in the species.

The pollen grains are bright yellow, spherical, tricolporate and with smooth exine sculpturing (Figure 2 *c*). The species produces 1188 ± 110 pollen grains which range between 1120 and 1280 per flower. The viability of pollen (TZ-test) was estimated to be 75–80%. The species produces four ovules per flower. The pollen/ovule (PO) ratio for the species turned out to be 297. This low P/O ratio also depicts self-pollinating nature of the species[11,12].

The breeding experiments revealed that the bagged unemasculated flowers set 80–90% seeds and emasculated flowers which were bagged prior to anthesis did not set seeds.

The species produces small (0.9–1.0 × 0.3–04 cm) and dull-coloured flowers. The flowers remain opened for 5–8 days. The anthers and stigmas of the same flower by a unique movement of stigmas come to lie in close contact, which aids selfing in the species. The low P/O ratio, exine sculpturing of the pollen grains and breeding experiments also point towards autogamy as the mode of pollination in

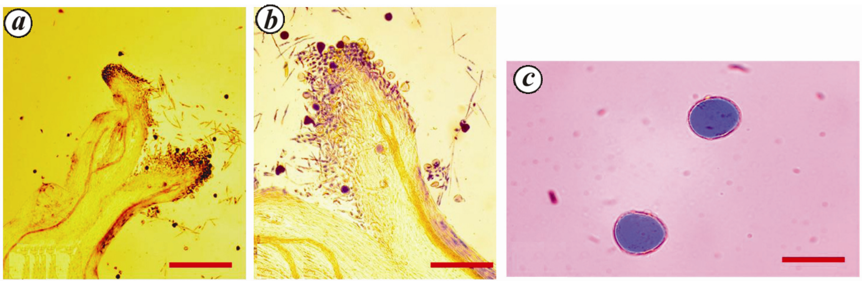

Figure 2. ***a***, Pollen load and germinating pollen grains on curved stigmatic branch and no pollen load on the non-curved stigmatic branch (scale = 150 µm). ***b***, Pollen load and germinating pollen grains on bent stigmatic branch (scale = 90 µm). ***c***, Spherical pollen grains with smooth exine sculpturing (scale = 100 µm).

the species. Breeding experiments also reveal that there is no apomictic seed formation in the species. De Clavijo[13] reported 100% seed production in *Ajuga chamaepitys* in bagged flowers as a result of autogamy. *Ajuga bracteosa* has evolved a novel mechanism to utilize the minimum resources to accomplish successful pollination.

The present study reveals that usually the plant species is not visited by any pollinator; however, occasionally ants (*Formica* sp.) visits the flowers produced near the ground and not the ones above. When these ants were observed under stereo-zoom microscope, usually no pollen load was seen on their body parts.

The change of reproduction from outbreeding to selfing is one of the most frequent evolutionary transitions in angiosperms[14–17]. Because of its frequency and its far-reaching implications for the genetic structure of individuals and populations, this transition has attracted considerable interest amongst taxonomists, ecologists and evolutionary biologists. The most widely accepted ecological scenario favouring the evolution of selfing is a condition of limited pollinator and/or mate availability[14,18–20]. It has also been advocated that selection either for rapid maturation in marginal habitats, or for reduced predation by herbivores leads to smaller flowers with reduced spatial and temporal separation between dehiscing anthers and receptive stigma as observed during the present study. These changes in turn would increase the rate of selfing as an incidental by-product, which could counter-balance the reduced attractiveness of the smaller flowers to pollinators[21–23]. It has also been reported that increased selfing may be selected to reduce outbreeding depression[24,25], gene flow via heterospecific pollen and assortative mating[24]. However, more studies on the effects of quantitative changes in outcrossing rates and potential for adaptation in selfing plants are needed[26]. In addition, there is growing evidence that transitions to selfing may themselves be drivers of speciation, which needs further study[26]. The presence of glands on the inner side of corolla and nectary guides depicts that the species have been derived from outcrossing derivative. Stebbins[15] noted that self-fertilizing species often possess remnants of floral structures devoted to outcrossing, and thus seem to be relatively recently derived from outcrossing ancestors.

1. Yang, S. X., Yang, C. F., Zhang, T. and Wang, Q. F., *Acta Bot. Sin*., 2004, **46**, 1071–1074.
2. Bai, W. N. and Zhang, D. Y., *J. Plant. Ecol*., 2005, **29**, 672–679.
3. Edwards, J., Whitaker, D., Klionsky, S. and Laskowski, M. J., *Nature*, 2005, **435**, 164.
4. Sun, S., Gao, J. Y., Liao, W. J., Li, Q. J. and Zhang, D. Y., *Ann. Bot*., 2007, **99**, 660–661.
5. Verma, S., Magotra, R. and Koul, A. K., *Curr. Sci*., 2004, **87**, 207–215.
6. Li, Q., Xu, Z., Kress, W. J., Zhang, L., Deng, X., Gao, J. and Bai, Z., *Nature*, 2001, **410**, 432.
7. Raun, C. J., Mopper, S., Teixeira da Silva, J. A., Qin, P., Zhang, Q. X. and Shan, Y., *Plant Syst. Evol*., 2009, **277**, 207–215.
8. Sun, S., Gao, J. Y., Liao, W. J., Li, Q. J. and Zhang, D. Y., *Ann. Bot*., 2007, **99**, 660–661.
9. Liu, K. W., Liu, Z. J., Huang, L. Q., Chen, J. and Tang, G. D., *Nature*, 2006, **441**, 945–946.
10. Verma, S., Kaul, V., Magotra, R. and Koul, A. K., *Curr. Sci*., 2008, **94**, 1372–1374.
11. Cruden, R. W., *Evolution*, 1977, **31**, 32–46.
12. Cruden, R. W., *Plant Syst. Evol*., 2000, **222**, 143–165.
13. De Clavijo, E. R. A., *Int. J. Plant Sci*., 1997, **158**(3), 282–291.
14. Stebbins, G. L., *Variation and Evolution in Plants*, Columbia University Press, New York, 1950.
15. Stebbins, G. L., *Am. Nat*., 1957, **41**, 337–354.
16. Stebbins, G. L., *Flowering Plants: Evolution above the Species Level*, Belknap Press, Cambridge, 1974.
17. Barrett, S. C., *Nature Rev. Genet*., 2002, **3**, 274–284.
18. Darwin, C., *The Effects of Cross and Self-Fertilization in the Vegetable Kingdom*, John Murray, London, 1876.
19. Baker, H. G., *Evolution*, 1955, **9**, 347–349.
20. Lloyd, D. G., *Int. J. Plant Sci*., 1992, **153**, 370–380.
21. Guerrant, E. O., In *The Evolutionary Ecology of Plants* (eds Bock, J. H. and Linhart, Y. B.), West View Press, Boulder, CO, 1989, pp. 61–84.
22. Snell, R. and Aarssen, L. W., *BMC Ecol*., 2005, **5**, 2.
23. Eckert, C. G., Samis, K. E. and Dart, S., In *Ecology and Evolution of Flowers* (eds Harder, L. D. and Barret, S. C. H.), Oxford University Press, Oxford, 2006, pp. 183–203.
24. Epinat, G. and Lenormand, T., *Evolution*, 2009, **63**, 2047–2060.
25. Lenormand, T., *Int. J. Ecol*., 2012, **11**, doi:10.1155/2012/508458.
26. Stephen, I. W. and Susan Kand Tanja, S., *Proc. R. Soc. London, Ser. B*, 2013; http://rspb.royalsocietypublishing.org/

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