citronella. Among the oil constituents, geraniol from palmarosa oil was the most active followed by citronellol (ex. citronella) and citral from the lemon grass oil. Minimum activity was shown by citronellal from citronella (Figure 1 *b*).

Interestingly, difference in activity of whole oil and citral has been reported[5], with lemon grass oil showing higher activity than this pure isolate. In our study citral, which had a low activity index producing smallest inhibition zones against *M. gypseum*, demonstrated the highest activity in terms of MID as well as MFC values comparable to the lemon grass oil. *M. gypseum* is known to cause hair and scalp infections in humans and thus lemon grass oil in general and citral in particular can be good candidates for medicated formulations like shampoos, hair oil, etc. In fact the combination of these with other active components like geraniol and citronellol can be tested for synergism, if any. Against *C. albicans* also lemon grass was most effective, but not citral. Against *A. niger*, however, palmarosa oil was the most effective in terms of inhibitory activity (MID), but that did not translate into fungicidal activity (MFC). MFC again was highest in lemon grass oil. Hence this combination might be useful in case of growth inhibition of *A. niger* and then its elimination. Against *S. schenckii*, geraniol showed the best inhibition, but for fungicidal activity (MFC) again lemon grass oil was the best. Hence lemon grass oil enriched with geraniol might be a good approach for its control.

This study being on genotype-specific oils distilled from field plants where chemotypic constituent is well stabilized and defined opens up new avenues for developing new oil compositions through genetic selections/hybridization to yield value-added oils with such effective combinations, so that these oils can be directly used as formulations. On the other hand, it will be important to study synergistic/antagonistic effects in combination (work in progress), so that these oils and their components could be converted into therapeutic or skin and hair care formulations.

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Significance of sequential opening of flowers in *Gloriosa superba* L.

Gloriosa superba (family Liliaceae), a perennial herb and an important medicinal plant as a source of colchicine used in gout, etc.[1], is characterized by very low seed set in nature[2]. Both its tuber and seed have similar medicinal properties[3], but because of low seed set only tubers are being harvested. Economical tuber harvest is after 3–4 years which leads to destructive harvesting resulting in the species coming under the threatened category[4]. Investigations to study the causes of low seed set in this species have revealed that the species is (i) both self- and cross-pollinated, and (ii) seed set is dependent upon both pollinator activity and the time of pollination[5,6]. Although there are no self- or cross-incompatibility barriers, the hercogamous and attractively-coloured flowers favour cross-pollination. Its flowers change colour and a particular colour pattern can be identified with a particular stage. The perianth lobes at the bud-opening stage are light-greenish in colour. This is followed by the stigma-receptive stage which is characterized by perianth lobes that are crimson-coloured at the tip, yellow in the middle and greenish towards the base. Post-pollination stage is characterized by the upper half of perianth lobes being crimson coloured and the lower portion being yellow coloured. Lastly, the perianth lobes turn entirely crimson coloured. The peculiar structure of the large flowers with six perianth lobes bent backwards, six radiating anthers and the style bent almost 90° at the point of attachment to the ovary, does not make them suitable for pollination by small insects. Only large insects like bumble bees and birds like *Nectarinia zeylonica* and *Nectarinia asiatica* with long beaks[7] have been

Table 1. Chronology of flower opening and development on a branch in *G. superba*

Sl. no. of flower starting from base on a branch	Stage of flower development (days after opening of first flower)			
	I	II	III	IV
1	0	3.20	5.80	9.00
2	2.20	5.20	7.40	10.80
3	4.20	7.55	9.05	12.50
4	6.00	9.25	11.25	14.75
5	7.80	10.96	13.30	16.63
6	8.90	12.20	14.70	17.50

I, Bud-opening stage; II, Stigma-receptive stage (perianth colour is crimson at the tip, yellow in the middle and greenish at the base); III, Perianth colour is crimson up to the middle portion and yellow towards the base; IV, Perianth colour is entirely crimson with lobes starting to dry.

reported to be visiting these flowers. This limits the possibility of good cross-pollination, although wind is another factor which would be aiding in its pollination.

To overcome this problem, the species has developed the mechanism of sequential opening of its flowers. An average of six flowers develop fully on a branch and they open in a sequential manner. The first flower opens towards the base of the branch with the subsequent flowers opening away from the first flower. No two flowers on a branch were observed to be at the same stage of development at any given time (Table 1). The next flower opens only after the earlier flower has undergone pollination which is characterized by stigma losing receptivity and the perianth colour gradually changing to scarlet crimson[5].

The amount of pollen delivered by natural pollinators is likely to vary independently of the stage of flower development. However, only the pollen delivered at the stigma-receptive stage has chances of siring seeds, thereby making seed production pollen-limited. As has been reported elsewhere[5], the low seed set in the species is a consequence of pollinator limitation and the stigma-receptive stage is characterized by the perianth colour being crimson at the tip, yellow in the middle and greenish at the base. The sequential opening of flowers ensures that every flower receives adequate attention from pollinators since the number of fully opened flowers (at the stigma-receptive stage) at any given time would be considerably less compared to if all the buds on a branch would bloom simultaneously. The species seems to have made a compromise between low seed set and good quality seed (through cross-pollination). The low seed set does not affect the chances of multiplication of the species as it can still multiply through its tubers, but cross-pollinated seed ensures newer gene combinations which enable the species to colonize diverse climatic regions, from the tropics to sub-temperate/sub-tropic regions. The altitudinal range of the species is up to 2100 m above mean sea level and in India it is spread from the hotter southern parts to the milder mid-hill zones of Himachal Pradesh, Jammu & Kashmir and Uttar Pradesh[1,8–10].

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Antioxidant property of the bulb of *Scilla indica*

Scilla indica (Baker), Liliaceae[1], is commonly known as 'Bhuikanda', 'jangali pyaj' (wild onion) or 'koal-kand' in Hindi and Indian squill in English. In the Ayurvedic pharmacy, a mixture of 2 species is used, *Urginea indica* Kunth and *S. indica* Baker. According to Ayurvedic literature, both the plants have similar biological property. Pharmacognostically, they have a prominent difference, i.e. *U. indica* has a tunicated bulb, whereas *S. indica* has a scaly bulb[2]. In our study we have selected samples of scaly bulb, which belong to the species *S. indica*. This plant grows wildly in the forests of Madhya Pradesh, Bundelkhand, Gwalior, Bihar, Mahabaleswar and all districts of the Tamil Nadu state, except the west coast, up to 4000 feet. It is a bulbous plant. Bulbs are ovoid, with scaly leaves of