



Bisexuality in dioecious male plant: An unusual phenomenon of sex expression in *Piper* species

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ABSTRACT

The *Piper* species in India occur in wild and are dioecious. An unusual sex expressions in male plants of two dioecious *Piper* species i.e., *P. mullesua* Buch. – Ham. ex D. Don and *P. sylvaticum* Roxb. occurring in north east India have been recorded. In both the species few abnormal male spikes were observed along with the normal spikes in some male plants. These abnormal spikes show the formation of ovary within the male flowers that subsequently develop into berries. The study of the abnormal spikes shows the occurrence of about 30% of bisexual flowers. Occurrence of 34% and 12.5% abnormal male spikes were recorded in individual plants of *P. mullesua* and *P. sylvaticum* respectively. Similar phenomenon was also noticed in *P. sarmentosum*, a common species of Malayan Peninsula.

Keywords : *Piper mullesua*, *P. sylvaticum*, *P. sarmentosum*, dioecious, male plant, bisexual flowers.

INTRODUCTION

The genus *Piper* L. (family Piperaceae) includes approximately 2000 species distributed in pantropical regions (Quijano-Abril *et al.* 2006). In India, the genus is represented by more than 100 species mainly distributed in Western Ghats and Eastern Himalayan region with about 65 species occurring in north eastern states (Gajurel *et al.* 2008). The genus *Piper* exhibits dioecious, monoecious, bisexual or unisexual flowering pattern and in *P. nigrum* all the forms have been recorded (Saji *et al.* 2005). The species of the new world i.e., American *Piper* (*P. aequale*, *P. arboretum*, *P. hispidum*) are bisexual whereas the species of the old world (except a few including *P. nigrum*) are dioecious (Saji *et al.* 2005, Bornstein & Coe 2007, Kumar *et al.* 2011). *Piper* species viz., *P. nigrum*, *P. betle*, *P. longum* and *P. methysticum* are of considerable economic and commercial importance (Jaramillo & Manos 2001, Mangion 2011). A number of secondary metabolites

having antifungal, antibacterial, aromatic and medicinal properties have been extracted from different *Piper* species (Parmar *et al.* 1997).

Our earlier studies on the genus *Piper* of North East India (Gajurel 2002, Gajurel & Rethy 1998, Gajurel *et al.* 2001) have made some significant contributions in understanding the taxonomic diversity, distributional status and uses. The present study on phenological and fruiting behavior of some *Piper* species, report an unusual appearance of sexes in two *Piper* species namely *P. mullesua* Buch.-Ham. ex D. Don and *P. sylvaticum* Roxb. The paper discusses the abnormal phenomenon observed in the two species viz., *P. mullesua* Buch.-Ham ex D. Don. and *P. sylvaticum* Roxb.

MATERIALS & METHODS

The observations on flowering and fruiting behavior with periodical recording of data of spikes formation,

flower initiation, maturity of spikes and flowers, fruit formation were made on the selected individuals of each of the two species namely *P. mullesua* and *P. sylvaticum*. The individuals with unusual spikes were marked and the details of the flowering and fruiting were recorded.

OBSERVATIONS

Unusual expression of sexes—Both the *Piper* species growing in experimental gardens show normal male, female and fruiting spikes (Figs. 1A, 1B, 1C, 2A, 2C). Abnormal male spikes occur in both the dioecious species (Figs. 1D, 2D). Although the female spikes are normal, a few individuals of male plants of both the species showed development of female flowers in a few male spikes. This behavior has not been noticed earlier in any population of *Piper* raised in the nursery. In *Piper mullesua* four plants were observed out of 30 plants and each plant showed about four abnormal spikes. While in *Piper sylvaticum*, out of 20 plants observed, three plants showed bisexual flowers with only one abnormal spike in each plant (Table 1). In each abnormal spike of *P. mullesua*, 29.85% flowers had unusual carpels. In *P. sylvaticum*, 29.46% flowers developed ovaries. As these ovaries are found together

with the stamens, they can be considered as bisexual flowers (Figs. 1E, 2E). These ovaries are similar in their structure as compared with ovaries of the female spikes. In a spike although the bisexual flowers are not fixed in a particular position of the spikes, they are mostly observed in basal portion of the male spike in *P. sylvaticum* and in *P. mullesua* usually in tip portion of the spike. In both the species these male spikes later bear fruits giving a complete different look of the male spikes (Figs. 1F, 2F).

Although the plants of both the species were grown in the nursery for last 10 years, but the first observation was made only in 2012 when two male individuals of *P. mullesua* and one individual of *P. sylvaticum* exhibited unusual male spikes. Again in 2013, the same phenomenon was observed in four individuals out of 30 in *P. mullesua* and three individuals out of 20 in *P. sylvaticum*. The same phenomenon was also recorded in natural populations of *P. mullesua* in Pasighat area of East Siang district of Arunachal Pradesh in *P. mullesua*. All the female individual plants were found with normal female spikes later producing normal fruiting bodies. The observations on male plants in both the species with number of spikes, flowers/spike are summarized in Table 1.

Table 1— Observations on male spikes of *Piper mullesua* and *P. sylvaticum*

S. No.	Observations	<i>Piper mullesua</i>	<i>Piper sylvaticum</i>
1.	Nature of the male spike	Erect, filiform.	Erect, slender
2.	Total number of individuals observed	30	20
3.	Number of individuals with abnormal spikes	4	3
4.	Total number of abnormal spikes observed	15	3
5.	Total number of spikes in each plant	11	8
6.	Average number of abnormal spikes in each plant	3.75 (H ⁴)	1
7.	Abnormal spike produced by an individual (%)	34	12.5 (H ¹³)
8.	Total number of flowers in each abnormal spike	407	431
9.	Number of bisexual flowers in male spike	121	117
10.	Bisexual flowers in each spike (%)	29.85 (H ³⁰)	29.46 (H ³⁰)
11.	Fruit set in abnormal flowers (%)	100	100
12.	Average number of fruits with viable seeds	23	9

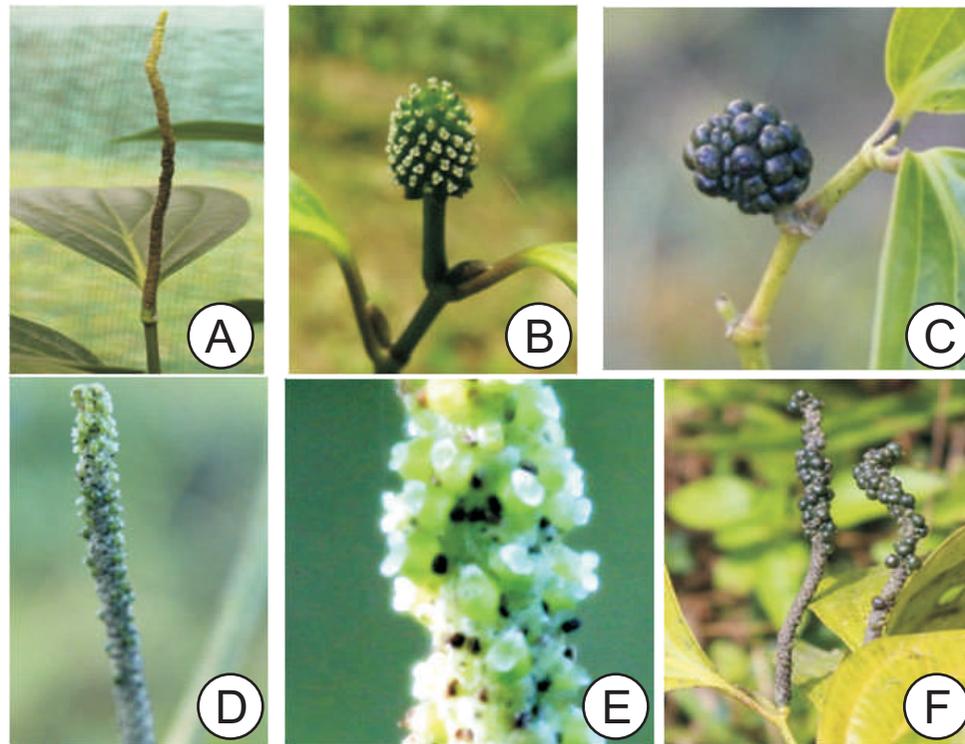


Fig. 1 A-F—*Piper mullesua*: A. Normal male spike, B. Female flowering spike, C. Fruiting spike, D. Abnormal male spike, E. Female flowers in male spike, F. Abnormal male spikes with fruits.

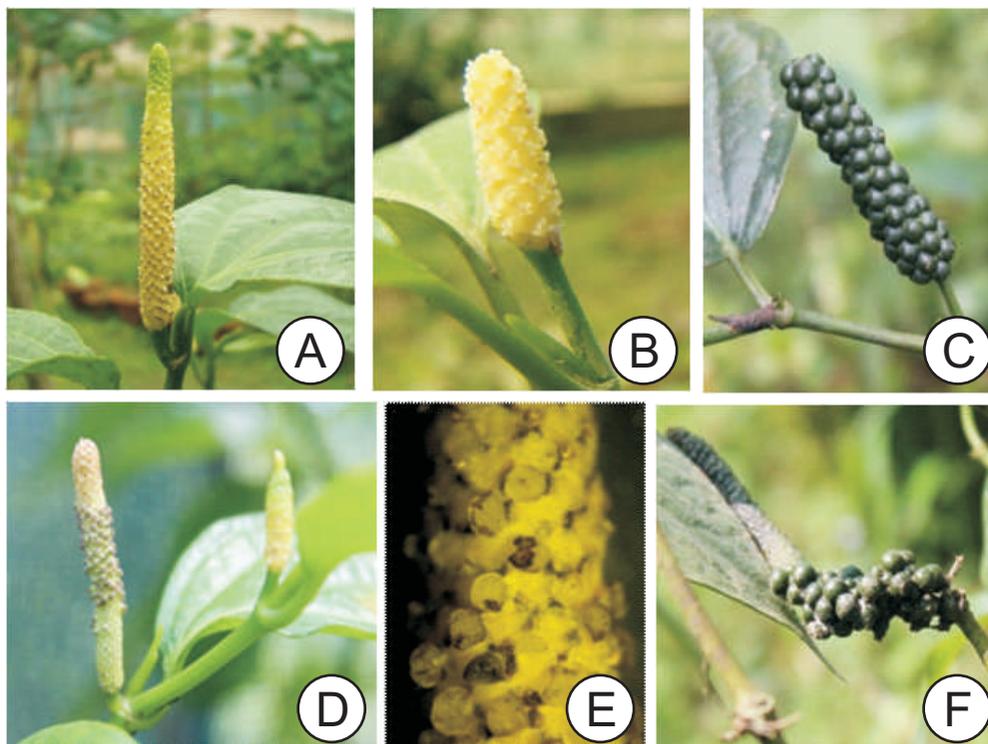


Fig. 2 A-F—*Piper sylvaticum*: A. Normal male spike, B. Female flowering spike, C. Fruiting spike, D. Abnormal male spike, E. Female flowers in male spike, F. Abnormal male spikes with fruits.

DISCUSSION & CONCLUSION

The *Piper* species of north eastern region, one of the centers of diversity of Indian Pipers, are truly dioecious. Distinct male and female individuals are encountered in natural population of the wild species (Gajurel *et al.* 2008). The occurrence of bisexual flowers only in male spikes of the two *Piper* species is an unusual appearance in the dioecious *Piper* species (present study). However, Saji *et al.* (2005) once reported the occurrence of fruits (berry) in male spikes of *P. thomsonii* Hook. *f.* from foot hills of Himalaya in New Jalpaiguri, West Bengal. Although the details of spikes and flower observation were not made, this can also be marked as the similar sex expression. The occurrence of such cases although recorded for two species in nursery condition, it is found only in the wild population of *P. mullesua*. Although the actual cause of such phenomenon is not known, it is assumed that it may be mostly due to the locality factors. Alteration in sexual stages mostly occur in dioecious and subdioecious species. This is caused due to the change in ambient environment or in size or age of the plant and enhances an individual's genetic contribution to the next generation (Freeman *et al.* 1980, Bawa 1980). Effects of seasonal variations on sex appearance with stressed environmental conditions have also been observed in some species. For instance in *Atriplex canescens* a common dioecious plant of North American region, the female plants become monoecious or male plant in unusual severe winter (Mc Arthur 1977). In *Hippophae rhamnoides* also the dioecious individuals become either monoecious or polygamomonoecious (Sen 2014).

One of us (PRG) had also noticed similar male spikes in a few individuals in *P. sarmentosum* Roxb. in Singapore during his visit to Singapore Botanic Garden in January, 2015. *Piper sarmentosum* the most common species of Singapore and mostly reported from Malayan Peninsula appears to be very similar with *P. sylvaticum* in majority of the characters. Occurrence of immature fruits in the male spikes was seen in two male plants in the population grown in the botanic garden.

These unusual characters showing carpels in male spikes of these *Piper* species indicate bisexual nature of the species as of American species. However all the female spikes show true unisexual flowers and not even

a single stamen was observed in any female spikes. It may indicate a false bisexual nature of these dioecious species with formation of limited bisexual flowers only in male plants. This situation led to the formation of three different types of flower in these dioecious species which are: (i) Female plants with pure female spikes, (ii) Male plants with true male spikes and (iii) Male plants with both true male and mixed bisexual spikes.

The above rare and unusual sex expression in dioecious *Piper* species, needs further studies involving developmental and reproductive biology of the species which will help in understanding the breeding system in the genus *Piper*.

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