An Observation of Flower Bud Differentiation and Development in the Early and Late Flowering Cultivars of *Phlox paniculata*

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早咲き系および遅咲き系クサキョウチクトウ (*Phlox paniculata*)の花芽分化について

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Summary

Flower bud differentiation and development were observed in the early and late flowering cultivars of *Phlox paniculata*. In the early flowering cultivar, flower bud differentiation started on the 9th of May . Pistils and stamens were observed on that day. Petals were observed on the 16th. Ovules and pollen grains were observed on the 30th of May. Flower opened on the 27th of June. It took 8 weeks from the beginning of flower bud differentiation to flowering.

In the late flowering cultivar, flower bud differentiation started on the 6th of June. It was four weeks later than the early flowering cultivar. Sepals were observed on the beginning day. Petals were observed on the 13th. Pollen grains were observed on the 20th of June. Flower opened on the 25th of July. The term was also 8 weeks from the beginning to flowering. The flower opened 4 weeks later than the early flowering cultivar.

The plant height of the early flowering cultivar was about 10cm taller than the late one at the flowering stage, but their heights were almost the same at the beginning of flower bud differentiation.

Introduction

Phlox paniculata L. is a perennial plant native to the North America continent. It has a stout erect stem with an inflorescence of terminal paniculate or corymb-like cyme consisting of many florets. They bloom from June to August in Japan, and are very popular as both garden plants and cut flowers (Yashiro, 1994). Many cultivars with different colors are offered. White flowers are especially popular as cut flowers.

Two cultivars of the white flower are cultivated in the field of Keisen Jogakuen College for cut flowers. They have different flowering periods, one blooms from late June to July, and the other blooms from late July to August. In this study, the developmental stages of flower bud of these two cultivars were observed. The cultivars' names are not identified.

Materials and methods

Two cultivars of *Phlox paniculta* were cultivated in the field of Keisen Jogakuen College at Isehara, Kanagawa. 5

plants were collected weekly from the 14th of .May to the 1st of August in 1987 for the late flowering cultivar, and from the 11th of April to the 4th of July in 2002 for early flowering cultivar. Plants were stored in FAA solution. Flower bud differentiation and formation was observed and sketched..

Results and Discussion

Plant structure

Leaves are lanceolate to elliptic, and they are decussately arranged (Fig.1, 2.). 24 to 25 nodes are formed beneath the lowest node of the inflorescence, which consists of 7 to 8 nodes. The flower stalks derived from upper 4 to 5 nodes produce 10 to 15 flowers, which make dense paniculate flower cluster (Fig. 1). The floret at the apical tip of the inflorescence develops faster than any other florets below (Fig. 2). The floret is hypocrateriform with a tubular throat (Fig. 11-A).

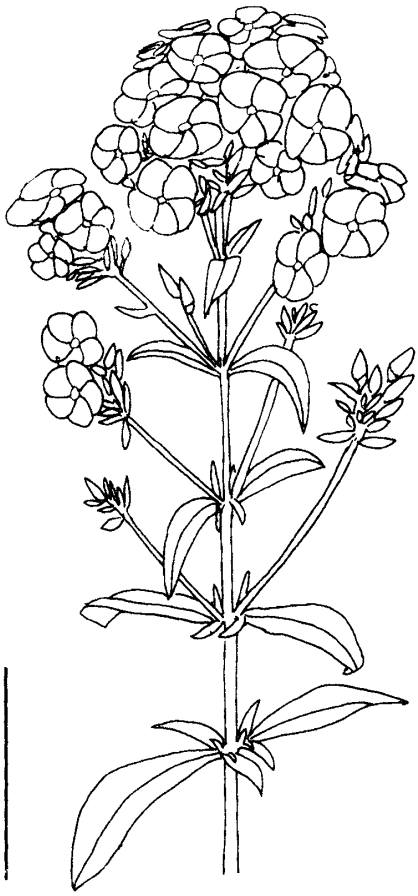

Fig. 1 Inflorescence of *Phlox paniculata* at flowering. Leaves are decussately arranged. Flower stalks extend from the upper 6~7 nodes. In particular, the stalks from the top 4~5 nodes are short and set beautiful flowers. Bar indicates 5cm.

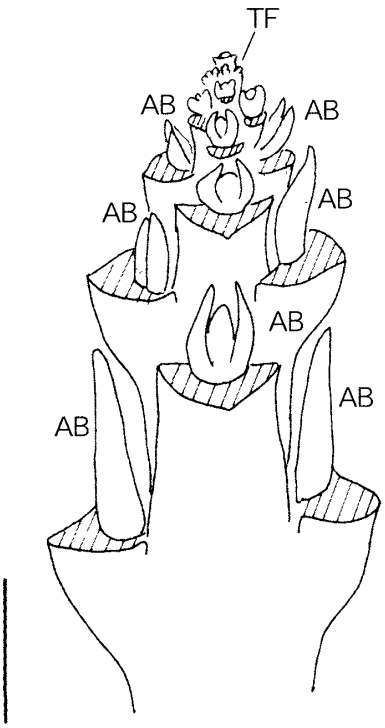

Fig. 2 Top region of inflorescence of *Phlox paniculata* at the stage of sepal formation of the top floret. The top floret develops faster than any other buds below. Leaves are decussately arranged. All leaves are removed. TF = Top floret. AB = Axillary bud. Bar indicates 5mm.

Floret development

Developmetal stages are determined as follows:

Stage I Floret undifferentiated. Shoot apex is round and it produces leaves decussately (Fig. 3).

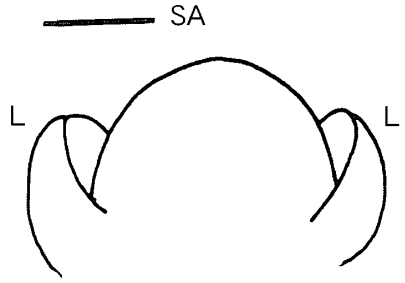

Fig. 3 Floret undifferentiated stage. Shoot apex is round and two leaves are formed at opposite positions. SA = Shoot apex; L = leaf. Bar indicates 0.1 mm in Figs. 3~7.

Stage II Sepal formation. The shoot apex becomes flat, and 5 sepals differentiate simultaneously beneath the shoot apex (Fig. 4, 5).

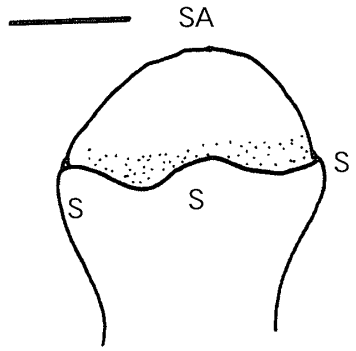

Fig.4 Floret at sepal formation. 5 sepals are simultaneously differentiated beneath the shoot apex. S = sepal.

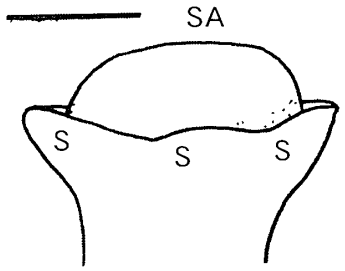

Fig. 5 Floret at sepal formation. Shoot apex becomes flat.

Stage III Stamen and pistil formation. 5 stamens and one pistil are differentiated from the flattened shoot apex simultaneously (Fig. 6, 7).

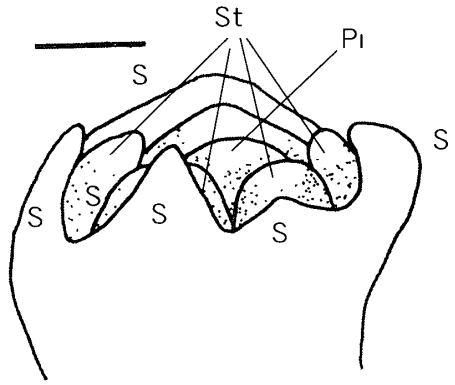

Fig. 6 Floret at stamen and pistil formation. Stamens and a pistil are differentiated at almost the same time. S = Sepal St = Stamen, Pi. = Pistil

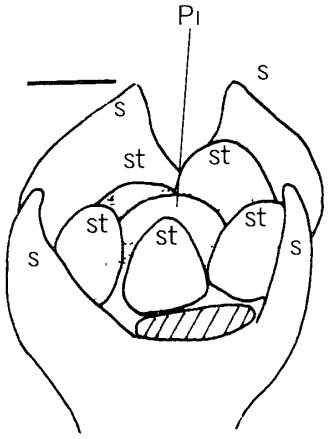

Fig. 7 Floret at stamen and pistil formation. One sepal is removed. One sepal is removed.

Stage IV Petal formation. 5 petals differentiate and make a circle around the stamens' circle (Fig. 8, 9).

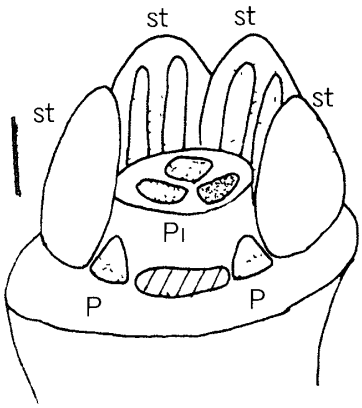

Fig . 8 Floret at petal formation. Petals are differentiated at the foot of stamen. Three locules of the ovary are seen at the center of pistil. P = Petal. Bar indicates 0.2mm. All sepals and one stamen are removed.

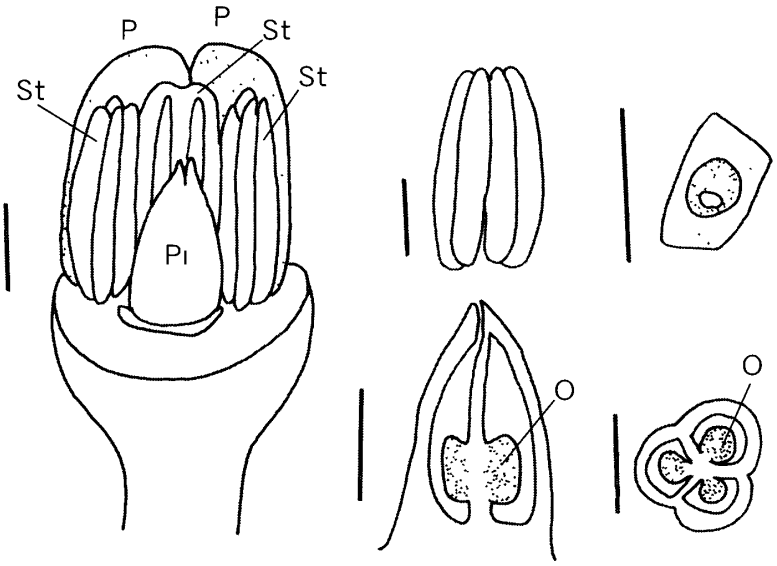

Fig. 9 Floret at ovule formation. A: floret with petals, stamens and a pistile. B: ventral view of stamen. C: pollen mother cell. D: ovary vertically cut showing ovule formation. One ovule is formed in one locule. E: ovary transversely cut.
O = ovule; P = Petal; Pi = Pistil; St = Stamen. Bar indicates 0.2mm in A~B and D~E, and 0.01mm in C.

Stage V Ovule formation. Ovary has an axial placenta with three locules. One ovule is formed in each locule (Fig. 9).

Stage VI Pollen grain formation. Pollen mother cell, pollen tetrad and matured pollen grains are observed (Fig. 9, 10).

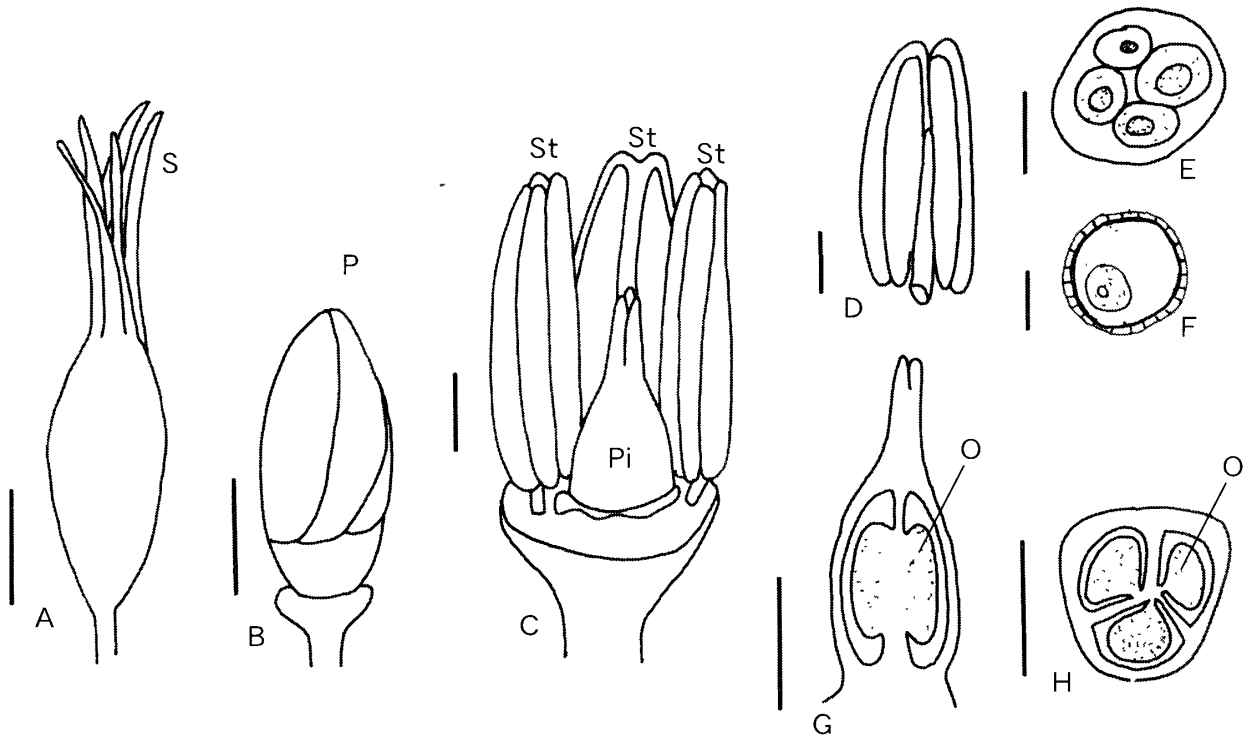

Fig. 10 Floret at pollen formation. A: intact flower bud. B: sepals are removed. C: stamens and pistil. D: back view of a sepal. E: pollen tetrad. F. pollen grain. G: pistil vertically cut. Ovules are seen. H: pistil (ovary) transversely cut.
O = Ovule; P = Petal; Pi = Pistil; S = Sepal; St = Stamen. Bar = 0.02mm in D, E and 1.0mm in others.

Stage VII Flowering. The floret at the tip of the inflorescence opens first (Fig. 11).

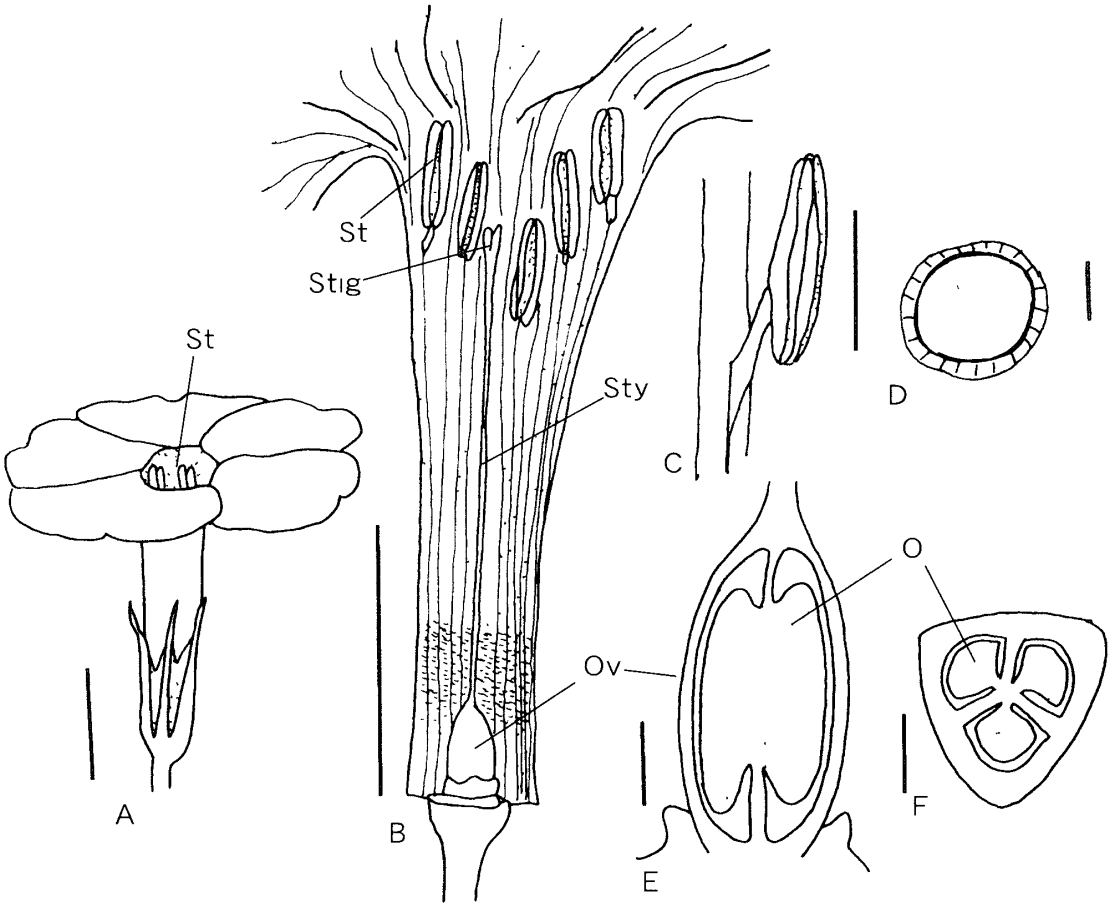

Fig. 11 Floret at flowering. A: intact floret. Stamens can be seen at the mouth of the tube. B: view of opened tube. Stamen has short filament and attaches at the top area of the tube. Pistil has a long style. Stigma is divided in three. C: stamen with short filament. Stamen is already opened. D: matured pollen grain. E: ovary vertically cut. F: ovary transversely cut. O = Ovule; Ov = Ovary; St = Stamen; Stig = Stigma; Sty = Style. Bar = 10mm in A, B; 2mm in C; 0.5mm in E,F and 0.02mm in D.

Comparative observation of the floret development in the early and late flowering cultivars (Table 1)

In the early flowering cultivar, no evidence of floret differentiation was observed until the 2nd of May. Floret differentiation began on the 9th of May. Sepals, and stamen and pistil were observed on that day. Petals differentiated on the 16th. Petals usually differentiate prior to stamen and pistil in other plants (Nishimura et. 1989, Kosugi 1976), but in this plant petals were observed later than the stamen and pistil. Ovules were observed in the locules of the ovary on the 30th of May. One ovule differentiated in each locule. Pollen grains were observed in the anthers on the 30th. Ovules differentiation began earlier than maturation of pollen grains (Fig.8). Flowers opened on the 27th of July.

On the other hand in the late flowering cultivar, flower bud differentiation began on the 6th of June by sepal formation. It was four weeks later than the early flowering cultivar. The stamen and pistil were observed on the 13th, and pollen grains were observed on the 20th of June. Flowers opened on the 27th of July. It was also four weeks later than the early flowering cultivar. The term from the beginning of flower bud differentiation to flowering was 8 weeks in both cultivars, and the pollen maturation stage continued about a month until the flowers opened in both cultivars.

Eguchi (1939) reported that flower bud formation started on the 5th of June, and flowered on the 25th of June. This means the flower developmental process complete itself within one month. In our observation it took about two months (Table. 1). Eguchi did not indicate by name the cultivar he used. He may have used a fast developing cultivar, or he may have considered the pollen grain formation as flowering.

The plant heights of two cultivars were almost the same (72 and 75 cm) at the beginning of flower bud differentiation, and the early flowering cultivar became taller at the pollen formation stage. In the end, it became 10 cm taller than the late flowering cultivar.

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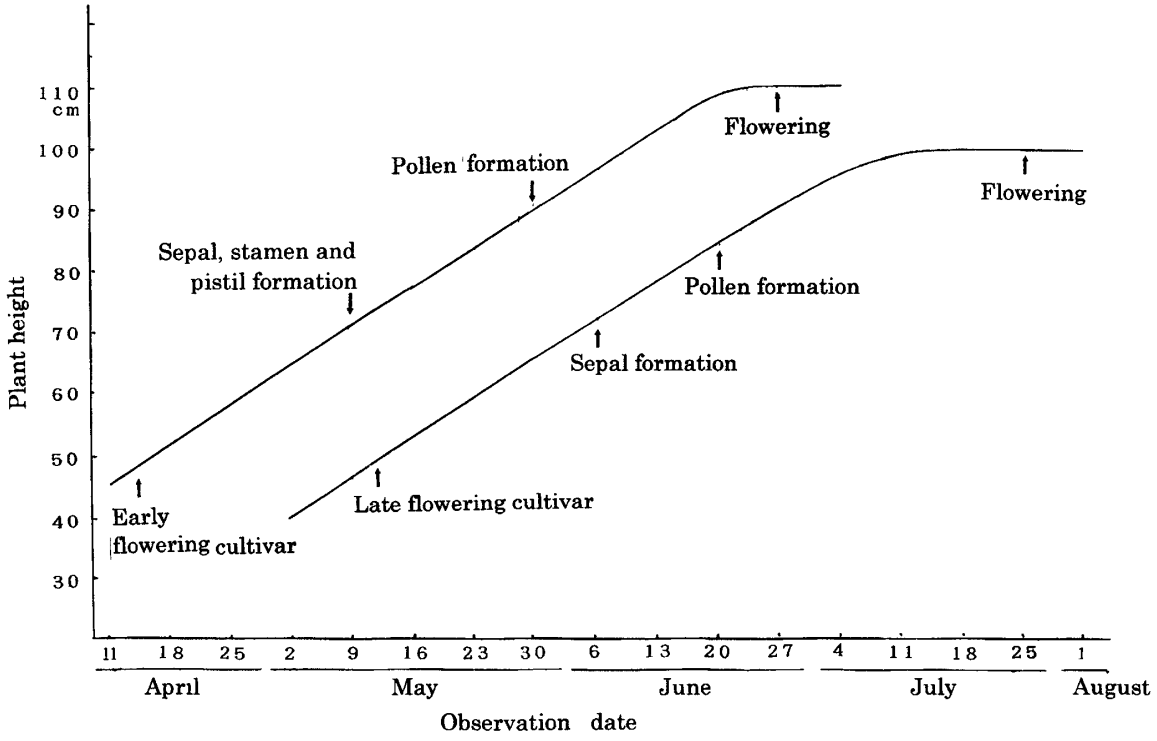

Fig. 12 Plant development and the developmental stages of the floret at the tip of inflorescence in the early and late flowering cultivars of *Phlox paniculata.*

Literature cited

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Table 1 Flower bud differentiation and development in the early and late flowering cultivars of *Phlox paniculata*

	April	May				
Developmental stage of floret	25	2	9	16	23	30
Undifferentiated	5*	5	4		1 ⑤ **	⑤
Sepal formation				1		
Stamen・Pistil formation			1	3	4	1
Petal formation				1		
Ovule formation						2
Pollen formation						2
Flowering						

June				July				August
6	13	20	27	4	11	18	25	1
②	②							
③	①							
	①				①			
	①							
		②	②	①	③			
5	5	5 ③	③	④	①	⑤	③	③
			5	5			②	②

*1 ~ 5 ⇒ plant numbers of the early flowering cultivar
** ①~⑤⇒ plant numbers of the late flowering cultivar
5 plants were observed weekly. Observations were conducted on the early flowering cultivar in 2002, and on the late flowering cultivar in 1987.