Fruit Buds of the Genus Prunus. Their Structure as Affecting Productiveness.

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Introduction.

Soon after the discovery of the process of fertilization among plants it was noted that certain differences in vigor and quality resulted in the offspring when a plant was fertilized by pollen from a distinct individual. The first facts pointing toward a general law were observed by investigators in the latter part of the eighteenth and the beginning of the nineteenth centuries. Andrew Knight approached the truth when he said, "Nature has something more in view than that its own males should fecundate each blossom. Kölreuter, Sprengel, and Müller understood something of the same law and added point after point, but without explaining very definitely the relations between the facts they noted.

Darwin put forth the first

statement that assumed the generality of a law, in 1862, when he summed up his observations by saying, "Nature abhors perpetual self-fertilization." In 1877, he published his work in Cross and Self Fertilization in the Vegetable Kingdom, containing the results of many long lines of experiments and setting forth these conclusions as clearly abstracted by Bailey: "Self fertilization tends to weaken the offspring, as compared with its natural condition; crossing between different plants of the same variety gives stronger and more productive offspring than arises from self fertilization; crossing between stocks of the same variety grown in different places or under different conditions gives better offspring than crossing between different plants grown in the same place or under similar conditions; and his researches have also shown that,

as a rule, flowers are so constructed as to favor cross fertilization."

Subsequent investigation has tended to verify these conclusions and give emphasis to them by proving their application to be more extensive than Darwin showed. The study of the extent of their application with the accompanying results is still a profound subject for science to investigate.

In the genus, Prunus it has been shown that not only can different varieties be crossed to advantage, but that there are distinct natural adaptations which render crossing easily possible, and self fertilization well nigh impossible.

It was with the hope of adding some data to the facts already collected concerning these adaptations and the influences they have in the production of fruit, that this study was undertaken.

Bud Development.

The genus, Prunus as now described by botanists, includes four important domesticated fruits; peaches, plums, cherries and apricots; drupaceous fruits with hard bony stones which are smooth in the plum, cherry and apricot but roughly grooved and corrugated in the peach. The blossoms proceed from buds borne laterally or on spurs in late summer of the preceding year. The buds attain maturity in August or September, thenceforth become passive and thus remain during the autumn and succeeding winter. Fruit buds and foliage buds appear to have the same origin, being often so nearly alike that they are with difficulty discriminated. Whether a bud is to produce a flower or a branch cannot be definitely proved during its early growth. Where the point of differentiation lies, and what governs it

are yet unanswered questions. Certain treatment such as systems of pruning seems to influence the proportion, and it is to be hoped that in time our knowledge will be extended to cover these points.

As the days grow long and warm in the spring, the buds become largely swollen and finally open. The peach and apricot to reveal, usually, a single flower from each bud, but plums and cherries show a variation from this. Instead of a blossom unfolding from the opening bud we find coming into view an aggregation of buds, which are the real blossom buds. They range in number from two to five, two to three being common in plums and three to five in cherries. Even these a few days later the blossoms appear.

Flowers.

The flowers are, in their normal

form distinctive throughout the genus. Borne single or in clusters, sessile or stalked; calyx five pointed or a bell or urnshaped tube which is deciduous after flowering; petals five, inserted on the calyx rim, spreading, white or pinkish; stamens twenty to thirty, inserted on the calyx; anthers two celled, versatile; pistil one, ovary superior, containing pendulous ovule; style long or short.

Of these parts the pistil and stamens are the essential organs in the production of fruit and seeds, the other parts serving only auxiliary or protective purposes. The stamens produce the pollen grains or male cells, and the pistil, the female egg cell. Before the production of seed can take place, the pollen grain must come in contact with the stigma, and send down a germinating tube through the parenchymous tissue of the style, enter the ovary and unite or

blend with the egg cell within to produce the ovule. The two sex elements must necessarily be mature at the same time. In the stamens the stage of maturity is shown by the dehiscence of the anthers, setting free the minute, yellow, mature pollen grains. In the pistil it is shown by the exudation of a viscous fluid to catch the pollen grain and hold it until it can send down its germinating tube to the ovary.

Since the stamens and pistil are the essential organs of reproduction, any influence affecting reproduction must be found in, or relating to, these organs.

Variations of Pistil and Stamens.

Variations in the relations of pistil and stamens are abundant. They fall chiefly into the classes mentioned below:

I. Heterogony; That variation in the length of style and filaments which separates the anthers and stigma

by placing them at different heights. Found to a greater or less extent in all the fruits here studied, but only in plums occurring frequently enough to be laid down as the rule and there only in certain varieties.* Results of observations seems to show considerable difference in different locations and different seasons. The following distinct forms of heterogony occur.

a. With style extended, bearing the stigma beyond the anthers.

b. With short pistil not reaching the anthers.

c. Similar variations on the part of the stamens.

It has been customary for botanists to describe the variations in this way† - Those flowers bearing long styles and short stamens occurring on one individual and those bearing short styles and long

* See table p. 13. also Annual Rept. Vt. Expt. Sta 1896-7 p. 126

† Gray's Lessons and Manual of Botany p. 116.

stigmas on another. The pollen is then carried by insects from the long stamens of one flower to the long pistil of the other and from the short stamens of the latter to the short pistil of the former. This would seem to imply the absence of cross-fertilization between flowers having short pistils and those having long stamens, and vice versa, - an inference which does not appear to be proved by actual fact, and which has no substantiation in reason. Insects in their busy rounds with flowers carry away the pollen from both long and short stamens, and it is entirely accidental which kind of pollen will adhere to the next stigma touched, whether it be long styled or short styled. But one other hypothesis remains, that of prepotency, and I know of no experiments showing that on long pistils the pollen from long stamens is prepotent over that from short stamens, or vice versa.

The tables on pages 12, 13, and 14 show the results of investigations made this spring in the station orchards. From the table showing variations in plums, page 13, it will be noticed that long, short, and normal pistils occur, in many instances upon the same tree. It has been before proved that varieties tending to long pistils in one locality may in another locality, or in different seasons in the same locality, tend strongly to short pistils.

While examining these forms one readily noticed the apparent weakness of many of the short styled pistils. Some were so much reduced as to awaken doubts as to whether they would fertilize at all or not. To test this, all the normal and long styled flowers on certain branches of Clifford and Robinson were removed leaving one hundred flowers on each variety with styles distinctly short. These have been observed and no fruit

Structural Variations of Each Blossoms.

Variety	No. Examined	Grams	Normal	Double Pistil	Long Style	Short Style	Pistil Lacking	No. Stamens	Defective Stamens
Oldmixon (Free)	200		173	7			20		5
Lemon Cling	100		61	25			18		21
*Twins "G" No 1	200		180	3			15		2
*Twins "M" No 2	102		88	1			13		
Elberta	200		183	2			6		9
Stump the World	181		114	41			20		6
Heath Cling	200		140				30		5
Bishop's Early	99		69	16			14		2
Wonderful	94		90				2		2
Alexander	100		90	1			10		
Family Favorite	100		91				5		4
†Governor Briggs	405		110	258			42		
Ringgold	200		191				9		
†Crawford's Early	200		72	100			28		
Crosby	200		143	35			22		

* A seedling of Hale's Early described in bulletin 73 Kans. Expt. Station

† A slight tendency towards proterogyny.

Structural Variations of Plum Blossoms.

Variety	No. Examined	Group	Normal	Double Pistil	Long Style	Short Style	Pistil Lacking	No. Stamens	Defective Stamens
*Sand	200	Prunus Watsoni				185	15		
Mariana	200	Prunus cerasifera	44		83	35	38		
†Robinson	400	Prunus chicasa	196		170	5	29	17	
Weaver	200	Prunus amer.	11		176		13		
Clifford	200	Prunus hortulana	87		2	73	38		
‡Wayland	200	"	25		110		65		
Wilgerka	200	Prunus domestica	65		75	25		30	10
Moldavka	192	"	30	1	160	1		27	
No. 24 Ord	20	"	18		2			27	
Early Red	126	"	125			1			
Communnia	125	"	20	1	100	3		26	1
Richland	207	"	20	5	168	5	7		
Hungarian Prune	100	"		5·8	97	2		26	
Wickson	80	Prunus triflora	68				12		

* Tends to be proterogynous

† Slight tendency to proterandry.

‡ Young tree

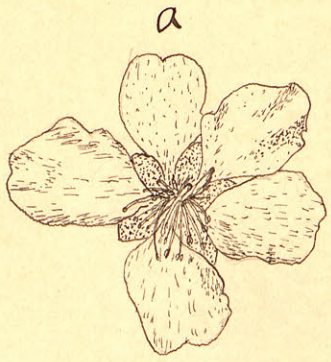
Structural Variations of Cherry Blossoms.

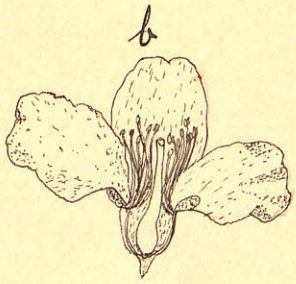
Variety	No Examined	Group	Normal	Double Pistil	Long Style	Short Style	Pistil Lacking	No. Stamens	Deficient Stamens
No. 109 Riga	100		94		3	2			1
*French Wichel	45		31	1			13	36	
Cerise de Ostheim	200	Heart	137		40	1	22	25.4	
Unknown	246	"	207		31	8		28.5	
Wragg.	200		150		40	7	3	27.5	
Early Richmond	224	Morello	214		9	1		29.1	
Montmorency	205	Duke	175	1	23	6		31.3	
Maydukc	220	"	84		133	1	2	27.	

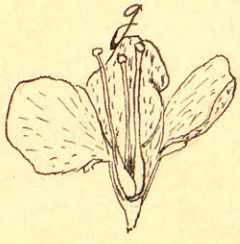
* Number of Stamens obtained averaging ten

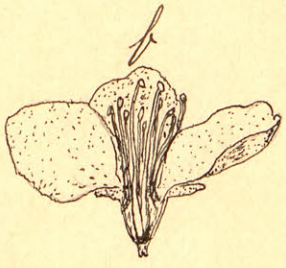
is found to have set on Clifford and but three on Robinson, while on the remainder of the trees the setting is, on Clifford fair, on Robinson, heavy. It appears to be true that trees showing many short styles are often shy bearers. Clifford shows this plainly. Out of two hundred blossoms seventy three were short. The variety has with us scarcely borne at all. The sand plum stands as an exception, possibly, though not certainly. Out of two hundred blossoms examined, one hundred and eighty five had short pistils. In the group of trees from which the blossoms are taken, some have a good setting of fruit, others, poor, so it cannot be said whether the Sand plum supports or antagonizes the rule. The above mentioned cases indicate that short pistils are really signs of sexual impotency rather than examples of natural selection as adaptations for cross fertilization.

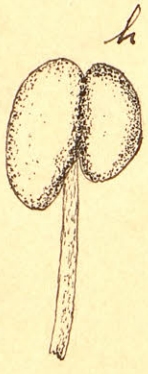
Plate I.











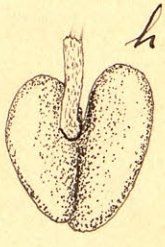


Plate II.

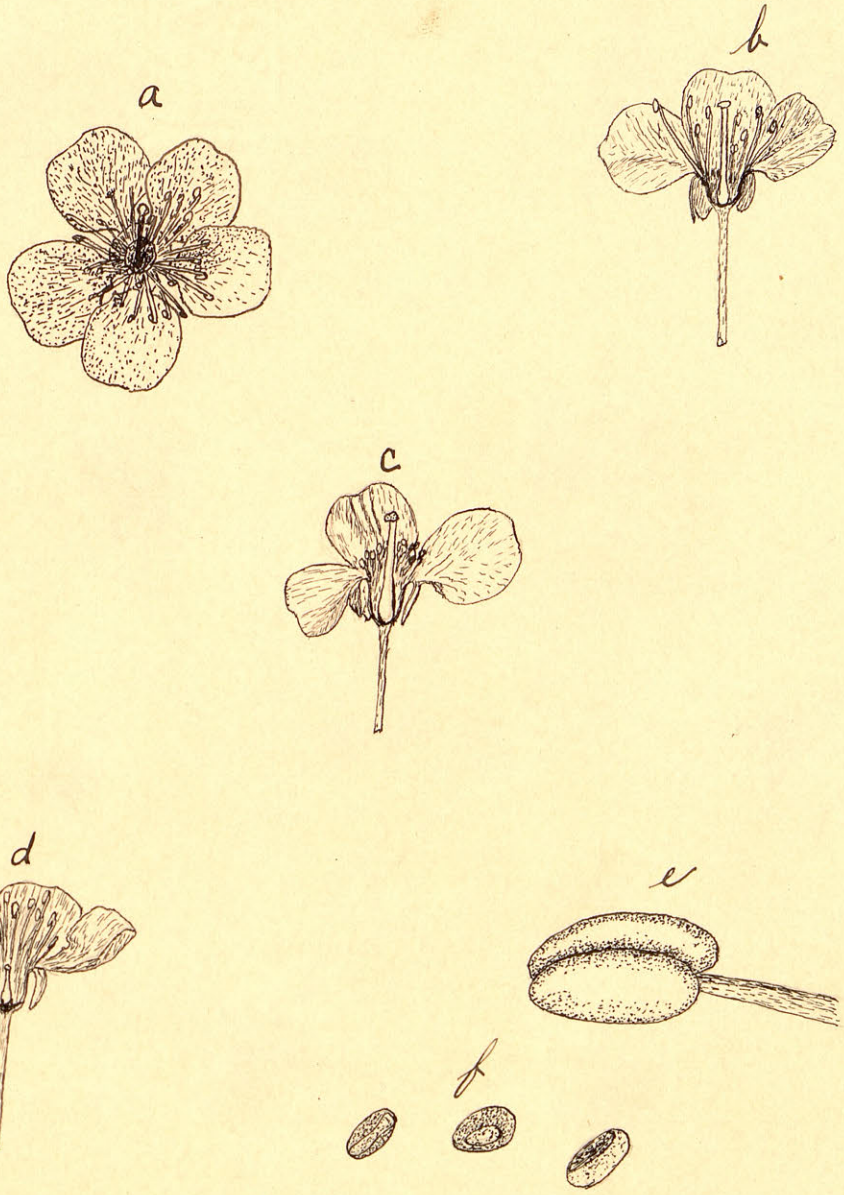


Plate III.

Fig. 1.

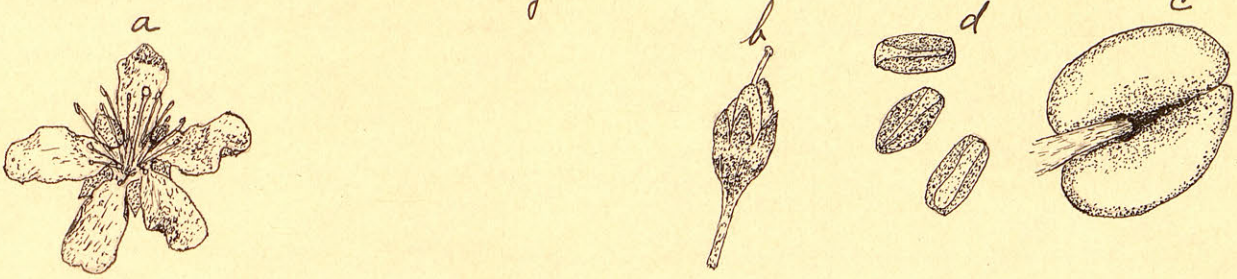


Fig. 2.

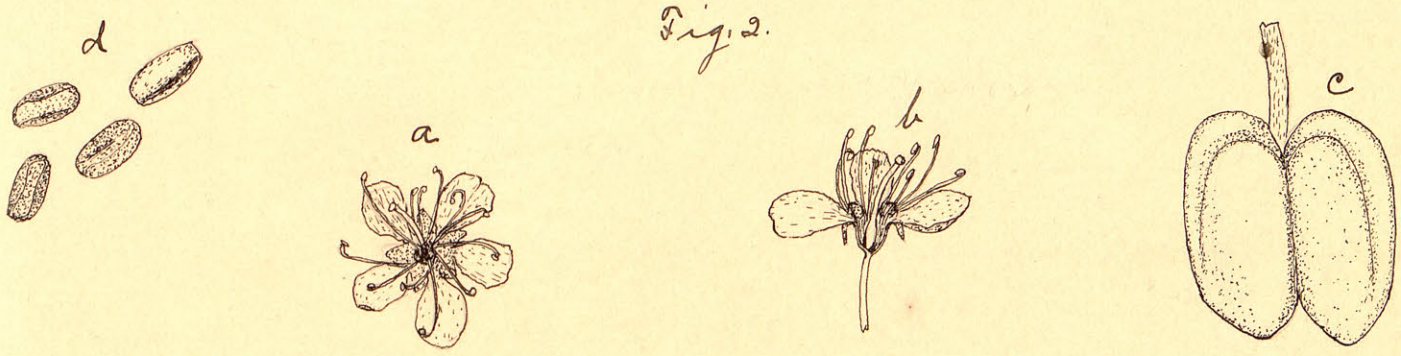


Fig. 3

Fig 4.

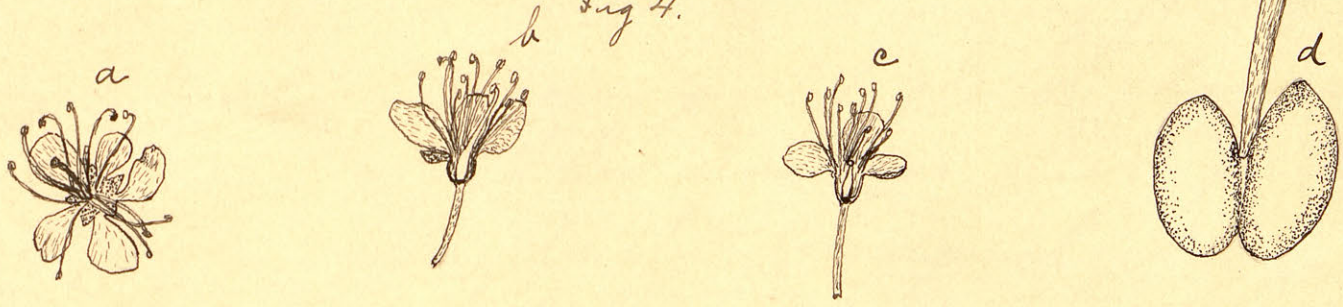


Fig 5.

Explanation of Plates.

Plate I. Flower of Peach.

a. Normal.
b. Normal, showing pistil.
c. Apetalous.
c, Proterogynous.
h. Anthers (Magnified).
d. Pollen-Grains (Magnified).
f. Double Pistil.
g. Triple Pistil.

Plate II. Flower of Cherry.

a. Normal.
b. Normal, showing pistil.
c. Long pistil, short stamens.
d. Long stamens, short pistil.
e, Anther, (magnified).
f. Pollen-grains (magnified).

Plate III. Flower of Plum.

Fig. 1. Communis, (P. domestica).

a. Normal.
b. Proterogynous.
c. Anther, (magnified).
d. Pollen-grain, (Magnified).

Fig. 2. Weaver. (P. Americana).
a. and b. Normal.
c. Anther. (Magnified).
d. Pollen-grains. (Magnified).

Fig 3. Emerson. (P. chicasa).
a. and b. Normal
c. Long pistil
d. Anther. (magnified).

Fig. 4. Morman. (P. hortulana).
a. and b. Normal.
c. Short pistil.
d. Anther. (Magnified).

Fig. 5. Spaulding. (P. domestica).
a. Normal.
b. Longstyled.

Examples of long styles are shown at c. Plates I and II, and Fig 1. b, Fig 3 c and Fig. 5. b. Plate III.

Short styles are shown at d. Plate II. and Fig. 3 b and Fig 4 c. Plate III.

II. Dichogamy, or that condition of the flower in which the two sex elements are not ready for fertilization at the same time. The flower maturing pollen first we call protanderous, that maturing the stigma first, protogynous. Dichogamy is often found combined with heterogamy, in which case the pistil extends beyond the unopened flower and is ready to be fertilized before the anthers of the flower discharge their pollen. (See e. Plate I. and Fig. 1. b. Plate III.). This condition was noticed to be frequent this spring upon the Sand plum and Sand cherry. It was the rule upon the flowering plum. (P. triloba), and frequent cases were also found upon certain varieties of peaches, notably Crawford's Early and Gov. Briggs.

It was not seen upon the cultivated cherries or the European varieties of plums. Proterogyny precludes the possibility of self fertilization and is one of the most effective natural adaptations for crossing.

III. Dioecia, or that condition in which the pistils are borne upon one tree and the stamens upon another. It rarely occurs in this genus. While it is true that the pistil is frequently wanting, it is generally because of injuries from frost or mechanical causes rather than natural adaptation. However the continuous shortening of the stamens on some flowers and the pistil on others results finally in dioecious flowers. Dioecia is the end and limit of heterogamy.

Duplication of Pistil.

One other variation is to be noted as having a possible effect on productiveness - the duplication of the pistil. The condition ~~is not frequent~~ is infrequent on the

cherry and plum. Out of 1540 cherry blossoms examined, but two pistils were double; out of 2450 plum blossoms 65 were double, nearly all the double ones occurring on one variety,—the Hungarian prune. In peaches a marked difference was found. In varieties such as Cramford's Early and Governor Briggs double pistils were in the majority, and even three and four pistilled flowers were found. The two pistils seem to fertilize to some extent and afterward grow as two peaches more or less united together, but it is questionable whether flowers with double pistils set and mature as large a proportion of fruit as those having single pistils. It is worth while to note that the two varieties showing so many double pistils have in the past been marked as shy bearers with us. The question remains to be decided by further investigation.

Prepotency of Pollen.

Aside from any structural variation of parts there is yet a marked disposition on the part of the stigma to accept the pollen of another individual of the species rather than from its own flower. Where pollen grains show no difference under the microscope those from another plant will fertilize the egg-cell when placed on the stigma sometime after pollen from the same flower. Darwin states that a plants own pollen is prepotent over that from a distinct species but that, "If two varieties are treated in the same manner the result is analogous, though of directly opposite nature; for pollen from any other variety is often or generally prepotent over that from the same flower."*

* Cross and Self Fertilization in Veg. Kingdom Page 391

While the rule that pollen from a distinct individual is prepotent over that from the same individual undoubtedly holds true in the genus, and there are now and then cases of self sterility, yet with a majority of varieties self fertilization will to some extent take place. This was tested by simply covering the flowers with paper bags during the blossoming period and until the fruit was beginning to grow.

Peaches appear most easily self fertile, showing sixty percent of the covered blossoms to have set fruit. Plums and cherries show a lower percentage, but still a very considerable proportion

The following table show the number of blossoms covered, also the number and percentage of fruit set.

Self Pertilization – Peaches.

Variety	No. Covered	No. Set.	Percent.
Family Favorite	50	40	80
Bishops Early	25	1	4
Olmixon (Free).	50	31	62
Elbera	50	40	80
Wonderful	25	18	72
Twins "J" No 1.	25	18	72
" "J" No 2.	25	19	72
" "M" " 1.	25	9	36

Self Pertilization – Plums.

Variety	No. Covered	No. Set.	Percent.
*Sayd	100	45	45
Clifford		1	
Emerson		2	
DeSoto		16	
Robinson		24	
Clinton		17	
Bluemont (?)		26	
Wyant		27	
Wayland (?)		16	
Weaver		18	

* Estimated

Self Fertilization — Cherries.

Variety	No. covered	No. Set.	Percent.
No. 109 Riga	50	13	26
No. 23 Orel	50	22	44
Montmorency	50	37	74
Early Richmond	50	19	38
No. 13 Vieris	50	17	34
Galapin	50	5	10

These results are gravely contradictory to those obtained by Prof. Waugh in his work at Denton, Maryland, 1897. From 6428 covered blossoms on fifty six varieties representing seven groups, he secured the setting of but five fruits, and drew from them this conclusion: "For all practical purposes all classes and varieties of native plums may be regarded as absolutely self sterile". Though he admits of possible slight exceptions.
It seems perfectly evident that Prof. Waugh had drawn his conclusions

from too limited a series of observations, either in time or space, or both. In our location, this present year, 1898, there are a number of varieties that have shown themselves to be not self sterile, but in a large, self fertile.

Conclusions.

The observations seem to warrant the following conclusions:

1. Heterogony and Dichogamy occur more or less frequently throughout the genus to secure the cross fertilization of the flowers.

2. Heterogony (especially short style) and Dichogamy characterize those varieties that tend most to sterility

3. Double pistils in peaches probably reduce the yield.

4. While there is evidence of the benefits of crossing, the flowers are not entirely self sterile.