T H E S I S

ON

PRELIMINARY BREEDING STUDIES WITH THE STRAWBERRY

Submitted to the Faculty

of the

O R E G O N A G R I C U L T U R A L C O L L E G E

for the degree of

MASTER OF SCIENCE

in

Agriculture

by

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June 1, 1912.

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INTRODUCTION.

Strawberries, until a comparatively recent date, were gathered only as a wild fruit or grown in the kitchen garden for home or local consumption. With the improvement of transportation facilities this fruit has been introduced to a large and growing market. It has increased in favor until it now holds a place as a standard market fruit. Strawberry culture is, consequently, receiving much attention from breeders and growers and in many sections it ranks as an established industry.

The work of improving the varieties has been largely scientific in nature yet it has been, unfortunately, very unscientific in method. As a result there is not only an absence of accurate and authentic data but also of valuable printed records.

These studies are therefore, of necessity, a preliminary work and are almost entirely experimental in character. As such, however, they were planned as a foundation for future research problems, the economic as well as scientific side being considered. With this idea in mind, horticultural varieties were cross-

ed in addition to the collecting and attempted hybridizing of botanical species. During the first season's work with the cultivated plants the Clark "Seedling" was used as a basis for the crosses, largely because of its superior packing and shipping qualities. The intervariety crosses were outlined with the intention of determining the possibility of improving the productiveness and size of this premier market variety. For this reason, the more productive varieties, Arizona Everbearing, Glen Mary, Magoon, Marshall, and Sixteen-to-One were used as the other parent in the crosses.

Reference work was done in addition to the pollination studies and work in propagation. Practically all available references were reviewed. From these sources some points of interest were obtained with regard to the origin of the scientific and common names, the history of the introduction of the strawberry and the development of the industry, and, finally, the botany of the genus.

Name.

The generic name "Fragaria" is derived from the Latin word fragrans, meaning fragrant.# This was applied because of the aroma or fragrance of the

Henderson's Handbook of Plants, p. 85.

the ripened berries. This characteristic is more pronounced in the European berries than in the American species. Hence the reason for the application of this name is more evident.

The origin of the common name "Strawberry" has been ascribed to various sources. The majority of these explanations are of a more or less traditional or mythical character. Throughout, there seems to have been a general tendency on the part of writers to correlate the name with the "straw" of grains. As a result, various suggestions have been made regarding the reason for the use of the word strawberry, based on the facts that straw was used to mulch the plants, that the berries were "strung on straws" to sell in the markets and because of the resemblence of the runners to straws.# A more logical reason for the name is found in the Anglo-Saxon word "strae" (stray).## If this is the true source of the name it was doubtless applied because of the "wandering" or spreading habit of the plants due to the production of numerous long runners.

History.

The uncertainty or vagueness concerning the origin of the common name of the genus Fragaria prevails also to a large extent, with regard to its dom-

Illustrated Strawberry Culturist, A. S. Fuller.p.8.

Columbian Cyclopedia, under "Strawberry".

estic history. In the first century A. D., Virgil mentions the wild strawberry. At a later period it was grown in the Roman gardens to a limited extent. The French and English gardners of the Middle Ages planted it more generally. However, there is no record of any improvement having taken place, other than that due to cultivation, until the seventeenth century, following the introduction into Europe of the American species F. Virginiana and F. Chiloensis. According to Bailey# the former was taken to France in 1624 and the latter reached Europe in 1712. De Candolle in his "Origin of Cultivated Plants" says that F. Virginiana was taken to England in 1629 and F. Chiloensis to France in 1715.

However, it was not until thirty years after the F. Virginiana plants had arrived in France that any noticeable improvement occured and it is reported that the original F. Virginiana stock remained unchanged for a century. This would be until about the time of the introduction into Europe of the Chilean species. The long continued constancy of the Virginian species was doubtless due to the fact, as our experiments would indicate, that the native European species, F. vesca does not fertilize it. As the reciprocal cross is possible it is very probable that the first horticultural variety of France the Fressant ## which appeared in 1660 was of a

Survival of the Unlike, p. 402.

##Survival of the Unlike, p. 400.

F. vesca x F. Virginiana parentage. The origin of this variety is not definitely known and its true parentage has been further obscured by its variation from the original type.

Some other minor varieties of little importance were developed but there was no other great improvement in the varieties until the appearance in England, in 1760, of the horticultural species, F. ananassa, Duch. or "Pine" strawberry. The origin of this species is also obscure. Bailey# says it is too constant in character to be a hybrid. Also, that it is botanically different from F. Virginiana. He claims it has developed, from F. Chiloensis. This opinion was based on its botanical characters and on the behavior of the Chilean plants under cultivation.##

There is no record of whether Professor Bailey had reference to the constancy within the species or to the absence of variation in the seedlings. As a type, it was variable enough to receive at least four specific names, three of which were applied by one man, Duchesne. This is according to the grouping in the "Cyclopedia of American Horticulture". Also there are several horticultural types, as Black Pines, Scarlet

Survival of the Unlike, p. 410.

Survival of the Unlike, p. 100.

Pines, True Pines, etc.# It would appear that the species F. ananassa is not constant or that there was a common origin for these difference but closely related Pines. If Professor Bailey based his opinion upon the behavior of in-bred seedlings to establish his point a question could be raised as to how variable the seedlings could reasonably be expected to be after 100 years of selection and propagation by runners.

While F.ananassa is botanically different from F. Virginiana it is, from all available descriptions, different also from F. Chiloensis. Although it may possibly be more closely related to the latter it is, however, intermediate between the two. The most distinctive F. Chilcensis plant characters,## the smooth upper surface and very dark green color of the leaves would not suggest as close a relationship to the garden varieties as would the depressed veins and lighter colored foliage of the F.Virginiana plants. From these points it is believed a well founded question could be raised regarding the opinion, that "the common varieties came from F.Chiloensis"### and thus excluding the possibility of as close a relationship to F. Virginiana. As the majority of the cultivated varieties are Pines the true origin and parentage of

Transactions of the Horticultural Society of London. Vol. VI. p. 147

Le Jardin Du Musem. Decaisne. Vol. IX. p. 53.

Cyclopedia of American Horticulture. Ed.Vol.III.p.605.

the species F. ananassa is one of the most important questions to be solved if the best results are to be obtained in future breeding work, especially as a knowledge of the history and parentage of a plant would be a key to its dominant and possible recessive characters.

In America, as was largely the case in Europe, the abundance and excellence of the wild berries resulted in little attention being given to strawberry culture. Roger Williams speaks especially of the "quality and abundance of fruit" growing wild in early colonial days.# He further states that the Indians used the berries in making "bread". While of little value except to an economic work, this last statement is interesting to note as a possible origin of the popular American dessert, strawberry shortcake.

With the depletion of the soil the berries were less abundant and admirers of the fruit began to cultivate them in gardens. However, as late as 1835 all of the varieties grown in America were of English origin. In 1834 Mr. Charles M. Hovey of Cambridge, Mass., the "father of American strawberry culture" originated the first American variety, the Hovey or Hovey "Seedling". This berry was a Pine, being a seedling of an English variety. It was first fruited in 1836.## Its origin is otherwise uncertain.

Evolution of Our Native Fruits. p. 426.

Fruits of America. p.75. - Hovey.

The cultivated varieties were slow to gain favor because the poeple had been so accustomed to using the wild berries. The perishable character of the fruit also tended to prevent a more ready sale. For these reasons it was little known to the market previous to 1840. Following the introduction of the second important American variety, the Wilson, in 1854, there was a large increase in strawberry culture but extensive plantings were not made until after 1865. This new variety was also a Pine according to Bailey but Thomas in his "American Fruit Culturist" says it is a "Scarlet" or descendant of F. Virginiana. He also reported F. Chiloensis as appearing "to be unworthy of cultivation". An Ohio Horticultural Report of 1885 stated that the Wilson had "run out" at that time. It has, nevertheless, been a favorite among growers in some sections until very recently. The extended popularity of this variety was principally due to the fact that it was for 40 years almost the only first class market berry, there being little improvement in either the firmness or productiveness of the strawberry from the time of the first American varieties until a few years ago. This condition was due to the failure of the breeding experiments based on wild species and to the careless practice of propagating from beds of old weak plants. The Eastern species F. Virginiana is reported as giving little promise under cultivation. Also, F. vesca which is normally an "everbearer"

has produced no everbearing varieties for Eastern growers. Hence, selection and inter-variety crosses were the other means of improving the varieties. When these were neglected there was consequently no development.

At present there is a demand for varieties which are adapted to special purposes as well as to special localities. Various companies, individuals and experiment stations are working on the problem and it is being gradually answered through the application of improved methods of selection and breeding. These companies are collecting and testing new varieties and improving the older ones by selection and scientific propagation. Valuable breeding work has been done at the South Dakota Experiment Station# in an attempt to obtain a hardy variety. There the native berries were used as a basis in an attempted improvement of the hardiness of the garden varieties. At present the outlook is very bright for a highly specialized and thoroughly developed industry.

Other than the writings of Professor Bailey there are no published results of investigations having been made to determine the botanical relations of the species and original parentages of the cultivated varieties. Authentic records of the older berries are not available. The lack of accurate knowledge of the origin

Bulletin No. 103, "Breeding Hardy Strawberries."

of a variety limits its value as a foundation or parent for future crosses. Accurate breeding experiments often reveal parentages through reversions and dominant characters of the seedlings. In addition they will show the constitutional weeknesses or virility of a variety or species. Knowledge of these facts is essential to the most intelligent breeding work. Until this knowledge is available breeders will have to labor under a serious handicap. This present work is an attempt to determine whatever is possible of these primary facts within the time available.

The History of the Strawberry in Oregon is very similar to the national history. The early settlers enjoyed abundant crops of large luscious wild berries. They are reported to have been "as large as the average tame berries of today", until as late as 1875. With the depletion of the pasture lands and cropping of the virgin soils the crop as well as the size of the berries has diminished until the supply of wild fruit is entirely inadequate to meet the demands for home consumption. Even the custom of using the wild berries on account of their flavor has been abandoned because of their now being an inferior product. Again, the introduction and improvement of garden varieties was necessary. In 1852 Mr. Seth Luelling of Milwaukee imported some plants of Hovey "Seed-

ling"# These plants never bore fruit. Dr. J. R. Cardwell of Portland reports that plants of this variety produced fruit for him at a later date. A few years after his failure with the Hovey plants Mr. Luelling obtained plants of Wiatt's## "British Queen". These produced what were doubtless the first cultivated strawberries grown in Oregon.

Until a recent date the principal varieties cultured in this state were of Eastern or European origin. The Clark "Seedling" is probably the first variety of local origin. It came from a planting of seeds of unknown parentage, by Fred Clark of Mount Tabor. ### Some Clark plants were taken to Hood River by T. R. Coon in 1883. It is interesting to note the success with which this variety has been grown there and the continued failure of the same variety in the Willamette Valley, where it originated. The "Magoon" is another variety of local origin. It is a chance seedling discovered by W. J. Magoon of Portland. This variety was first exhibited at Mount Tabor, June 9, 1894. Another very promising variety, the "Oregon", originated near Salem. Mr. Z. Mills of Springbrook grew the "Gold Dollar"

Second Report, Oregon State Board of Horticulture.

Myatt.

H.M.Williamson in Pacific Homestead, June 1911.

from a large number of seedlings. Its parentage is unknown but it is believed to be from the "Excelsior".

Many new varieties are being propagated and advertised. Some few of these are very promising. Great advancement has been made in the industry through the introduction of these varieties of local origin. There is however, a great need for varieties having special adaptations to the different climatic and soil conditions throughout the state. Also, a special market variety is sadly needed for sections other than the Hood River Valley. Chance seedlings might eventually supply these demands but they will be supplied very much sooner if the crosses can be based on a definite knowledge of the dominate characters of the parents. Then, with an exercise of this knowledge the past necessary guess work could be largely eliminated. Hence, the greatest need at present in the development of better strawberry varieties is accurate experiments, scientifically performed, properly recorded and planned for the purpose of revealing the value of the different varieties and species as parent stock.

Botany.

There are reported to be about 130 described species of Fragaria.# Some writers would greatly

Cyclopedia of American Horticulture, under "Fragaria".

limit this number even reducing the number of types which are distinct enough to have specific rank, to from three to twelve. As the conferring of a name depends entirely upon the discretion of the person describing the plants, there are many named species which, from the available descriptions, appear to have no other than locality differences. Many names are also synonymous, the plants having been described by different men. However the descriptions are mostly in general terms and comparative language. Hence, a well founded opinion with regard to names of species and their relations can not be given without making a close study of the plants in question, when growing under uniform conditions for a rather extended period.

The following description of the genus Fragaria is found in Decaisne's "Le Jardin Fruitier Du Museum" Vol. 9. pp 25-26.

Fragaria, Tourn.

Flowers: Hermaphrodite, dioecious or polygamously dioecious, bracteolate, white.
Calyx, with a cup shaped base, 5-parted, with entire or denticulate margined smaller bracts between them, persistent.
Corolla consists of 5 orbicular petals, shaped like a very short finger nail.
Stamens 20, short filaments, erect, persistent, glabrous; anthers didymous; the locules separated by a thickened wall, dehiscing longitudinally.
Pistils numerous, attached to a convex receptacle; styles short, filiform, stigma punctiform.

Ovules solitary, located in the middle of the cell, micropyle superior.
Akenes numerous attached either superficially to or indented in a globose or cornical fleshy succulent receptacle, smooth, slimy, dark, covered with a shell.
Seed rising above the ventral hilum; testa membranaceous, dark; embryo with plano-convex cotyledons; radical superior.

Herbs, occuring all over the world in temperate and alpine regions, perennial, runner bearing; alternate, trifoliate leaves; leaflets obovate, coarsely serrate; stipules attached to the base of the petioles, subvaginate, membranaceous, brownish or reddish; peduncles erect, several flowered, (with flowers bound together by halved bracts, whenever dioecious); receptacle pulpy, edible.

F. Chiloensis, Duch. as described in Decaisne's works# has "pale rose colored fruit" and "rich green" foliage and grows "on high ground" in Chile. The representative of this type (F. cuneifolia, Nutt.) growing in the Willamette Valley in Oregon has dark to bluish green foliage and light to dark red fruit and grows on the low land. Otherwise the descriptions agree. This difference might be due to the difference in elevation and locality where the plants were growing. This would also give evidence of a correlation between the color of foliage and fruit as reported in the "Biggle Berry Book." From the descriptions of the species growing in Oregon, F. cuneifolia, would not appear to be sufficiently different from those in Chili to have a different name. But as plants from Chili were not available for comparative studies no at-

Le Jardin Frutier Du Museum, Vol. IX. p.53.

tempt will be made to establish their identity.

The local species is extremely variable as may be noted from Plates II A, II B and II C; also from such items in the description as: Plant, erect or spreading, tall to dwarfish; Flowers, pistillate or perfect; Petioles, green to red and Leaflets, three to five. Yet, there are no sharp divisions where a variety could be named as the gradations are very gradual and much intermingled. This seems to be true with regard to all the plant characters. An illustration of extremes appears in Plate I, Fig.2. The plant on the left was taken from a wooded area and has never fruited. The other plant grew in the open.

The species is very disappointing under greenhouse conditions. It produces but very few flower stems. The plants are very susceptible to the attacks of powdery mildew. In the garden it behaves as shown in Plate I, Fig.1, and produces few flower stems. This is opposite to the behavior of F. Chiloensis for Professor Bailey.# When growing wild in the Willamette Valley it produces scattering blossoms in the fall and early winter; in 1911-1912 it did so throughout the winter. Much of the so-called"blighting" of the berries is due to the production of pistillate blossoms, large areas having only female plants. The plants received from Portland and

Survival of the Unlike, p. 100.

British Columbia were pistillate.

Fragaria cuneifolia, Nutt.

Habitat: Lower Willamette Valley, elevation 40 to 500 feet, Hood River Valley, Umpqua Valley, Sea coast bluffs at Newport, British Columbia. Was not found in the Rogue River Valley around Medford. Grows on open ground and edge of woods, both moist and dry soil. Seldom in heavy woods.

Plant: Medium compact, erect or spreading and appearing from tall to dwarfish. Plate I.

Runners: Medium to numerous, stout, red, rather long, making two to four plants, appearing with or after fruit.

Crowns: One to three, compact, short, rather small.

Flower Clusters: Three to eight blossoms to the cluster; peduncles very short; branching almost at crown, always low; very spreading, loose; pedicels rather long.

Flowers: Pistillate or perfect; four to seven, generally five petals; calyx lobes quite wide, rather short, with usually entire margins; Stamens rather large of medium length, erect; pistils short, not numerous, appearing separated.

Berry: Below medium to small, roundish to roundish ovate, occassionally necked; red; soft to firm juicy, tender, pinkish flesh.

Seeds: Few to medium; quite prominent and somewhat indented; large, plump; dark red to almost purple.

Leaves: Petioles short to long, separated, green to red, thickly pubescent; leaflets three to five in number, roundish to roundish obovate, thick, Margins rather sharply but not deeply serrated and these serrations mainly at the apical end; these leaflets often show a slight wedge shape

tendency; veins not prominent; midrib fairly prominent; surface of blade between veins flat, not pubescent above, very pubescent below; dark, black or blue green above, silvery green beneath; margins fringed with pubescence; stipules green to red; occasionally one or two small supernumerary leaflets are developed part way down on the petioles. Plate II A and Plate II B.

Fragaria Virginiana, Ehrh.

The plants of this species were received from Professor W. J. Beal, Botanist at Michigan Agricultural College. As they were grown in the cold frames and greenhouse, they may not be typical specimens. However, they correspond very closely to the description in Decaisne.# Plate III, Fig. 2 shows two plants, the one at the right grown in the cold frame and the other after having fruited in the greenhouse. Their description is as follows:

Plant: Medium compact, erect, tall, a few lower leaves spreading.

Runners: Numerous, long, rather thick, appearing with fruit or sometimes before fruit.

Crowns: One to six, usually not numerous, quite compact, rather short, medium size. Plate IV, Fig. 2, at left.

Flower Clusters: Six to fifteen blossoms to a cluster; peduncles short to very short, branching near the crown; branches widely diverging, spreading in habit, fairly compact.

Le Jardin Du Museum. Vol. IX. p. 43.

Flowers: Perfect; four to seven, generally five, small petals; calyx lobes narrow, medium long, with entire margins; stamens medium size, short to long, erect, somewhat incurving; pistils long and slender, appearing separated.

Berry: Below medium in size, roundish ovate; usually slightly necked; bright scarlet. Plate III Fig. 1. (x $1\frac{1}{2}$)

Seeds: Medium in number, prominent, deeply indented, large, plump, narrowly ovate, pale yellow. Plate III, Fig. 1.(x $1\frac{1}{2}$).

Leaves: Petioles long, rather stout, green except at base, thinly pubescent; leaflets three in number, rather narrowly ovate, medium thick, margins rather sharply serrate; veins prominent; surface of blade between veins flat; upper surface rather dark green, lower surface grayish green, slightly pubescent, with more pubescence on the lower sides; leaflets stalked, with central leaflets distinctly stalked; stipules red. Plate II C. Fig. 15, 16.

Fragaria vesca, L.

The following description is of greenhouse grown plants. They were found near the old greenhouses, probably having been introduced by the late Professor Coote, an English gardner. Plate IV, Fig. 1.

Plant: Medium to compact in habit; erect but with lower leaves somewhat spreading; tall; everbearing. Plate V, Fig. 2.

Runners: Numerous, long, slender, red, appearing with fruit.

Crowns: Rather numerous, from three to nine, medium loose, medium to long, rather small, quite slender; Plate IV, Fig. 2. At center and right. The one at the right is from a yearling greenhouse plant the other from an old wild plant. This species produces new crowns from the top while

F. Virginiana produces them from the bottom or sides. (See same Fig).

Flower Clusters: Generally a good many flowers to a cluster, from three or four to fifteen; the peduncles are long; branching unusally near the ends, quite erect and loose. Plate IV, Fig. 1.

Flowers: Generally perfect, occasionally with abortive stamens; four to six, generally five small petals; calyx lobes small, short, medium wide, often with serrate margins; pistils short, small, close together, compact.

Berry: Below medium in size, ovate to ovate conical sometimes slightly necked; bright scarlet, glossy, spongy, juicy, slightly fibrous, with open core; flesh whitish. Plate V, Fig. 1.

Seeds: Medium in number, very prominent, superficial and outstanding, large in size, rather narrow, dark scarlet. Plate V, Fig. 1.

Leaves: Petioles long, rather slender, appear red near crowns, covered with a fairly thick pubescence; leaflets three in number, ovate to obovate in shape, rather thin, fairly deeply serrate; midribs and veins prominent; surface of the blade between veins raised; light green above and grayish green below; pubescence short, fine and not prominent; leaflets, slightly stalked; stipules greenish. Plate II C. Fig. 17.

Fragaria vesca var. alba.

Seeds of this variety were obtained from the seedhouse of John Lewis Childs, Philadelphia, Pennsylvania. (See Plate I, Fig. 1, background). It differs from F. vesca as follows:

1. It produces no runners.

2. Has many crowns, 50-60 in two year old plants,

3. Usually has smaller flower clusters,

4. The berry is white to waxen, and

5. The seeds are pale yellow.

This variety is strongly self fertile and "comes true" from seed. Can also be propagated by separation.

Fragaria Californica, Cham. and Schlecht.

The American vesca is typified by F. Americana Britt. but as this has superficial seeds ("Flora of Colorado", Rydberg) F. Californica is not synonymous with it. The wild plants are as follows:

Habitat: Observed to grow in woods along Willamette River basin from Salem to Portland at about 100 feet elevation above sea level; Wooded hills in Eastern Linn County and around Corvallis in Benton County, above about 500 feet elevation; along Santiam River near Lebanon, Oregon, and along the Southern Pacific Railway in the Calapooia mountains at 1000 feet elevation. Always in the woods or newly cleared land. Sometimes intermingled with F. cuneifolia and usually blossoming from two to four weeks later. In 1913 it blossomed at about the same time. The plants from the Santiam appeared slightly different at first, being stocker and darker green but wen cultivated together they are identical.

Plant: Loose, erect, tall. In the greenhouse the plants were lower with short petioles and peduncles. Plate VI, Fig. 2.

Runners: Numerous, slender, red; appear with blossoms.

Crowns: One to three, medium to compact, long, medium small, slender.

Flower Clusters: Two to twelve blossoms, long, erect, open, loose;

peduncle long; pedicels short.

Flowers: Perfect or sometimes pistillate from four to six, generally five petals occasionally having serrated outer margins; calyx lobes medium broad, medium long; stamens erect, in three whorls; not incurving; pistils few, long, open.

Berry: Small, roundish, dark scarlet, glossy.

Seeds: Small, pitted, very dark red, not numerous.

Leaves: Petioles long, thick, green to red, fine pubescence; leaflets, three, roundish ovate to oblong ovate, thin, margins shaply and rather deeply serrate; prominent veination, furrowed, light green above, silvery green below; slight pubescence above, thick but very fine below; stipules greenish to red. Plate II C, Figs. 19-20.

Variations in the numbers of stamens, petals and sepals, including bracts, are shown in the following table:

TABLE I. VARIATIONS IN FLOWER PARTS.

Species, Variety.	No. Stamens.	No. Petals.	No. Sepals.
F. cuneifolia	15 to 29	4 to 7	8 to 14
F. vesca	16 " 26	4 " 6	8 " 15
F. Virginiana	20 " 32	4 " 7	8 " 13
Clark "Seedling"	30 " 43	5 " 10	10 " 18
Magoon	33 " 40	5 " 10	10 " 16

The principal combination or ratio of parts in F. cuneifolia and F. vesca is 20-5-10 and 24-5-10 in F. Virginiana with almost as large a number of blossoms with a ratio of 25-5-10.

The increase in the number of flower parts in the garden varieties is very noticeable.

The number of pistils on F. vesca berries varied from 120-230 with a constant number of 10 sepals, including bracts. The ratio between the number of seeds developed and the size of the berry is not direct, but apparently only relative.

Methods, Experiments and Results.

The first operation is to bag the flower clusters before any blossoms have opened, as illustrated in Plate VIII, Fig. 1. This prevents the visits of insects and consequent introduction of foreign pollen. Two-pound bags are of a suitable size for this purpose. It is very convenient to keep a memoranda on the bottoms of the bags regarding the dates of bagging, emasculating and pollinating.

The bagged clusters must be carefully watched so the earliest blossoms can be emasculated before any anthers have ripened and self pollination taken place.

There is also a possibility of error in using clusters where the terminal or earlier blossoms have ripened their anthers and pollen has been scattered over the clusters. (See notes to Table VII, p. 32). The pollen for crosses can be obtained at the time of emasculating. The green anthers are removed with sharp forceps and ripened on smooth clean paper. Small straight vials with cotton stoppers are used to hold the ripe pollen. These should be carefully labelled and kept isolated as much as possible without being too inconvenient. In order to secure earlier or larger quantities of pollen the cages shown in Plate VIII, Fig. 3, can be used.

Generally, better results are obtained by deferring the pollinating from one to three days after the time of emasculating. The pistils appear to be more readily receptive at about the time when the anthers would, normally, be ripe. Our observations would not substantiate the opinion of some authorities that self pollination is guarded against by the pistils not being receptive at the time the anthers ripen, or vice versa.

From two to three berries to the cluster was the usual number pollinated, the others being removed. All pollinated berries should be carefully labeled, metal rimmed tags being safest and best for this. The young berries should be examined from three to five days after being pollinated in order to determine if any of the pis-

tils were not fertilized during the first operation and are yet receptive. Owing to the large number of pistils and their inconvenient position some few are often missed, at the time of the first application of pollen. The "neck" on many berries is due to the basal pistils not having been fertilized. See Plate V, Fig. 1,Center berry. When the berries have set and all danger of foreign pollination has passed better light and air is given the berries by tearing open the bags. Better protection is given the berries by placing cloth bags over them as illustrated in Plate VIII, Fig. 2. The blossoms on the plants in the greenhouse were not bagged except as further stated.

TABLE II. POLLINATION WORK IN APRIL-MAY, 1910.

Variety.	Pollen.	No. Poll.	No. Set.	% Set.
Ariz. Everbearing	Clark "Seedling"	15	14	93.33
Clark "Seedling"	Ariz. Everbearing	37	36	97.29
" "	Magoon	35	35	100.00
" "	Marshall	27	26	96.29
" "	Self	38	14#	36.84

See Plate X, Fig. 2. Practically all of the self pollinated Clark berries were abortive while the cross pollinated berries were well formed as shown in the illustration.

TABLE II. CONTINUED.

Variety.	Pollen.	No. Poll.	No. Set.	% Set.
Clark "Seedling"	Sixteen-to-One	26	26	100.00
Glen Mary	Clark"Seedling"	60	58	96.66
Magoon	" "	28	23	82.14
"	Self	31	28	90.32
Marshall	Clark"Seedling"	29	27	93.10
Sixteen-to-One	" "	28	23	82.14
Species				
F. cuneifolia	F. vesca	25	0	0.00
F. vesca	F. cuneifolia	40	36	90.00

From the above table Clark "Seedling" pollen gave a lower average percent of berries than the reciprocal crosses. Also, the Clark pollen on Magoon gave a lower set of berries than self pollinated Magoons.

All berries that set were practically perfect specimens with the exception of the self pollinated Clark. Plate IX; PlateX; Plate XI and Plate XII.

The species crosses were made in the greenhouse.

Seedlings.

When the berries ripened in June they were macerated and washed and the remaining pulp and seeds were

dried. When thoroughly dry the seeds were sown in flats of sharp soil, being about 1/2 sand and the remainder being loam with a little manure. Seedlings grew from all the crosses except Magoon x Self. In August 369 plants were large enough to be pricked off. In late September these were placed in thumb pots. Early in November the pots were plunged in coal cinders to give a more uniform moisture condition. An alkali absorbed from the cinders killed practically all the seedlings. Transplanting into clean soil and pots and plunging into clean sand did not save them. The few which survived were so checked as to be little larger than the second crop of seedlings.

The hybrids --- F. vesca x F. cuneifolia--- made the most rapid growth but were less stocky plants. Plate VI, Fig. 1. Those showing cuneifolia characters, about one in eight to ten, were sickly and were heavily attacked with mildew almost without exception. Those with vescan characters were very healthy. They produced runners after starting their sixth to seventh leaf.

When the seedlings were first pricked off, the flats containing the ungerminated seed were placed out of doors and left until after the November frosts. When brought into the greenhouse in December a large crop of seedlings from all of the crosses germinated readily. These were pricked off and made a good growth. A third

crop was pricked off in April, 1911.

Professor V. R. Gardner took charge of all seedlings and species collections about May 1, 1911. These were placed in the field for scientific and systematic study. The Magoon x Self plants were much weaker than the Magoon crosses. Otherwise the plants of all variety crosses are very promising. These are fruiting this year (1912) and a better knowledge of the value of the seedlings can be obtained when the berries ripen. Runners have been taken from the plants of the variety crosses and transplanted to the sandy loam soil of the home orchards where the economic work will be continued. Also, comparative studies will be made between the parent plants of Professor Gardner and the daughter plants here.

In April and May, 1911 it was not possible to duplicate all of the 1910 crosses as some of the older beds had been plowed up. Among these were Glen Mary, Arizona Everbearing and practically all Marshalls.

It was planned to make a large number of crosses but the rainy weather extending throughout the blossoming season very materially decreased the amount of work that could be done. The frosts in early April also damaged many blossoms. This is particularly true of the Magoons. The blossoms having the pistils killed

produces much stronger anthers and larger quantities of pollen than usual. The pollen was also virile. Because of the rain the work could not all be completed promptly. On some Magoon plants the pistils remained receptive from April 29 when the blossoms were emasculated until May 19 and set perfectly when pollinated on the latter date. With Autumn Belle, some were receptive from April 27 to May 20 and after this length of time developed normally upon being pollinated.

TABLE III. VARIETY CROSSES APRIL-MAY, 1911.

Variety.	Pollen	No. Poll.	No. Set.	% Set.
Autumn Belle	Clark"Seedling"	2	1	50.00
" "	Magoon	5	5	100.00
" "	Self	36	30	83.33
" "	Sixteen-to-One	3	3	100.00
Clark"Seedling"	Autumn Belle	8	6	75.00
" "	Magoon	8	6	75.00
" "	Self	142	76	53.52
" "	Sixteen-to-One	8	0	0.00
Magoon	Autumn Belle	10	8	80.00
"	Clark"Seedling"	22	22	100.00
"	Self	76	75	98.68
"	Sixteen-to-One	25	23	92.00
Sixteen-to-One	Autumn Belle	6	6	100.00
" "	Clark"Seedling	14	14	100.00
" "	Magoon	22	22	100.00
" "	Self	105	103	98.09

The Magoon and Sixteen-to-One pollen used on Clark "Seedling" was old as the Clark blossoms were late owing to the rains.

Outside of the Clark "Seedling" berries there were only 14 in 326 which did not set; Autumn Belle, 7; Magoon, 5; Sixteen-to-One,2. However, the self pollinated Autumn Belle berries were often abortive. Also, Sixteen-to-One x Autumn Belle.

The large set of Sixteen-to-One berries with all pollen is very notable.

Clark "Seedling" x Self were abortive berries again as in 1910. Plate X, Fig. 1, at left.

By transposing Table III a better idea of the relative value of the varieties as pollenizers can be obtained. This is not truly representative as the same number of crosses was not made in each case.

TABLE IV. TRANSPOSITION OF TABLE III.

Pollen	No.Pollinated	No. Set	% Set.
Autumn Belle	60	50	83.33
Clark "Seedling"	180	113	62.78
Magoon	111	105	94.59
Sixteen-to-One	141	129	91.49

In order to determine the possible effect upon the development of the berries of removing the sepals,

the following crosses were made. The sepals and bracts were removed at the time the emasculating was done.

TABLE V. EFFECT OF REMOVING SEPALS.

Variety	Pollen	No. Poll.	No. Set.	%Set
Autumn Belle	Self	2	2	100
Clark "Seedling"	Magoon	2	2	100
Magoon	Clark "Seedling"	3	3	100
"	Self	3	3	100

The berries developed normally and there was no apparent effect from having the sepals removed.

In the following crosses pollen from the species was used:

TABLE VI. SPECIES POLLEN ON THE VARIETIES.

Variety	Pollen	No. Poll.	No. Set.	%Set.
Clark"Seedling"	F.cuneifolia	17	9	52.94
" "	F.vesca	4	1	25.00
" "	F.Virginiana	9	1	11.11
Magoon	F.cuneifolia	27	23	85.18
"	F.vesca	2	0	0.00
"	F.vesca var.alba	1	0	0.00
"	F.Virginiana	15	8	53.33

TABLE VI. CONTINUED.

Variety	Pollen	No. Poll.	No. Set	% Set
Sixteen-to-One	F.cuneifolia	18	16	88.88
" "	F.vesca	6	0	0.00
" "	F.vesca var.alba	3	0	0.00
" "	F.Virginiana	10	8	80.00

The Clark "Seedling" x F. cuneifolia berries set with pollen that was a month old.

F. cuneifolia pollen gave the highest average set of berries, F .Virginiana second and F. vesca produced but one berry in 16 attempts. In fact, this is the only berry set with the vesca pollen in any variety or species cross and is probably due to an error although no suggestion as to a possible mistake can be made.

Sixteen-to-One plants gave the highest set of berries. Magoon set only about half the berries with F. Virginiana pollen and the Clark plants gave a poor set with all pollen. Magoon x F. Virginiana berries were medium poor.

In order to see if there was any stimulas to development in the irratating effect of the pollen brush the following work was done. With those marked "sterile"

a sterile brush was used. Those marked "blank" were merely emasculated and bagged.

TABLE VII. EFFECT OF MECHANICAL STIMULUS.

Variety	Treatment	No. Treated	No. Set.	%Set.
Magoon	Sterile	9	0	0.00
"	Blank	4	0	0.00
Sixteen-to-One	Sterile	4	0	0.00
" "	Blank	11	1	9.09

The Sixteen-to-One berry was very poor having but 23 seeds. This berry is more probably the result of error or accident than it is an example of parthenogenesis. The bad weather so delayed the work that it was necessary to use some clusters on which the earliest blossoms had opened. Although all such blossoms were removed they were so close to the other blossoms in the clusters that pollen could be readily transferred and, later, pollinate these late blossoms through an accidental shifting. Also, another chance of error is possible in the short exposure of the blossoms during emasculation, pollination and examinations. On some blossoms the young petals do not entirely cover the pistils. However, the use of these was guarded against. While any of these reasons might account for the abortive Sixteen-to-One berry yet no suggestion as to the cause of its development can be given.

In addition to the above test green aphis were found on some young blossoms. These were emasculated but no seeds developed from the stimulus of the movements of the insects.

The following work was done for the purpose of determining the set of berries without the agency of insects, wind or mechanical stimuli. The clusters were bagged before any blossoms had opened and were kept bagged until after the berries had set or died.

TABLE VIII. CLOSE FERTILITY TESTS.

Variety.	No. Clusters.	No. Blossoms Total	No. Blossoms Average	No. Set.	%Set
Autumn Belle	11	99	9.0	50	50.5
Clark "Seedling"	44	252	5.7	59	24.41
Magoon	18	139	7.7	99	71.22
Marshall	5	42	8.4	22	52.38
St. Louis	11	112	10.1	38	33.92
Sixteen-to-One	21	122	5.8	68	55.74

In making the counts only the berries which were sufficiently developed to be of commercial value were counted as having "set."

With Autumn Belle the latest blossoms were those which did not set. Plate XIII, Fig. 2. The berries are yet young but their state of development can be noted.

The Clark "Seedling" clusters were the smallest of all the varieties. The berries were practically all very poor as was the result with the self pollinated berries. Plate XIII, Fig. 1.

Magoon gave a higher set of berries by 15% than any of the other varieties. Plate XIV, Fig. 2.

The Marshall berries were medium poor and the St. Louis were very poor.

The small number of blossoms per cluster of Sixteen-to-One was largely due to the fact that they were late clusters. Plate XIV. Fig. 1.

Plate XV shows diagrammatic sketches of how the green aphis of the Strawberry may pollinate the berries. The sketches were made from observations in the field.

In Fig. 1 an aphis is shown while crawling upon an anther. In this way its antennae, legs and body become covered with pollen grains. A later visit to the pistils will result in pollination, as shown in Fig.2. Fig. 3 is of one of the lice resting on the pistils under a dehiscing anther. Its antennae are also disloging the ripened pollen grains. Fig. 4 illustrates an aphis resting on a sepal directly under a dehiscing anther. Its body and appendages are thus becoming covered with pollen. A subsequent visit to the pistils, as per Fig. 2 again,

would doubtless result in their being pollinated.

On a smooth surface, as paper, one of these lice will travel at the rate of one inch per minute. Allow 18 hours a day for feeding and rest and figuring but 10% efficiency because of obstructions they could yet travel three feet per day.

In order to carry on more extensive pollination tests a number of plants were grown in the greenhouse. The garden varieties gave very poor results but the species with the exception of F. cuneifolia responded very well to the off-season treatment.

TABLE IX. CROSSES IN GREENHOUSE, OCTOBER, 1910-Feb., 1911.

Variety	Pollen	No. Poll.	No. Set	% Set.
Ariz. Everbearing	F. vesca	2	0	0.00
" "	F. Virginiana	1	0	0.00
" "	Self	1	0	0.00
Clark "Seedling"	F. cuneifolia	1	0	0.00
" "	F. vesca	3	0	0.00
" "	F. Virginiana	4	0	0.00
" "	Self	15	1	6.66
Glen Mary	F. Virginiana	2	2	100.00
Magoon	F. cuneifolia	1	0	0.00
"	F. vesca	4	0	0.00

TABLE IX. CONTINUED.

Variety	Pollen	No. Poll.	No. Set	% Set
Magoon	F.Virginiana	5	5	100.00
"	Self	3	3	100.00
Sixteen-to-One	F.vesca	5	0	0.00
" "	F.Virginiana	7	3	42.85
" "	Self	1	1	100.00
Species				
F.Californica (Portland)	Clark"Seedling"	12	2	16.66
" "	F.cuneifolia	5	1	20.00
" "	F.vesca	5	4	80.00
" "	F.Virginiana	9	0	0.00
" (Linn Co)	"	1	0	0.00
" "	Self	1	1	100.00
F.cuneifolia	F.vesca	1	0	00.00
"	F.Virginiana	11	6	54.54
"(Lebanon)	"	4	4	100.00
F.vesca	Ariz.Everbearing	2	2	100.00
"	Clark"Seedling"	14	9	64.28
"	F.cuneifolia	7	6	85.71
"	F.Virginiana	23	16	69.56
"	Magoon	13	9	69.23
"	Self	36	33	91.66
"	Sixteen-to-One	12	8	66.66

TABLE IX. CONTINUED.

Species	Pollen	No. Poll	No. Set	%Set.
F. Virginiana	Clark"Seedling"	16	0	0.00
"	F. cuneifolia	3	0	0.00
"	F. vesca	16	0	0.00
"	Magoon	1	0	0.00
"	Self	22	7	31.81
"	Sixteen-to-One	4	0	0.00
"B"	Clark"Seedling"	8	3	37.50
"	F. cuneifolia	3	2	66.66
"	F. vesca	6	6	100.00
"	F. Virginiana	7	2	28.57
"	Magoon	4	4	100.00

TABLE X. TRANSPOSITION of TABLE IX.

Pollen	No.Pollinated	No.Set.	%Set
Ariz.Everbearing	3	2	66.66
Clark"Seedling"	65	15	23.07
F.Cal.(Linn Co.)	1	1	100.00
F. cuneifolia	20	9	45.00
F. vesca	78	37	47.48
F. Virginiana	85	39	45.88
Magoon	21	16	76.19
Sixteen-to-One	17	9	52.94

Points of interest to Tables IX and X:

In 23 Clark "Seedling" blossoms which were pollinated but one berry set yet the same plants readily set fruit later in the spring during the normal fruiting season.

The F. Californica plants from Portland set no berries with F. Virginiana pollen, a few with F. cuneifolia and a good number set with pollen of F. vesca. This suggests a close relationship between F. Californica and F. vesca.

F. vesca did not fertilize any other variety or species except its apparent relatives F. Californica and "R" yet it was readily fertilized by all other pollen.

With F. Virginiana the contrary was true. Its pollen fertilized nearly all other varieties and species yet none would fertilize it.

From the pollination results and botanical characters "R" is apparently closely related to F. vesca. It was found along the Corvallis and Eastern Railroad track at the intersection of 16th and Railroad Streets in west Corvallis. No description of its plants was given in the report on the botany of the species because of its questionable origin. There were in all only three or four plants and their runners. It is very similar to F. Californica. It has slightly heavier foliage with more color. Also, the stamens are practically always abortive. No at-

tempt will be made to say whether it is an escaped Horticultural variety or a native species probably F. Californica, brought from some distance. After a study of its progeny an answer to this question might be given.

From the last table the results would show the Clark "Seedling" to be the poorest pollenizer. However, the pollen was taken from weak plants. The species F. cuneifolia, F. vesca and F. Virginiana gave about equal results. As usual the variety Magoon would appear to be the strongest pollenizer. There is, however, an apparent relation between the vigor of the plants of the garden varieties and their value as pollenizers.

During the normal fruiting season of April and May the plants in the greenhouse also blossomed. The best results were obtained with young unfruited plants. Plate III, Fig. 2, at left. The F. cuneifolia plants were more or less sickly and badly attacked with mildew. They produced very few blossoms. The F. cuneifolia pollen for the crosses was obtained from unopened blossoms of wild plants growing in the pastures about Corvallis.

The results in the next table are of little value and should never be quoted because of the presence of some blue flies during the latter part of the season. The freedom from insects in the other seasons had made it seem unnecessary to take extra precautions. Bagging is imprac-

ticable because of the small clusters and short, delicate peduncles of some species. However, cages as those shown in Plate VIII, Fig. 3, would be[a] sufficient and fairly convenient protection.

TABLE XI. CROSSES IN GREENHOUSE IN APRIL-MAY, 1911.

Species	Pollen	No. Poll.	No. Set.	%Set
F. Cal. (Clackamas)	F.cuneifolia	3	2	66.66
" "	F.Virginiana	1	0	0.00
" "	Self	3	3	100.00
" (Corvallis)	F.cuneifolia	2	2	100.00
" "	F.vesca	1	1	100.00
" "	F.Virginiana	1	0	0.00
" "	Self	1	1	100.00
" (Linn Co.)	F.Cal.(Portland)	1	1	100.00
" "	F.cuneifolia	8	2	25.00
" "	F.vesca	2	2	100.00
" "	F.vesca var.alba	1	1	100.00
" "	F.Virginiana	2	0	0.00
" "	Self	4	4	100.00
" (Portland)	F.cuneifolia	8	3	37.50
" "	F.vesca	1	1	100.00
" "	F.vesca var.alba	1	1	100.00
" "	F.Virginiana	1	1	100.00
" "	Self	4	4	100.00
F.cuneifolia (Hills)	F.Virginiana	1	1	100.00

TABLE XI. CONTINUED.

Species	Pollen	No. Poll.	No. Set	% Set.
F.cuneifolia (B.C.)	F.cuneifolia	1	1	100.00
" "	F.vesca	1	0	0.00
" "	F.Virginiana	3	3	100.00
" (Portland)	F.Cal.(Portland)	3	2	66.66
F. vesca	Autumn Belle	14	14	100.00
"	Clark "Seedling"	9	7	77.77
"	F.Cal.(Clackamas)	1	1	100.00
"	" (Linn Co.)	2	2	100.00
"	F. cuneifolia	7	4	57.14
"	" (Hills)	1	1	100.00
"	F.vesca var.alba	6	6	100.00
"	F.Virginiana	19	16	84.21
"	Magoon	5	5	100.00
"	Self	5	5	100.00
"	Sixteen-to-One	1	1	100.00
F.vesca var.alba	Clark "Seedling"	2	2	100.00
" "	F.Cal.(Portland)	5	5	100.00
" "	F. cuneifolia	5	5	100.00
" "	F. vesca	4	4	100.00
" "	F. Virginiana	2	2	100.00
" "	Self	4	4	100.00
F. Virginiana	Autumn Belle	22	0	0.00
"	Clark "Seedling"	18	0	0.00
"	F.Cal.(Portland)	2	0	0.00

TABLE XI. CONTINUED.

Species.	Pollen.	No. Poll.	No. Set.	%Set.
F. Virginiana	F. cuneifolia	41	2	4.88
"	" (Hills)	2	0	0.00
"	F. vesca	9	0	0.00
"	Magoon	20	0	0.00
"	Pear pollen	12	2	16.66
"	Self	38	0	0.00
"	Sixteen-to-One	24	3	12.50

The results as shown by this table are practically the same as the results in the winter of 1910 and 1911, with the exception of the F. Virginiana plants. In fact there was little chance of error through the presence of flies until near the close of the work. As all of the work with F. vesca var. alba plants was done at this time the large set of berries might be accounted for in this way. But as an indefinite though small part of the results was made uncertain in this manner none of them will be taken as correct.

Hence, it is uncertain whether the two in three F. cuneifolia (Portland) berries set with F. Californica (Portland) pollen would indicate a closer relation between F. cuneifolia and F. Californica than between F. cuneifolia and F. vesca or whether the result was due to insect pollination. The latter is more probably true.

The poor results obtained with apple, pear and raspberry pollen and with a sterile brush could not be duplicated when the plants were isolated and protected.

From the results there would appear to be NO RELATION between the set of F. Virginiana berries and the pollen used. This statement is borne out by the following detailed observations:

F. Virginiana plant "One" producing two berries with pear pollen did not set fruit with the following pollen: Other pear, apple, Autumn Belle, F. cuneifolia, Magoon, Self and Sixteen-to-One.

F. Virginiana plant "Two" setting two berries of F. Virginiana x F. cuneifolia did not set with the following pollen: Other F. cuneifolia, Autumn Belle, F. Californica (Portland), Self and Sixteen-to-One.

F. Virginiana plant "Three" set no fruit. The pollen used was Autumn Belle, Clark "Seedling", F. cuneifolia, Magoon.

F. Virginiana plant "Four" set three fruits with Sixteen-to-One pollen but did not with Clark "Seedling", F. cuneifolia, Magoon, and Self.

F. Virginiana plant "Five" set no fruit with pollen of Autumn Belle, F. cuneifolia and F. vesca.

S U M M A R Y.

Conclusions would be warranted in but a few instances because of the limited extent of the work or necessarily small experiments. However, there are a number of results which are of sufficient importance and interest to be worthy of summarizing and restating:

1. F. cuneifolia is very disappointing under cultivation especially in the greenhouse, where it was very susceptible to mildew. The same was true of the hybrids with F. vesca which showed marked cuneifolia characters. These latter appeared much stronger during the second season in the field.

2. The species F. cuneifolia is almost as good a pollenizer for the varieties of Western origin as are the varieties themselves, when crossed. F. Virginiana is also a fair pollenizer for these varieties.

3. F. vesca pollen would fertilize no variety and no species which was not closely related botanically, F. Californica being the only species which it would fertilize. Yet, pollen of all the other plants would fertilize this species.

4. F. Californica is closely related to F. vesca as shown by the crosses as well as botanical characters.

5. F. Virginiana would fertilize all varieties and species yet from the few results none would fertilize

its blossoms.

6. F. Virginiana plants acted very erratic and further work would be necessary before any definite idea of its normal behavior could be formed.

7. The species worked with can be hybridized with the possible exception of F. Virginiana with F. Californica although a reciprocal cross is not always possible.

8. The garden varieties were disappointing under out-of-season treatment.

9. Clark "Seedling", from all results, was a poor pollenizer both with other varieties and species as well as its own blossoms. Also, the Clark plants gave a lower set of berries than other plants, the pollen being the same.

10. The pistils on some berries were observed to remain receptive for 23 days and set perfectly when pollinated, after that length of time.

11. The removal of the sepals did not affect the development of the berries.

12. Insects or other agents are necessary to the production of a "crop" of good commercial berries.

13. Such insects as plant lice are a factor in pollination but are possibly more detrimental, because of their parasitic habits, than beneficial.

14. Magoon x Magoon plants appear much weaker than the crosses even though the Magoon pollen is very virile both for close and cross pollination and the parent plants are very vigorous.

15. There is an apparent relation between the value of a variety as a pollenizer and the vigor of its plants.

I hereby state my acknowledgement and very grateful appreciation of the assistance of Professor C. I. Lewis in planning the work, Professor V. R. Gardner in botanical translations and descriptions, Professor E. J. Kraus in advise, suggestions and generous loans of apparatus and Mr. J. A. Gilkey in the greenhouse work.

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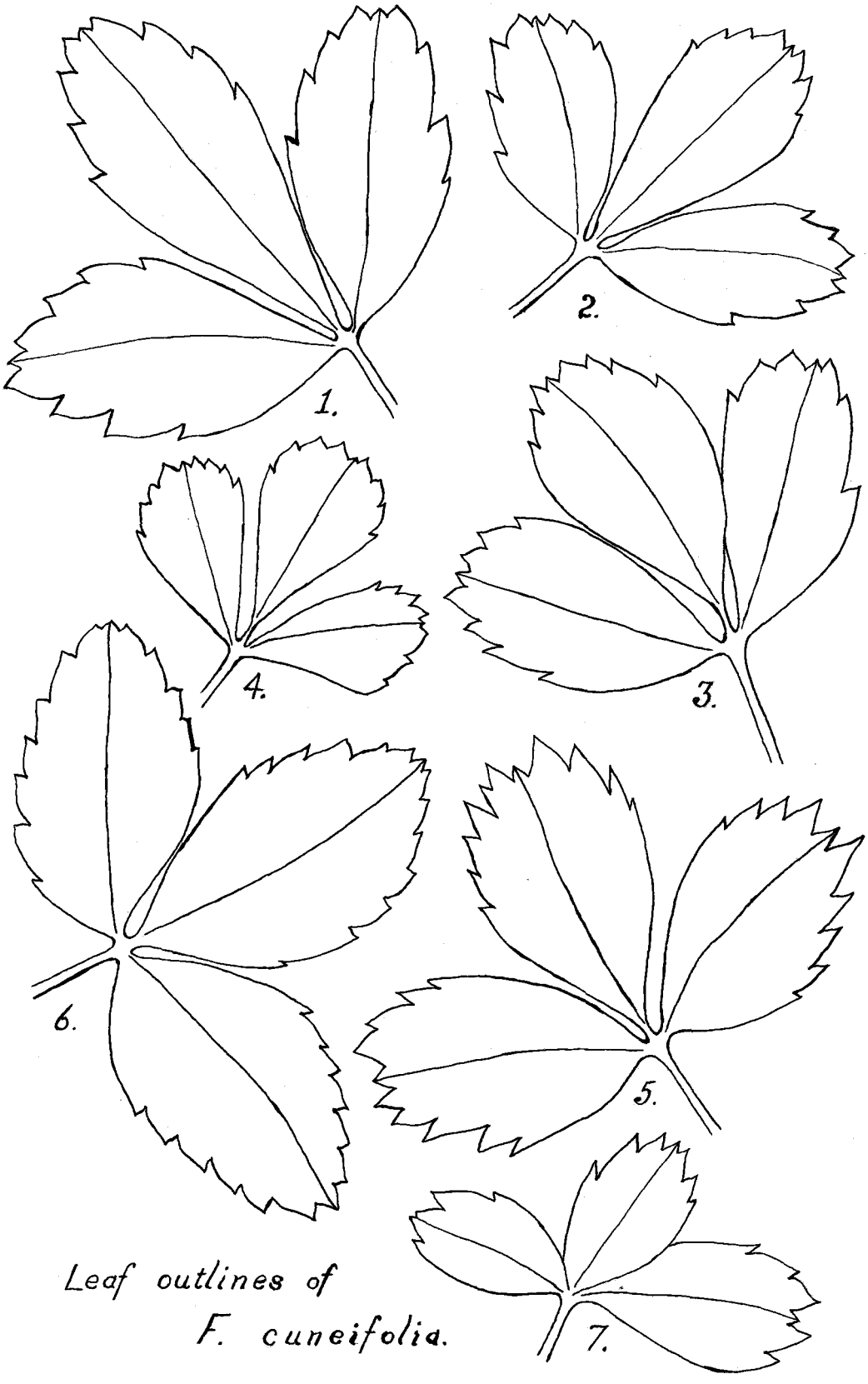
P L A T E I.

Fig. 1. Behavior of F. cuneifolia under cultivation; F. vesca var. alba in background.

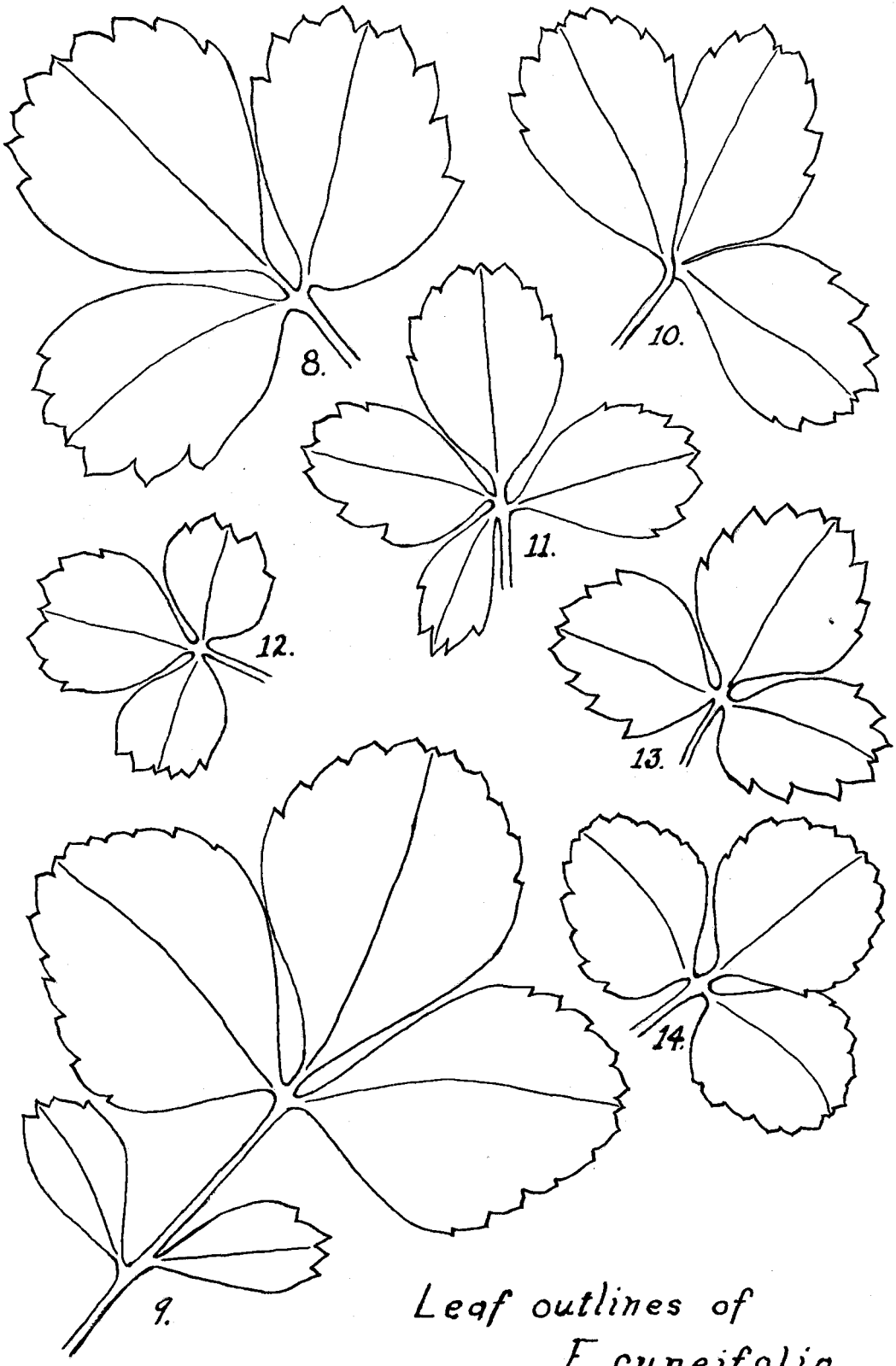
Fig. 2. F. cuneifolia plants from woods (at left) and prairie (at right) after growing in the greenhouse.

Plate II A.



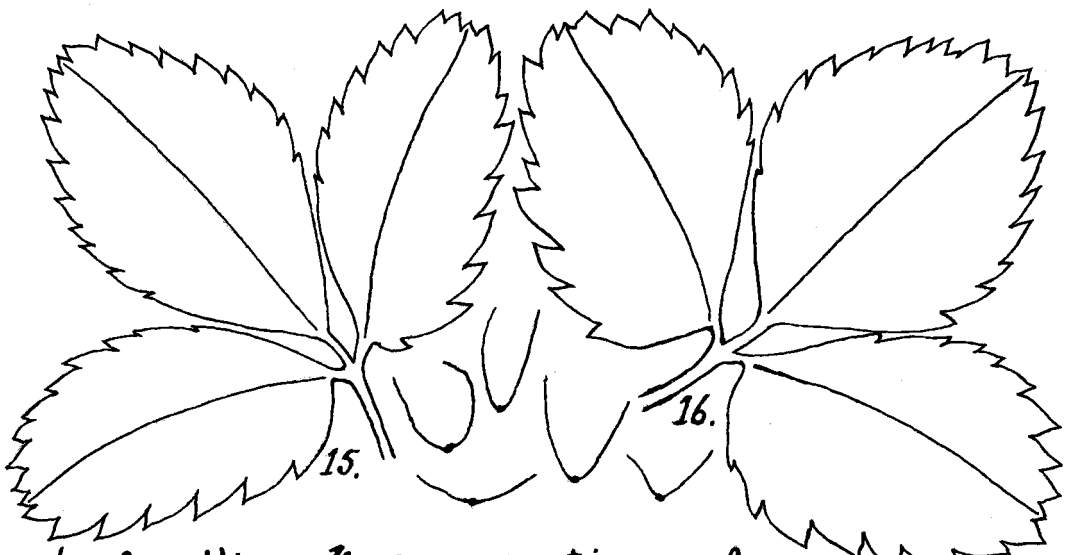
Leaf outlines of
F. cuneifolia.

Plate IIB.

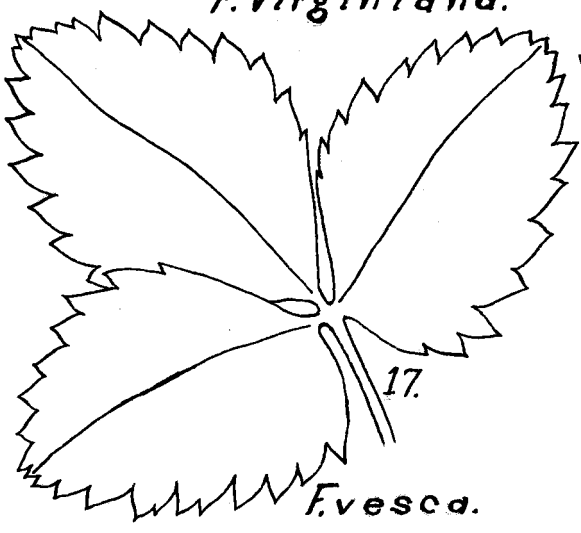


Leaf outlines of
F. cuneifolia.

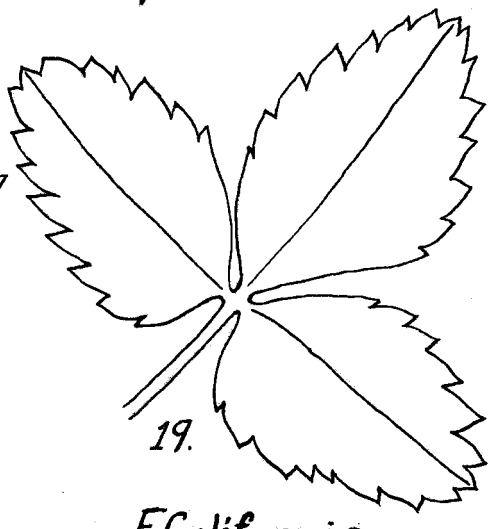
Plate II C.



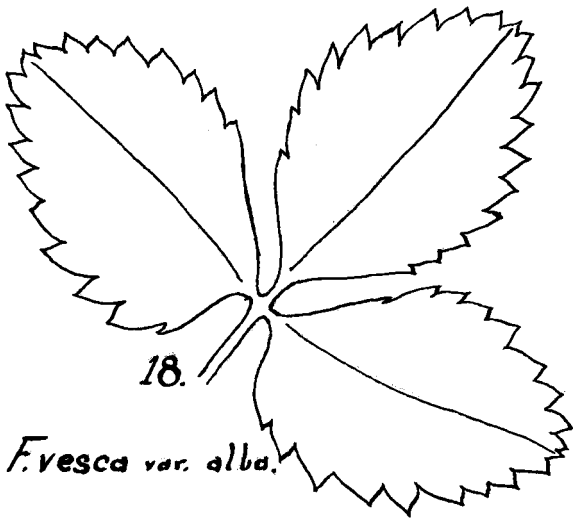
Leaf outlines ½ cross-sections of
F. Virginiana.



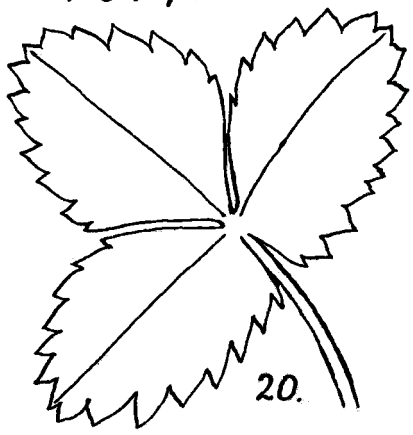
F. vesca.



F. Californica.



F. vesca var. alba.

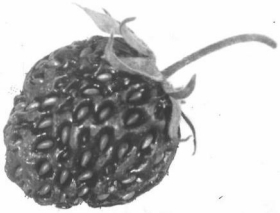


F. Californica.

P L A T E III.

Fig. 1. F. Virginiana Berry, x $1\frac{1}{2}$.

Fig. 2. F. Virginiana. Cold frame plant, left, and after having fruited in the greenhouse, right.



P L A T E IV.

Fig. 1. F. vesca; plants transplanted from wild.

Fig. 2. Left, F. Virginiana crown; center and right, old and young F. vesca crowns.

P L A T E V.

Fig. 1. F. vesca berries, showing fair development with very few seeds.

Fig. 2. F. vesca and F. Virginiana.

P L A T E VI.

Fig. 1. F. vesca, F. cuneifolia, and hybrids. Two plants marked "X" show marked cuneifolia characters; others, vescan characters.

Fig. 2. F. Californica (Portland).

P L A T E VII.

Fig. 1. F. Californica (Portland), "B", and F. cuneifolia.

Fig. 2. F. vesca and F. cuneifolia.

P L A T E VIII.

Fig. 1. Paper bags on flower clusters.

Fig. 2. Cloth bags on fruit clusters.

Fig. 3. Cloth cages over vines.

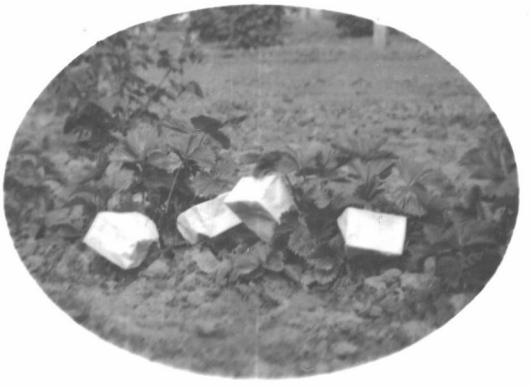
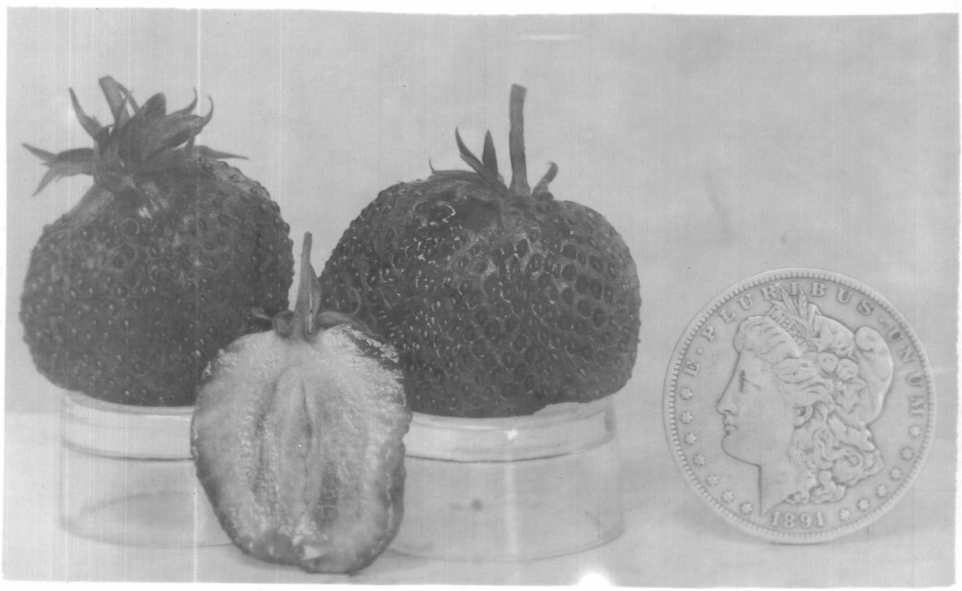


PLATE IX. ARIZONA EVERBEARING.


E PLURIBUS UNUM
1891

P L A T E X.

Fig. 1. Clark "Seedling".

Fig. 2. At left, self pollinated and, at right, cross pollinated Clark berries.


E PLURIBUS UNUM
LIBERTY
1890

P L A T E XI.

Fig. 1, Glen Mary, x 11/12.

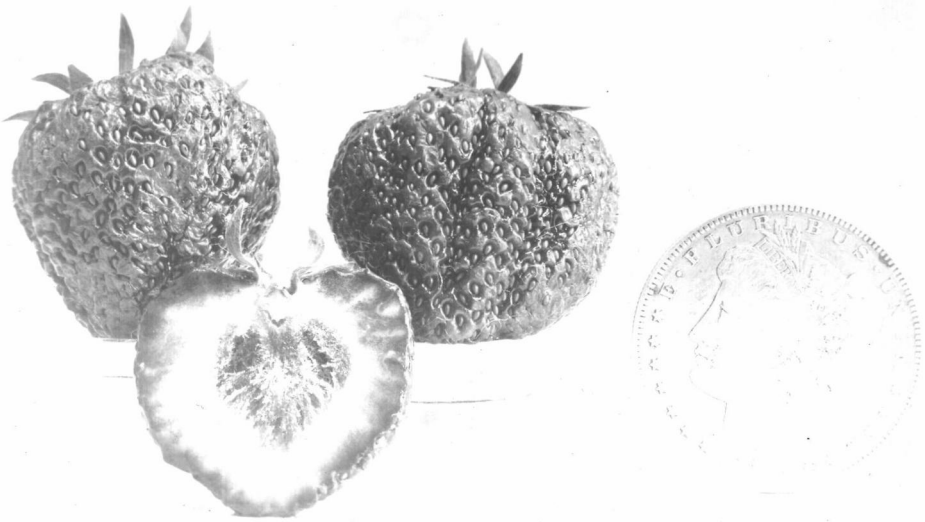
Fig. 2, Magoon.

P L A T E XII.

Fig. 1. Marshall, x 5/6.

Fig. 2. Sixteen-to-One.


E PLURIBUS UNUM
LIBERTY



P L A T E XIII.

Fig. 1. Clark clusters.

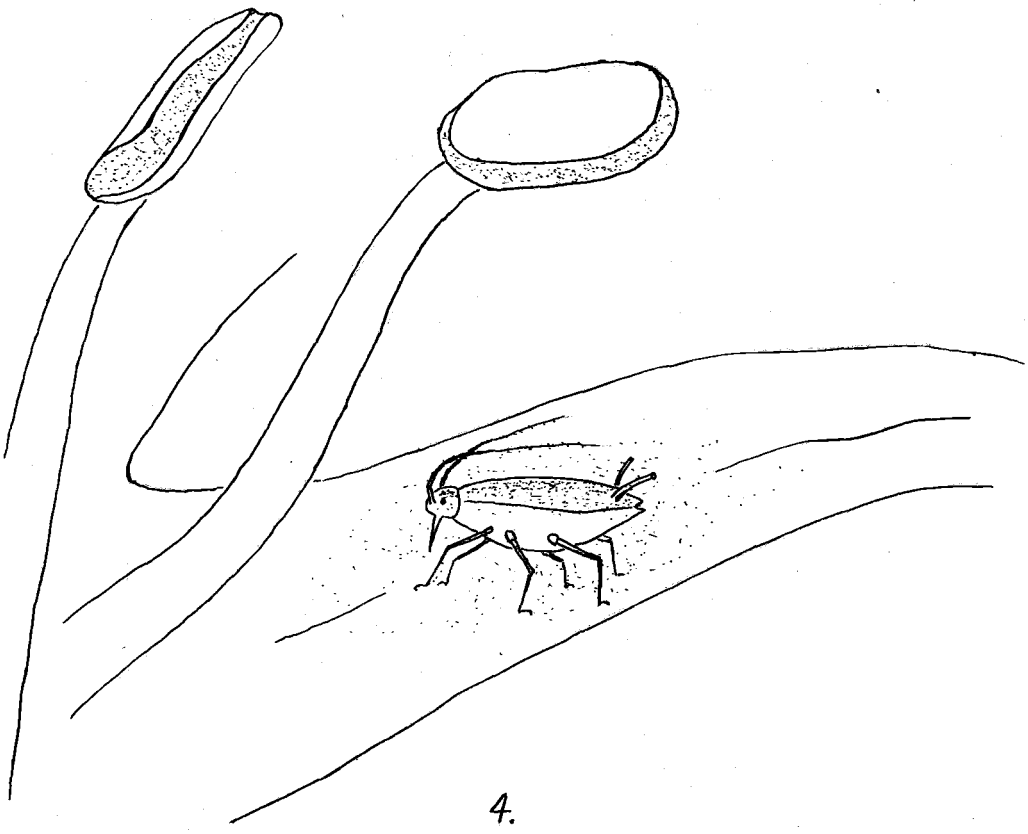
Fig. 2. Autumn Belle clusters.

P L A T E XIV.

Fig. 1. Sixteen-to-One clusters.

Fig. 2. Magoon clusters.

Plate XV.



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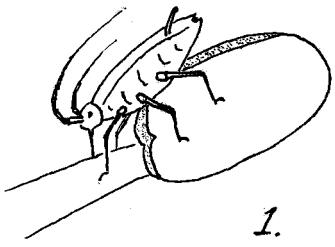

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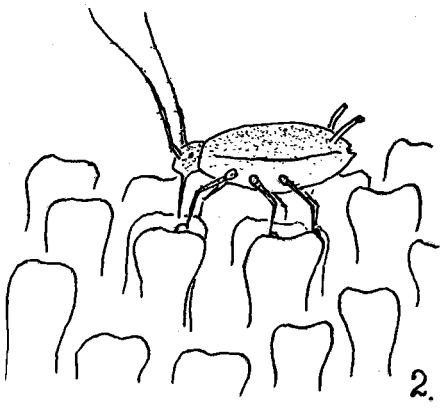

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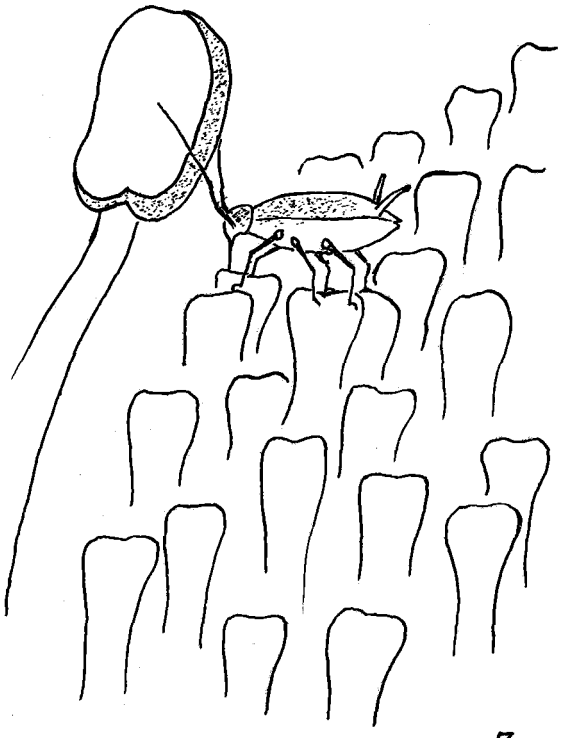

3.