Dual Cycle of Avocado Flowers

study of the continuous dual opening cycle of the avocado flower shows need of large flying insects for pollination

Peter A. Peterson

The dual opening cycle of the avocado flower directly influences effective pollination and fruit setting—necessary steps—in developing useful hybrids by plant breeding.

To plan and execute particular variety crosses properly, it is highly important to understand the flower cycle because pollen and receptive stigmas of the desirable parents are not always readily and simultaneously available.

The avocado flower normally opens first in the female stage—Stage I—and then closes and reopens in the male stage —Stage II—in a continuous cycle that occurs over a period of two days.

A time-lapse motion picture of an avocado—Zutano—flower opening made it possible to study the process and to compute accurately the exact time required for each movement in the cycle. Filming was initiated prior to the first opening—Stage I—with a picture taken every 30 seconds until the filming was terminated after pollen was shed in Stage II, a total period of 22 hours.

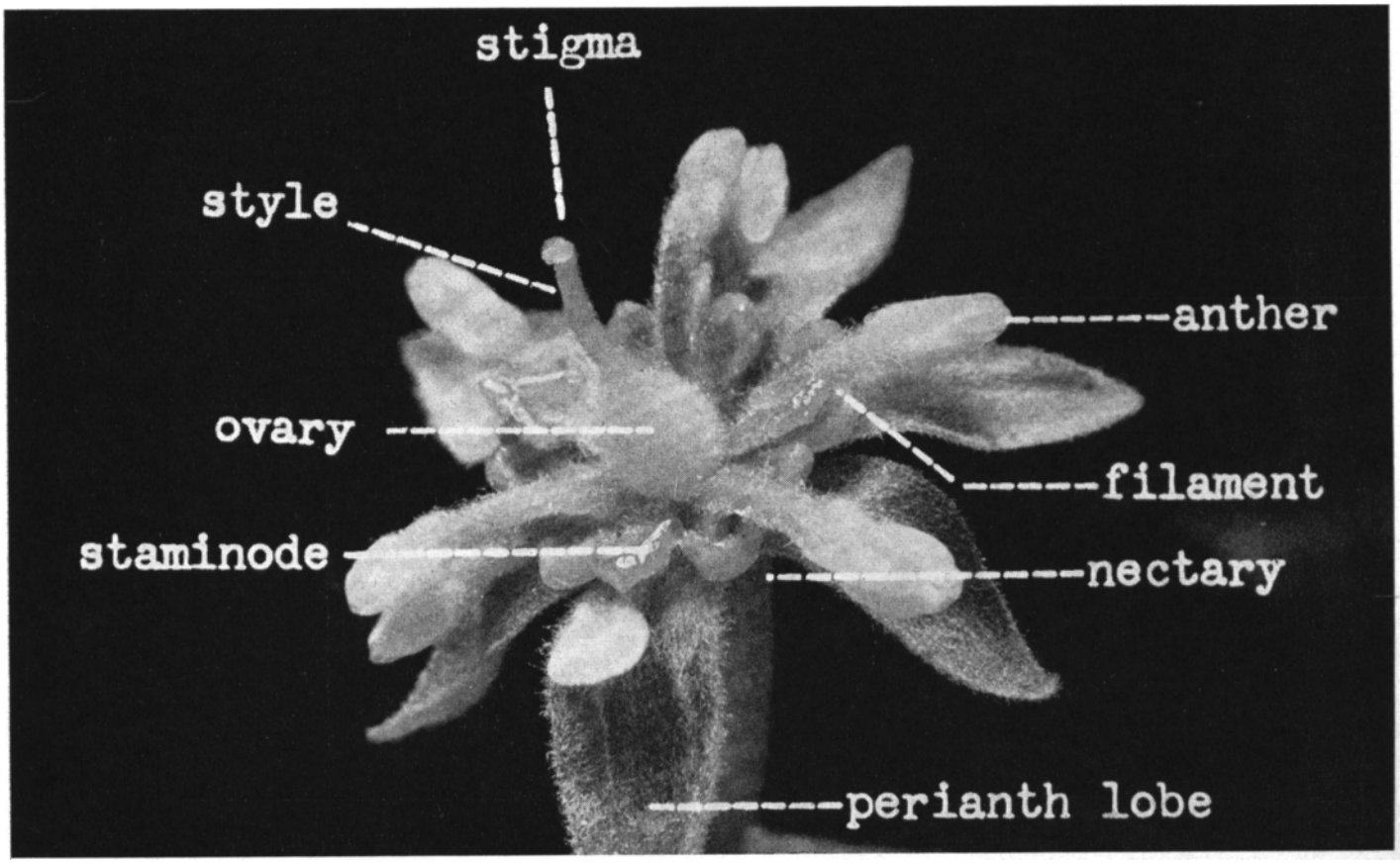
In Stage I the flower changed from a closed to an open position, with the receptive stigma exposed, in a period of five minutes. Under glasshouse conditions, the flower remained open for three hours and 40 minutes, the maximum time interval in which effective pollination may occur. Following the initial opening, the perianth parts closed tightly.

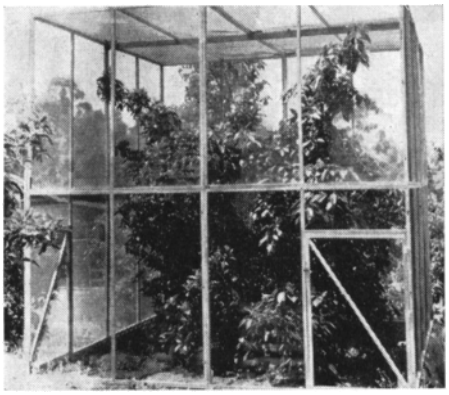
The opening of the flower in Stage II started before sunrise and required more than two hours. During this period no pollen was shed. At 8:40 a.m., the first spoon-shaped valves of the anthers began to open, exposing the pollen. The four valves of an individual anther do not open at the same time. Individual valves opened rapidly—in from 30 seconds to 9½ minutes—to expose their pollen, although most valves opened in two to three minutes. All the valves were fully open after a period of 69 minutes, and pollen remained available on the valves until the flower closed.

In the dual opening cycle of the avocado flower, Stage I is distinguished by the prominent, erect pistil, with the receptive, fresh-appearing stigma at the tip of the style. All the stamens are reflexed outward against the perianth lobes at a 90-degree angle to the pistil. Stage II differs from Stage I in that the stigma has become brown and withered, the three stamens of the outer whorl are at a 45-degree angle to the pistil. In this stage the trapdoor-like valves of the anthers lift, exposing sticky clumps of pollen.

With respect to this dual behavior, avocado varieties fit into two general patterns, type A—such as Rincon, Decem, MacArthur, Emerald, Hass, and Anaheim—and type B—such as Bacon, Zutano, Fuerte, Irving, and Ryan—with each pattern represented by approximately half the varieties. Under glass-

Stage I of avocado flower in dual opening. Stigma is receptive to pollination.





Typical caged tree used in bee experiments. A hive was placed in one corner. In the control, no bees were included within the cage.

house conditions Stage I in the type A varieties occurs in the morning and Stage II occurs in the afternoon of the following day. In type B varieties, Stage I occurs in the afternoon of the first day and Stage II in the morning of the following day. In Stage I the individual flower is always in the pistillate phase, whether the opening occurs in the morning or in the afternoon.

A comparable time-lapse motion picture of a flower of a type A variety is not available for detailed study, but observations were made at 30-minute intervals on a flower of the Rincon—type A—variety in the glasshouse.

Flowering Behavior of Rincon Variety of Avocado

Stage I. January 5, 1955	
Opening	7:25 a.m. to 8:10 a.m.
Open	8:10 a.m. to 11:00 a.m.
Closing	11:00 a.m. to 1:10 p.m.
(Effectively open for five hours and 45 minutes)	
Stage II. January 6, 1955	
Opening	11:00 a.m. to 12:00 noon
Open (no pollen)	12:00 noon to 1:20 p.m.
Pollen shed	1:20 p.m. to 10:00 p.m. and beyond

When the flowers of the Rincon—type A— variety are receptive to pollination, pollen is being shed by flowers of the Zutano—type B—variety; and when flowers of the Rincon are shedding pollen, flowers of the Zutano are receptive to pollination.

The receptive stage of flowers of the Zutano tree under glasshouse conditions appeared just before 3:00 p.m. and continued for more than three hours. It is during this period that pollination must occur, although no pollen was shed by any flowers on this tree for more than two hours prior to this Stage I opening. Under such conditions, it is impossible for close pollination—the transfer of pollen from the stamens of one flower to the stigma of another flower of the same tree—to occur, since the tree is female at one time and male at another. When the flowers operate under such a strict schedule, and it is the same throughout the whole tree, pollination is apparently effected by the transfer of pollen from complementary varieties that shed pollen during the period when the flowers of the Zutano tree are in Stage I.

Interplanting of type A and type B varieties to insure fruit set has been suggested. However, in cool, cloudy weather there is some degree of overlap in the stages of flowers on the same tree, so some close pollination can occur.

Avocado flower behavior has been reported as commonly erratic in the coastal regions, with considerable overlapping of stages, but in the interior regions of California such erratic behavior occurs only in bad weather. During periods of unfavorable weather or temperature conditions, Stage I flower opening fails to appear. In spite of the apparent necessity of interplanting reciprocal varieties—as indicated by the flower studies—flower behavior depends primarily upon weather conditions which influence the dual-opening cycle of the avocado flower.

Pollination studies with honeybees led to the conclusion that large flying insects are necessary for pollination of avocados.

In the spring of 1954, two different plots were established—one in San Luis Rey Heights with the Hass variety, representing type A, and the other at River-

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Stage II of avocado flower in dual opening. The pollen is exposed. Three of the nine stamens are closely adjacent to pistil and six at 45° angle, each anther having four pollen-laden valves.

Soil in 1-A and 1-B was taken from an area near Bangor, after a regular brush burn. Soil in cans 2-A and 2-B was taken nearby but where no heat was involved. The cans were seeded on January 12, 1954 and photographed on April 22, 1954.

Soil in cans 3-A and 3-B was from an open area of Redding-type soil where brush was piled and burned. Soil in 4-A and 4-B was from a nearby, unburned area.

that brush and pine seedlings react similarly to other vegetative growth and are stimulated by fire-heated soil. Generally speaking, the seeded perennials did not spread to adjoining territory in subsequent years. However, there were limited exceptions.

To verify observations made on the range, a series of tests was made with annual ryegrass seeded—January 12, 1954—in heated and unheated soil samples. The resulting seedling growth was photographed on April 22, 1954. The procedure was the same in each test.

In one test, Aiken soil was taken from an area near Bangor—after a regular burn—and the white ash was removed. As a check, soil was taken also from a nearby area that had not burned, so no heated soil was involved. Both samples of soil were placed in No. 10 cans and seeded. The soil was kept moist. Comparative growth of the seedlings is shown in the illustration at the upper left.

A second test was made with Redding-type soil taken from a site where brush had been collected, piled, and burned. The intense heat from the burning piled brush produced white ash, indicating the ground temperature had been raised. The soil for the check cans was taken from an adjacent spot where brush was not burned. The picture at the right shows the vegetative growth obtained in this test.

The third test was made with soil of the Aiken series. One soil sample was taken from an open area near a brush patch. The other sample was taken from under heavy brush. Neither sample had been heated by fire. Growth of the ryegrass in this test is shown in the picture on page 12.

From range observations and the results of the verifying tests it appears that a seeding rate or mixture can not be determined until after a fire—it's impossible to tell in advance how successful a brush burn will be—and furthermore, growth stimulation by the heated soil depreciates about 50% the second year and is practically gone the third year after the fire.

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side with the Zutano variety, representing type B.

The plots contained two trees of approximately the same age and vigor. Each tree was caged individually, and if any advantage existed among the trees, that tree was chosen as the one to be caged without bees. All cages were 12′ × 12′ × 16′ except tree No. 2 in the Hass plot which was only 12′ high. The cages were constructed of regular window screening with a Lumite cloth top, except for tree No. 1 of the Hass plot which had a cheesecloth covering on top. Prior to completing the enclosure of the trees, all fruits and open flowers were removed and only enclosed buds remained.

The trees in the Hass plot were caged on March 1, and a hive was placed in the cage under tree No. 2 on March 3. Single story hives containing 10 frames were used. In the Hass plot, eight frames were full; in the Zutano plot, two were full. On June 14, at the end of the blooming season, the bees were removed and the cage dismantled.

In the Zutano plot, cages were erected on February 23 and 24, 1954. The trees started to bloom during the first week in March and a hive was placed in the cage under tree No. 2 on March 15. On May 20 the bees were removed, and the cages were dismantled on June 2 and 3.

After the removal of the cages, the fruit on each caged tree was counted. The Zutano without bees had four fruits; the Zutano caged with bees had 120 fruits. The beeless Hass tree had five fruits, as compared to the 284 fruits of the Hass caged with bees.

Because an individual flower—apparently—cannot pollinate itself and subsequently produce a fruit, it is important that the pollen arrives on the stigma at the proper time in the flower cycle. Therefore, some agent of pollen transfer must be necessary. However, close pollination is possible through the medium of bees when the two flower stages overlap, so that for brief periods of the day pollen and receptive stigmas are present on a tree at the same time. In addition, residual pollen might be carried by the bees and remain viable for effective pollination even if no overlap of stages occurs.

Although there is a need for some form of insect visitation for pollination and subsequent setting of fruit, there is no evidence that the introduction of additional bees to the existing natural population of wild bees or other large flying insects can increase fruit set.

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Duration of Movements in the Dual Opening Cycle of a Flower of Zutano (Type-B) Avocado Variety, as Disclosed by Motion Picture Study under Glasshouse Conditions.

Procedure	No. of minutes	Approximate time	
Stage I—1:15 to 7:15 p.m., May 18, 1954			
Filming begun		1:15 p.m.	
Preopening—flower bud expanding	95½	1:15 to 2:50 p.m.	
Flower opening	5	2:50 to 2:55 p.m.	a*
Opening movements of flower parts continuing	85	2:55 to 4:20 p.m.	a*
No movement	65	4:20 to 5:25 p.m.	a*
Closing movements	65	5:25 to 6:30 p.m.	a*
Termination of stage I (flower closed)	42½	7:15 p.m.	
Stage II (same flower)—5:40 to 11:00 a.m., May 19, 1954			
Filming begun		5:40 a.m.	
Preopening—flower bud expanding	41	5:40 to 6:21 a.m.	
Flower opening	85	6:21 to 7:46 a.m.	
Flower fully open, but pollen valves still closed	52½	7:46 to 8:40 a.m.	
Pollen exposed—various valves open	69	8:40 to 9:49 a.m.	
Flower open, all valves open, filming stopped		11:00 a.m.	

a* Maximum period of pistil receptivity for fertilization—220 minutes (3 hours and 40 minutes).