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FRUIT SPOILAGE DISEASES OF FIGS

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TABLE OF CONTENTS

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RALPH E. SMITH[1] AND H. N. HANSEN[2]

INTRODUCTION

The fig was one of the first of the typical semitropical fruits of the Mediterranean region to be introduced into California. For tree growth and fruit production it found itself perfectly at home in an entirely congenial habitat. So long as the fruit was used for local or home consumption, and particularly while the comparatively disease-free Black Mission[3] variety predominated, the fig was considered almost immune to pests and diseases.

When plantings of the Adriatic and Calimyrna varieties began to assume considerable proportions and the problem of pollinating the latter variety had been solved by the introduction and establishment of the blastophaga insect, the earlier writers were most enthusiastic over the prospects of fig culture in California (Howard, 1901; Roeding, 1903; Shinn, 1915).[4] Some of them anticipated the time when California would furnish not only the entire fig supply of the United States but even extend into the markets of the world at large, on account of the superior quality and condition of her product. Gradually, however, with the more extended planting of the white fig varieties, the situation described in the following paragraphs came into existence, and the production has scarcely been maintained at even the figures quoted.

The situation in figs has been described as follows (Phillips, Smith, and Smith, 1925, p. 4):

> The fig deserves to be one of California's best commercial fruits. It shares with the olive and grape the distinction of being one of the oldest cultivated fruits. It is nutritious, appetizing, of attractive appearance, and wholesome. The fruit has a great variety of uses, not only in the usual dried form, but also for eating fresh and in such manufactured forms as jam, marmalades, preserves, canning, candy, bakery products, breakfast and health foods, beverages, and medicinal preparations. The well-known salutary properties of dried figs lend themselves particularly well to advertising. The fig is one of the healthiest

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[3] The Mission is a black, and the Adriatic a white-skinned fig, planted extensively in California. The Calimyrna is the 'Lob Injir' variety of Smyrna, which requires pollination (caprification), not necessary with the other varieties mentioned.

[4] See "Literature Cited," at the end of the bulletin, for complete data on citations, which are referred to in the text by author and date of publication.

of fruit trees, easily suited as to soil and moisture, and well adapted to a wide area in California and (for dried figs) to no other portion of the United States. The quality of California-grown figs at their best is admittedly unsurpassed.

And yet, it must be said that fig culture is not so well established in California as that of many other fruits, and considerable difficulty is experienced in disposing of the comparatively small dried-fig crop of the state at even moderate prices. California produces less than 10,000 tons of dried figs per annum (9,000 tons in 1923), as compared with 25,000 tons of walnuts, 100,000 tons of prunes, and 250,000 tons of raisins. Even though foreign competition is keen, exchange rates low, and fig production in the Mediterranean countries very large, it seems remarkable that this small tonnage of California-grown figs cannot readily be marketed at good prices.

The greatest obstacle to the success of the fig industry at the present time is the occurrence of various forms of rotting, souring, and molding of the fruit, which at times becomes very abundant and troublesome. Such defects reduce yields and make it very difficult to put up a high-grade, dependable pack, of sufficient quality to compete on better than even terms with the foreign product, and one upon which the arts of advertising and salesmanship can confidently be practiced. It is only by such advertising, backed by superior, uniform quality, that our increased production of other foreign-competing fruit products has been successfully marketed.

The excessive amount of spoilage which occurs in figs has been the subject of investigation by the Experiment Station for several years. This trouble was regarded at first as a normal, or at least an unavoidable consequence of climatic influences, but more and more evidence has been obtained to suggest that it may be due primarily to specific infections, dependent like other plant diseases upon the presence of certain pathogenic organisms, the proper agents of transmission, and favorable environmental conditions. Any real knowledge and positive control of fig spoilage must therefore depend primarily upon a thorough, fundamental understanding of these three factors. The present publication is intended to bring together rather fully the available evidence upon the subject, which is at present in a very scattered condition, and also to present certain new information which is published here for the first time. Material has been freely drawn from California Agricultural Experiment Station Bulletins 319 and 387, Circular 311, and Hilgardia, Volume 2, No. 7.

NATURE OF THE FIG

The fig is a nearly closed, more or less hollow receptacle, the inner walls of which are lined by very small flowers when immature and by the seed-like fruits when ripe. It is not, therefore, a fruit in the strict botanical sense of the word, but an aggregration of fruits lining the cavity of a hollow receptacle, technically a synconium, with an opening at the center of the flattened end which is closed during the early stages by overlapping scales or bracts (fig. 1). After the fig begins to ripen and soften these scales loosen and an opening is formed, the diameter of which varies from 2 to 10 millimeters, according to the variety of fig. This opening is usually referred to as the 'eye' of the fig. Figure 2 shows successive stages of the opening of the eye in the Adriatic and Kadota[5] varieties.

Fig. 1.—Interior of nearly mature Calimyrna fig, twice enlarged, at the stage when ripening begins and pulp is about to soften and liquefy. It is at this stage that decay and souring begin. The whole problem of control of fig spoilage depends upon knowing what organisms cause this, when and how they get into the fig, and how they may be kept out or their development prevented.

As the edible fig ripens, the outer wall becomes thickened, fleshy, and sweet, and the pedicels and calyces of the individual florets become enlarged and pulpy. Quite suddenly at full maturity the flesh of each floret becomes almost liquid and very sweet. The whole inside of the fig then breaks down, coalesces, and dries into a pulpy, sirupy, and finally a homogeneous, gelatinous mass, in which the seeds are embedded. Figure 1 shows a longitudinal section of a nearly ripe Calimyrna fig with the eye at the end, the enlarged fleshy florets each with one seed, and the outer wall.

[5] The Kadota is a white fig planted extensively in California for preserving. It is the Italian variety 'Dotatto,' of which word the name is a corruption.

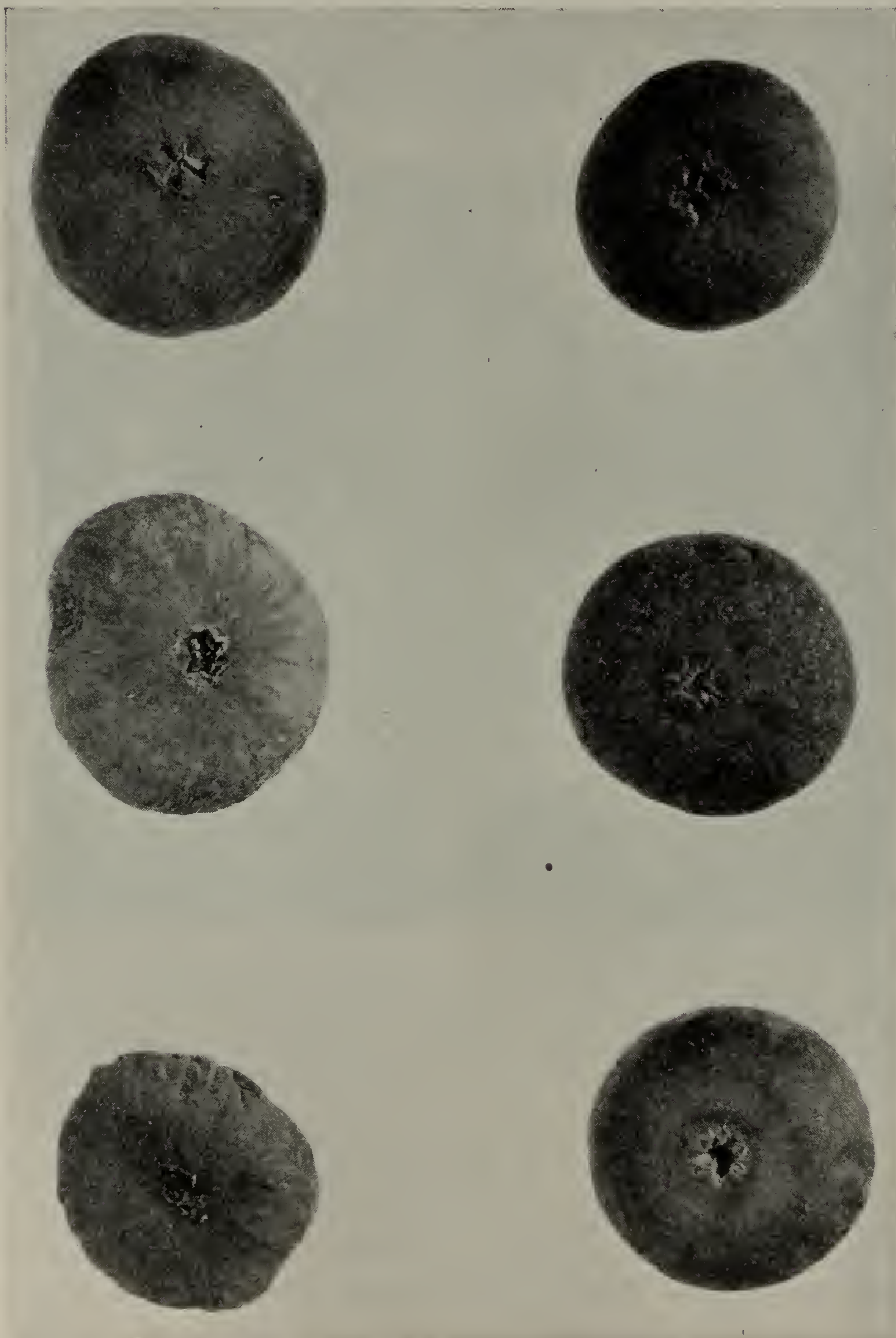

Fig. 2.—Successive stages in the opening of the eye of the fig, from top to bottom. Left, Adriatic variety; right, Kadota variety.

The saccharine pulp enclosed in the soft, outer wall forms an ideal medium for saprophytic microorganisms and insects, and the fig, more than almost any other fruit, seems unprotected from such attacks. That it does under favorable conditions escape is due mainly to two circumstances: First, so long as the outer wall is intact the only ingress to the interior pulp is through the apical opening or eye, which does not open until the fig is nearly ripe. This helps to exclude insects and even microorganisms until the susceptible period is nearly past. Second, in the rainless summer climates to which the fig is best adapted, a comparatively rapid evaporation of water and concentration of sugar begins at about the time when the eye opens and final ripening begins. Soon after this stage is reached the fruit normally falls from the tree. Normally, therefore, before the fig falls to the ground the pulp has become sufficiently low in moisture and high in sugar to prevent or arrest decomposition by spoilage organisms. The duration of the susceptible period, however, or inversely the rate of dehydration, practically governs the progress of such decomposition. This idea is well expressed by Coit (1921) in the quotation on page 21.

Table 1 shows the percentage of moisture and sugar in figs as they naturally ripen and dry.

TABLE 1

ANALYSIS OF ADRIATIC FIGS AT DIFFERENT STAGES OF MATURITY

Type	Per cent moisture	Per cent sugars
3	83.25	9.12
4	80.80	12.92
5	74.65	18.87
6	61.00	33.04
7	52.45	46.36
8	42.50	46.04
9	29.00	56.85
10	13.10	69.58

From: Phillips, E. H., E. H. Smith, and R. E. Smith. Fig smut. California Agr. Exp. Sta. Bul. **387**:19. 1925.

Figures 3, 4, and 5 show the normal maturing, breaking down, and drying in Adriatic figs. The stages of development shown in these figures represent a series chosen by Phillips, Smith, and Smith (1925) to form a basis for reference, and this series has been commonly used as a standard in later work. These types are described as follows:

1. Fruit not quite full grown, still green and hard.
2. Full grown, eye scales beginning to loosen.
3. Eye fairly well opened, fruit still green and firm.
4. Slightly yielding to pressure, pulp succulent, but still firm.

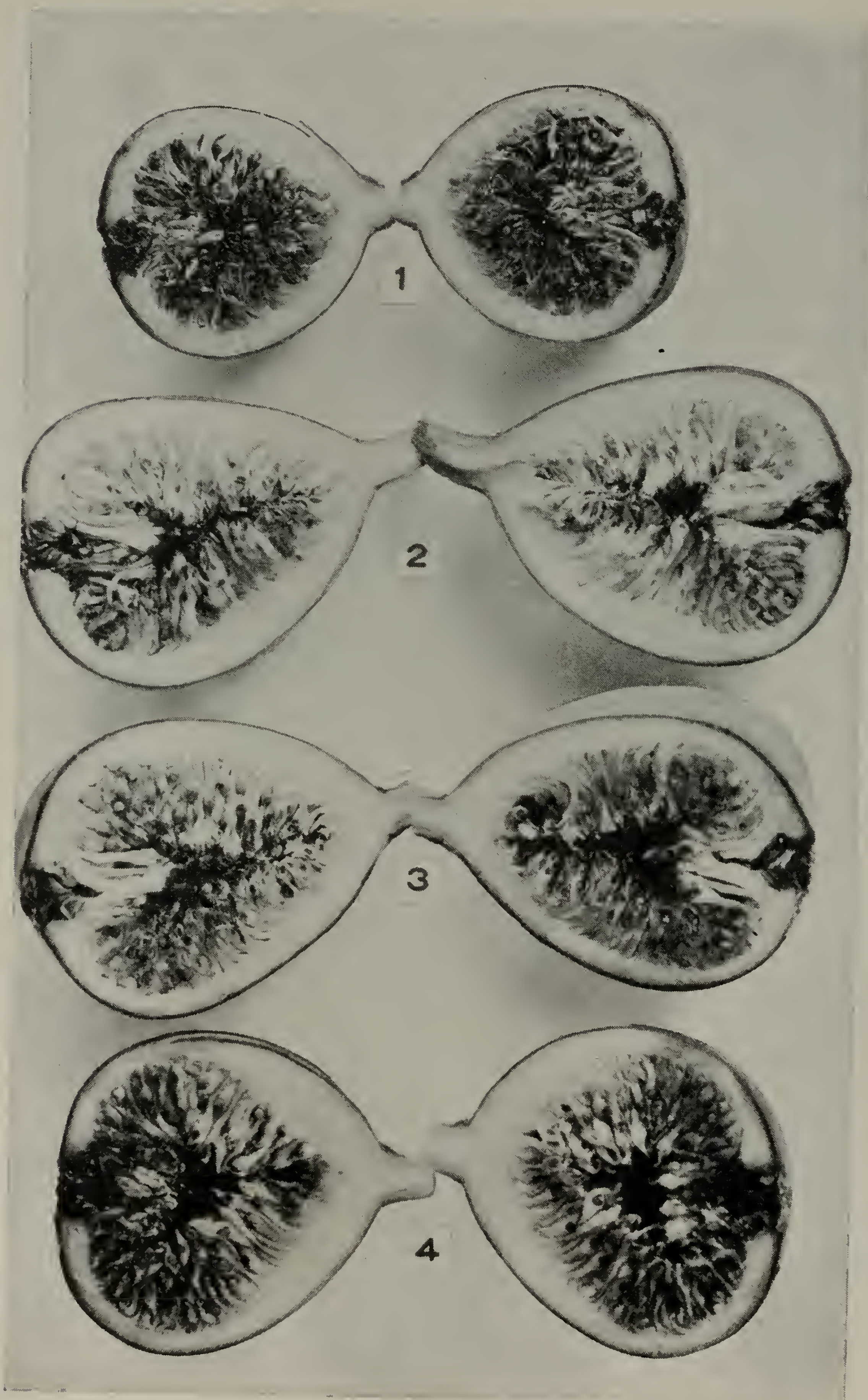

Fig. 3.—Stages of maturity in Adriatic figs, types 1–4.
(From Bulletin 387.)

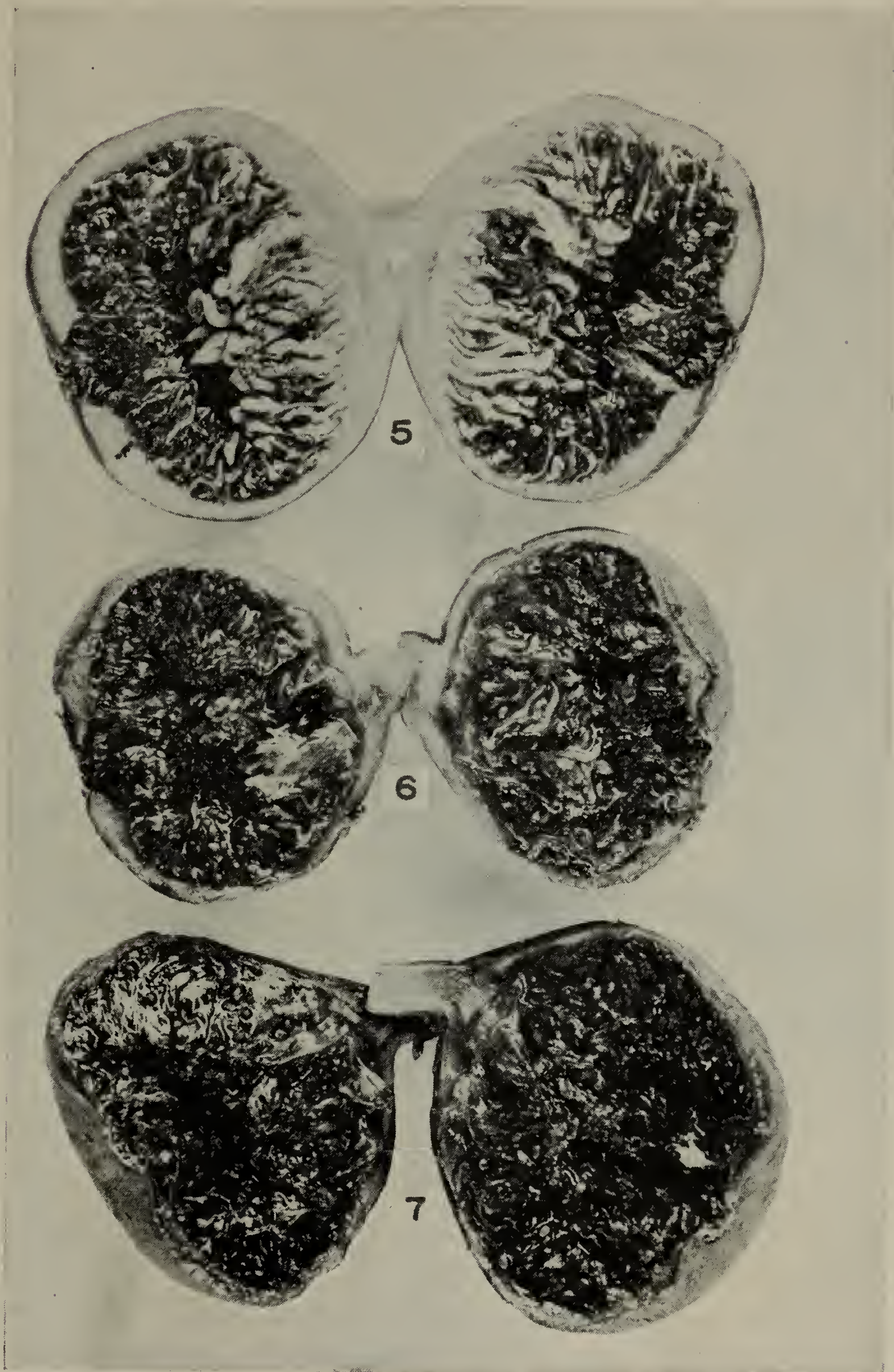

Fig. 4.—Stages of maturity in Adriatic figs, types 5–7.
(From Bulletin 387.)

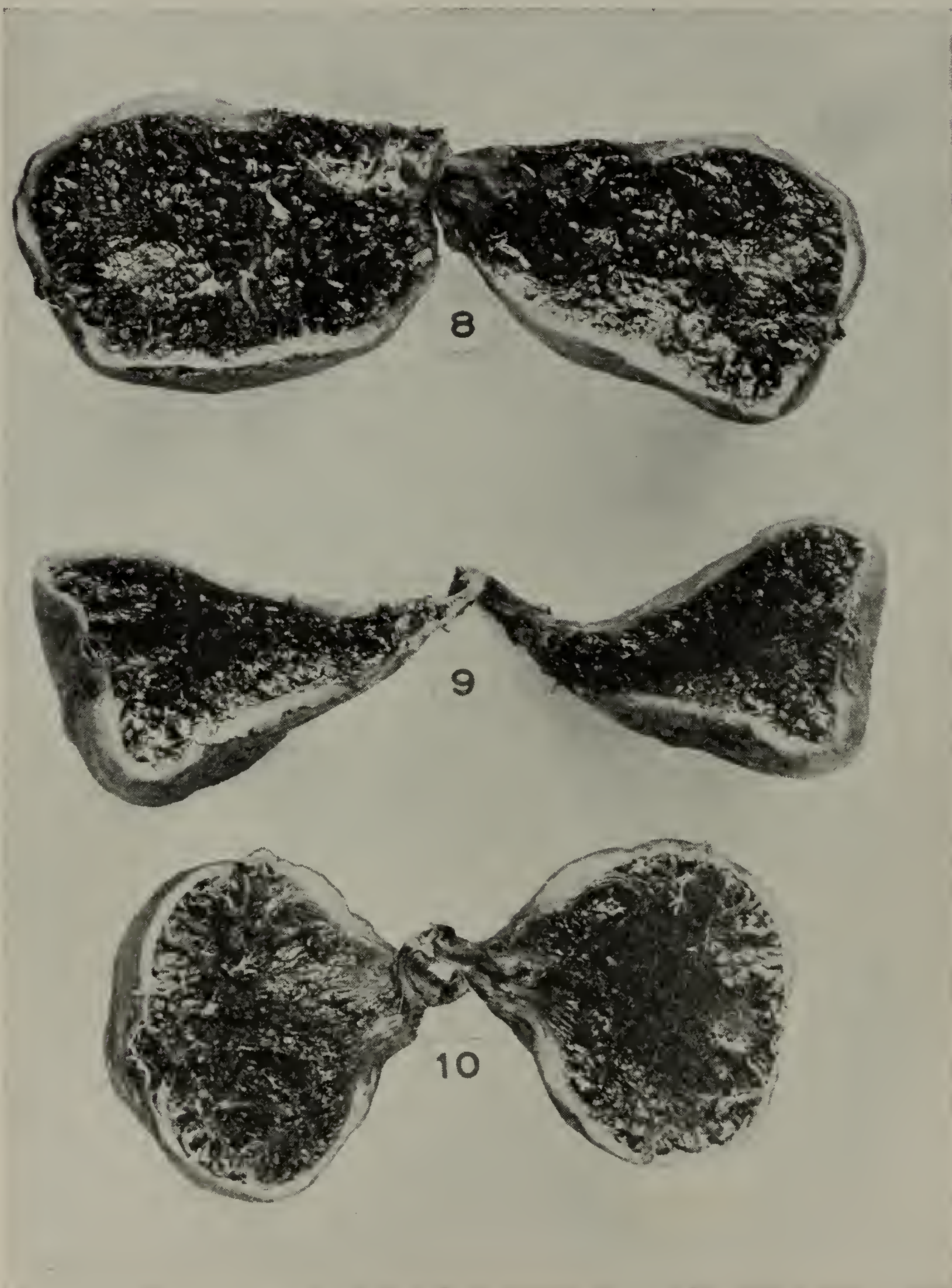

Fig. 5.—Stages of maturity in Adriatic figs, types 8–10.
(From Bulletin 387.)

5. Fig ripe as for picking for fresh shipment. No shriveling, pulp opaque.
6. Skin slightly shriveled, pulp somewhat translucent.
7. Distinct shriveling, contents still red, not sticky.
8. Much shriveled and skin beginning to discolor. Pulp mahogany color, slightly sticky.
9. Skin brown, but flexible, pulp brown, translucent, sticky. Stage of completed normal drying.
10. Overdry, stiff, and hard. Flowers stand out separately in pulp.

Fig. 6.—A Milco caprifig tree, showing the mamme crop which must be removed and destroyed or treated in order to eradicate endosepsis. (From Bulletin 319.)

The fig is a diecious, insect-pollinated plant, the staminate flowers and the edible fruit being borne on different trees. The male tree (figs. 6, 7) is known as the caprifig. In its receptacles (fig. 8) are borne chiefly two types of flowers. The staminate flowers which produce the pollen are arranged, in most varieties, just inside the eye, and the gall flowers (modified female flowers) occupy the rest of the cavity. The gall flowers have a very short style (fig. 9), particularly suited to the needs of the pollinating insect, as will be explained later. The caprifig bears a succession of fruit (fig. 10)

Fig. 7.—Gathering the profichi crop for caprifying the edible, Calimyrna figs. (From Bulletin 319.)

known as the 'mamme' or overwintering crop, the 'profichi' or spring crop, which is the important one in relation to the edible figs, and the 'mammoni' or fall crop. This succession of crops provides the proper habitat for the insects throughout the year. The caprifigs are not edible. They are usually rather small and nonsucculent, the size varying with the variety.

The female tree also bears a succession of crops, one produced in the spring on the wood of last year's growth and a second in the summer on the new growth. Both crops are edible, but in most cases

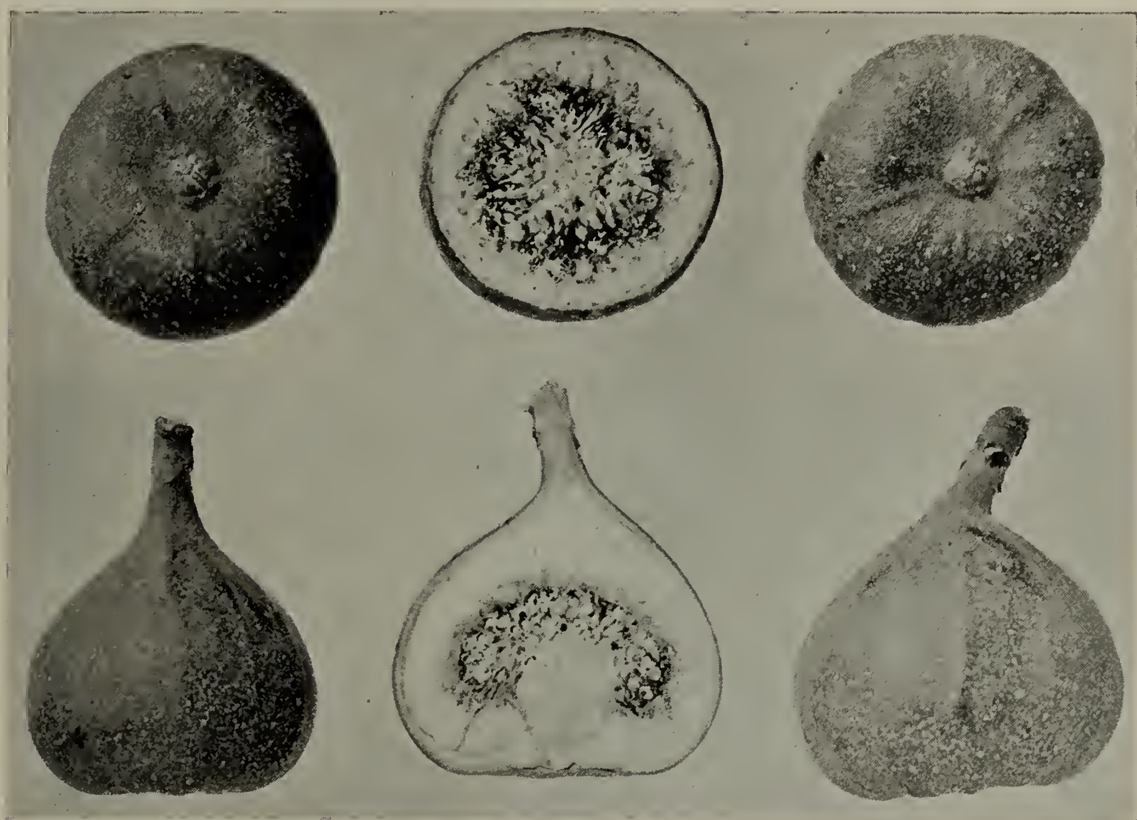

Fig. 8.—Caprifigs (profichi) showing in upper center the staminate, pollen-bearing flowers, with the blastophaga galls in the interior of the fig below. (From Bulletin 319.)

the second is the one of principal commercial importance. The receptacle of the edible fig is lined with a single kind of flowers, the pistillate, which resembles the gall flowers of the caprifig except that the style is much longer (fig. 9).

The edible fig varieties are of two types, the parthenocarpic, or varieties which develop fruit without pollination, and the varieties that require pollination (caprification). The important varieties of the first category, grown in California, are the White Adriatic, the Black Mission, and the Kadota (Dottato), while the varieties which require pollination are chiefly those called Calimyrna, Stanford, and

San Pedro (second crop). The Calimyrna and Stanford were introduced into California from Asia Minor, the former being the commercially famous 'Lob Injir' of Smyrna.

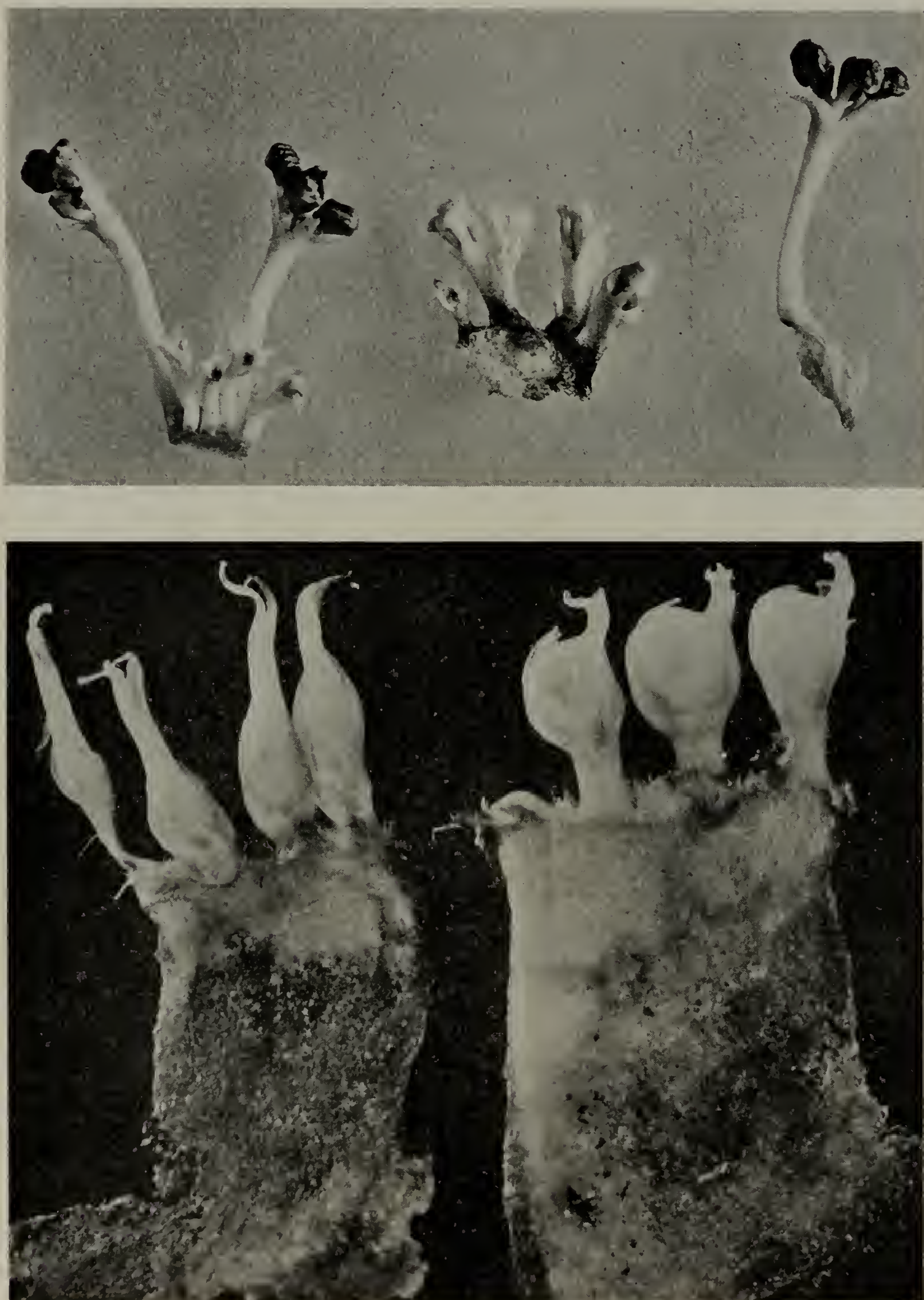

Fig. 9.—Above, staminate flowers of caprifig (× 10). Below, right, short-styled gall flowers of caprifig; left, long-styled flowers of edible fig (× 5). (From Bulletin 319.)

CAPRIFICATION

The process of pollinating the pistillate flowers of the fig is known as caprification. It is effected through the agency of a small hymenopterous insect, *Blastophaga psenes* L. (*B. grossorum* Grav.). Eisen (1901), Vallese (1904), Rixford (1918), Condit (1922), and Grandi (1920, 1923), have given extensive accounts of caprification and its agent. A brief account of the process is here given.

Fig. 10.—Caprifigs, showing blastophaga insects passing from mamme figs (below) to profichi (above). (From Bulletin 319.)

The male or caprifig, as already stated, has three crops of fruit during the year. The figs of the mamme crop, which may be taken as a starting point, are formed in the fall and remain on the trees over the winter. In early spring the new figs of the next crop appear on the woody twigs of the previous year's growth. These are the profichi. At this time the blastophaga insects are present in the galls or enlarged florets of the mamme figs, where they have passed the winter. With the first warm days of March or April (the exact time varying with locality and season) the profichi reach the receptive stage and the insects in the mamme figs begin to function. The adult males (fig. 12) issue first from their galls, fertilize the adult females while the latter are still in their galls (fig. 13), and open the way for them to emerge later (fig. 14). The males, as a rule, never leave the figs. The females (fig. 11) come out through the eye of the fig, fly to nearby profichi (fig. 10) (to which they are apparently attracted by the odor) and enter by forcing their way through the unopened eye of the young fig, often losing their wings in the process. The mamme figs ordinarily contain no pollen and pollination is not required to set the profichi.

In the gall flowers of the profichi the blastophaga inserts its ovipositor through the style and deposits an egg in the ovule. The egg hatches and the larva develops inside the gall, where it finally pupates. Meantime the fig has grown to full size. In early summer (June) the profichi and the blastophaga contained in them have become mature, and on the new growth of the caprifig trees another crop of figs, the mammoni, has appeared. Simultaneously there has developed on the edible fig trees an abundant crop of young figs. Another crop of female blastophaga issue from the profichi and enter the mammoni figs on the same tree and the female (edible) figs on any nearby trees, whether they are of the Smyrna type which require pollination or others which do not.

The profichi produce a large amount of pollen from stamens just inside the eye. As the female blastophaga leave the profichi they rub against the staminate flowers which surround the orifice and shed their pollen at that time. The insect may then carry the pollen into a fig of an edible variety or she may enter another caprifig, perhaps on the tree bearing the one from which she just emerged.

The majority of the insects travel but a short distance, although occasionally caprification occurs in figs which are several miles distant from the nearest caprifig tree. It is customary to interplant caprifig trees to some extent in Calimyrna orchards or in a block at one side. In order to obtain uniform caprification the profichi are usually gathered from the trees (fig. 7) and hung in small wire baskets in the edible fig trees. Extra mamme figs are sometimes used in the same manner in the caprifig trees to increase the setting of the profichi. In the male figs caprification is not necessarily a process of pollination but is primarily a setting of the fruit due to a stimulus derived from the parasitizing of the ovaries by the insects.

Fig. 11.—The female blastophaga (× 27). (From Bulletin 319.)

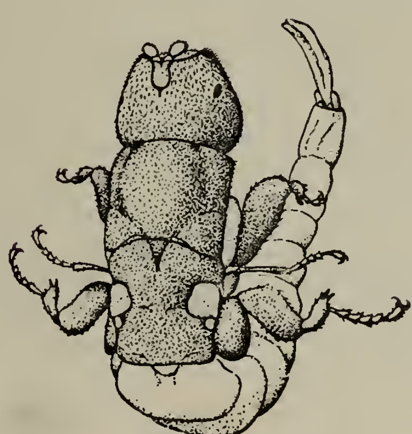

Fig. 12.—The male blastophaga (× 27). (From Bulletin 319.)

In the case of edible figs the female blastophaga (fig. 11) enters the young fruits for the purpose of oviposition and in so doing carries pollen from the caprifig. Oviposition, however, is not effected, because the styles of the female flowers are too long for the blastophaga to oviposit. The insect usually perishes in this vain attempt, but not without an effect, for the introduction of the pollen fertilizes the flowers and causes the fruit to mature fertile seed. Without such a stimulation the fruit of the Calimyrna, San Pedro, and Stanford varieties does not set but drops when about one-fourth grown; that of the parthenocarpic varieties continues growth to maturity, but the seeds are not fertile (phenospermic). If the fruit of such varieties (Mission, Adriatic, Kadota) should be accidentally caprified, as often happens in the vicinity of caprifigs, fertile seeds are produced and the character of the fruit is slightly changed and sometimes improved.

The mammoni and mamme figs contain little or no pollen and for the setting of the mamme crop by the mammoni, and the profichi by the mamme, no pollen is required. The mammoni figs sometimes contain a few fertile seeds, but the chief function of this crop is to perpetuate the insect in the galls. They mature in the fall and caprify most of the mamme figs in October.

The caprifigs used in California are classified into a number of named varieties which differ considerably from one another.

SOURING

Up to a comparatively recent time practically all the spoilage in figs in California was referred to as 'souring' or 'fermentation' and thought to be the natural, unavoidable consequence of such influences as cool nights, moist winds, slow drying, rain, overirrigation, or high water table. Roeding (1903), for instance, says "In soils where the water levels throughout the year stand close to the surface, Smyrna figs should not be planted, for in such locations . . . . there is a possibility of some of the figs souring should cool weather set in during the drying season. . . . . In the early part of the harvesting season of 1901 westerly winds, which always carry a great deal of moisture, prevailed, and in consequence of this many of the figs soured." Shinn (1915) says, "The fruit in some districts in some seasons ferments on the trees ('fig sour'). This sometimes seems to come from overirrigation, sometimes from lack of vitality, and most often occurs in very tender and juicy varieties."

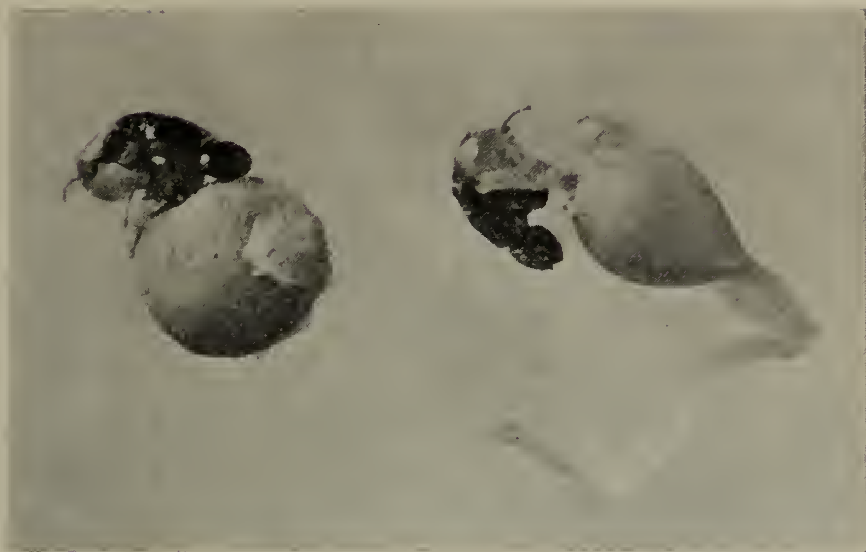

Fig. 13.—Right, male blastophaga emerging from gall; left, male impregnating female inside gall. (From Bulletin 319.)

Fig. 14.—Female blastophaga emerging from gall. (From Bullein 319.)

Wickson (1926, p. 383) says, "The intrusion of the coast influences borne eastward by the winds of summer gives a night temperature too low for ripening of some of the varieties, which turn sour upon the trees. . . . . Even in southern California fig-souring is quite prevalent."

Lelong (1892) makes similar suggestions.

As early as 1892 Newton B. Pierce (1893), the pioneer plant pathologist of the Pacific Coast, recognized the importance of pathogenic organisms and insect carriers in fig spoilage. He states: "Another of the industries of the state which has been gradually extended of late is seriously threatened. This is the growth and curing of figs. It has been observed since the cultivation of this fruit has been attempted that the growers had to contend with a destructive fermentation of the fruit which often caused the loss of nearly the entire crop." Pierce found that the fruits spoiled both while on the tree and on the drying trays and states further, "A series of field and laboratory investigations resulted in the isolation of an organism capable of exciting fermentation. This proved to be a yeast." From inoculations made with pure cultures of this organism the typical fermentation was produced in figs. It is further stated that "The fruit is inoculated by insects, the yeast cells being carried by them to the ripening fruits."

Eisen (1901, pp. 178–179) came to the same general conclusion. "The souring of the figs is directly caused by a fungoid fermentation undoubtedly related to the fungus which causes acute fermentation in other sweet substances such as wine. A more distinct cause of souring is the want of proper sweetness in the figs, too much water in the soil, or unsuitable soil. Figs which grow in moderately moist ground sour less than those which grow in wet soils. . . . . To counteract this tendency to souring the soil should be kept dry, though excessive dryness will also injure the figs. . . . . As long as the eye is closed bacteria and fungi are kept out and no fermentation can take place. There is no doubt that the principal function of the eye of the fig is to keep out bacteria and insects, and the closed form of the fig receptacle is undoubtedly effected by nature in order to prevent parasites from spoiling the sugary juice of the fig."

Howard (1901) also suggested insect transmission of souring, while Condit (1917, p. 16) and Hodgson (1918) mention a similar possibility in the case of the fungus infection called smut. Condit (1919) states that souring is only another name for fermentation caused by the action of yeasts, molds, and bacteria, of which yeasts are probably the most common. He attributes the introduction of these organisms into figs to insects, particularly "small beetles" and occasionally the vinegar fly. Concerning the relation of soil moisture and climatic conditions to souring the following statement is made:

> Yeasts, which are probably the most common organisms to cause figs to sour, cannot grow in the interior of the fruit until it becomes fairly mature and moistened with exudation from the pulp of the sweet, watery juice. The growth of the yeast under such conditions changes the sugar present into alcohol and carbon dioxide and, if long continued, causes the complete softening of the entire fruit through the breaking down of the cell walls. The sour flavor of such figs is probably due also to bacterial action of the nature of lactic acid and alcoholic fermentation.
>
> The growth of the yeast is dependent also upon the degree of concentration of the sugar in the juice of the fruit. There is what we may call a neutral point at which the yeast cells remain in a resting state. If the moisture in the fruit increases and the solution of sugar becomes diluted, the yeast becomes active and starts into growth. If, on the other hand, the moisture in the fruit decreases and the sugar solution becomes more concentrated, the growth of the yeast is inhibited and the fruit develops normally. As already explained in regard to splitting, the percentage of humidity in the air influences the amount of moisture in the fruit and we can now understand why damp, foggy weather increases the tendency for some varieties of figs to sour. Excessive irrigation or a high water table also brings about conditions favorable to souring for the same reasons.
>
> Varieties of figs differ greatly in their susceptibility to souring. . . . . The so-called Kadota is known as a fig which practically never sours in the San Joaquin Valley. The Mission and the Brown Turkey very seldom sour. In what respect are these varieties resistant to the yeast organism which causes souring? I have no data to prove my assertion but I believe it is due to the earlier concentration of sugar in the maturing fruit. A Kadota or Brown Turkey fig tastes sweeter in the stages preceding full development of color and full maturity than the Adriatic fig does at that stage and for that reason the former varieties are more suitable for the fresh fruit market.

Coit (1921), on the basis of considerable field work, reached similar conclusions. As to the factors which influence souring he states the following:

> Inasmuch as the atmosphere is filled with spores of many kinds of yeasts, molds, smuts, and bacteria, and since the eye of the Smyrna fig is open, it is unavoidable that these agents gain access to the interior of the majority of the figs. If the juice were all retained within the cells, then only pathogenic organisms, or those capable of penetrating the cell wall, would accomplish decay. As the sap is free, however, all the organisms within the fig will have an opportunity to grow, being limited only by the concentration of sugars in the sap.
>
> We have come to the conclusion that the term 'souring' is a very unfortunate and misleading term. A dried fig is one that is preserved by the density of its own juice. A sour fig is one which has suffered decay on account of lack of juice density. As there are many different kinds of rots in apples and other

fruits, so there are many kinds of decay in figs, each with a characteristic appearance, odor, and taste. There are molds, mildews, and smuts of various kinds, the growth of each of which is limited by a different density point of the juice. With a very thin juice we find a number of them working together; as evaporation concentrates the juice the growth of one after another is stopped. Wild yeast appears to be able to grow on a very dense medium, and being one of the last to stop growth, is largely responsible for souring. We have found

Fig. 15.—Sour fig. (From Circular 311.)

yeast in what appear to be perfectly sound figs; and are of the opinion that it may clarify the situation somewhat if we consider all Symrna figs as potential sour figs and recognize the best grades of packed figs as those in which progress of 'souring' was stopped very soon after it began. The successful curing of Smyrna figs will depend, therefore, on the density of the sap when released from the cells and the speed with which the water is removed by evaporation. The first factor is dependent upon the relation between available soil water and the transpiration from the leaves. The second factor depends upon evaporating power of the air.

Coit's conclusion is that excessive soil moisture or atmospheric humidity produce a lowered concentration of the sap of the fig and thus render souring unavoidable.

Investigations on Souring.—The first comprehensive investigation of fig spoilage by laboratory methods was that begun by Phillips in 1920 and reported on in part by Phillips, Smith, and Smith (1925).

Fig. 16.—Sour figs dried on tree, showing 'black-neck,' 'blue-stem,' and 'black-end' conditions. (From Circular 311.)

These workers, whose investigation was mainly directed at the so-called 'smut' disease, examined and cultured large numbers of figs of the Adriatic variety at various stages of maturity in order to determine the time of the initial entrance of microorganisms into the fruit, the identity of the organisms concerned, and the mode of transmission. As a basis of investigation ten representative stages in the development of the fig (see figs. 3, 4, and 5 and their description on page 7) were arbitrarily chosen. The earliest of these stages represents the condition of the fruit when it is not quite full grown, still hard and green and with the eye scales tightly closed. At stage 3 the fig is still hard and green but full grown and with the eye partly open. Stage 5 represents figs in the condition when they are picked for the fresh fig market, the eye being fully open and the pulp beginning to soften. The later stages represent successive steps in the ripening and drying of the fig up to that of complete drying. Table 1 (p. 6) shows the respective percentages of moisture and sugar of figs at these different stages.

On the basis of individual examinations and cultures from nearly 10,000 figs, Phillips, Smith, and Smith concluded that, under the conditions of their investigation, the interior of uncaprified Adriatic figs is sterile (free from fungi, bacteria, and yeasts) until the time when the eye opens and the pulp begins to soften (stages 4–5). They were of the opinion that no rotting or souring takes place without such organisms, and that they are introduced mainly by insects and not by air currents, basing this conclusion on the fact that spores of the black-smut fungus (*Aspergillus niger*) did not cause infection or gain entrance when blown forcibly with an atomizer against the open eyes of figs at the susceptible stage. Similar spores introduced into the interior cavity of the fig with a needle or in a watery suspension by means of a pipette produced infection very readily.

Further evidence that insect transmission is the principal factor in the introduction of microorganisms into figs was deduced from an experiment in which two large fig trees were inclosed with a cheese-cloth-covered frame to exclude insects (fig. 17). No sour figs developed on these trees although souring was abundant on all the other trees in the orchard. An excessive amount of splitting occurred in the figs on the enclosed trees but even these did not sour. The temperature within the tent was somewhat lower and the humidity greater than on the outside.

These workers obtained a considerable variety of fungi and bacteria from mature figs, including various species of yeast, *Aspergillus, Rhizopus, Alternaria, Cladosporium, Penicillium,* and *Hormodendrum.* It was thought by them that the dried fruit beetle, *Carpophilus hemipterus* (L.) (fig. 18), is the principal carrier of infection, since this insect was found to be very abundant in ripening figs and its appearance in them was coincident with the beginning of fruit spoilage. Most of the figs were sterile up to the time when the beetles began to enter them, and the organisms which cause spoilage were found very abundantly on the bodies of the beetles. The vinegar fly, *Drosophila ampelophila* (Loew), was thought to be of secondary importance. The experiment with the cheese-cloth tent just described above was thought to give further evidence of the fact that the exclusion of these insects prevented souring.

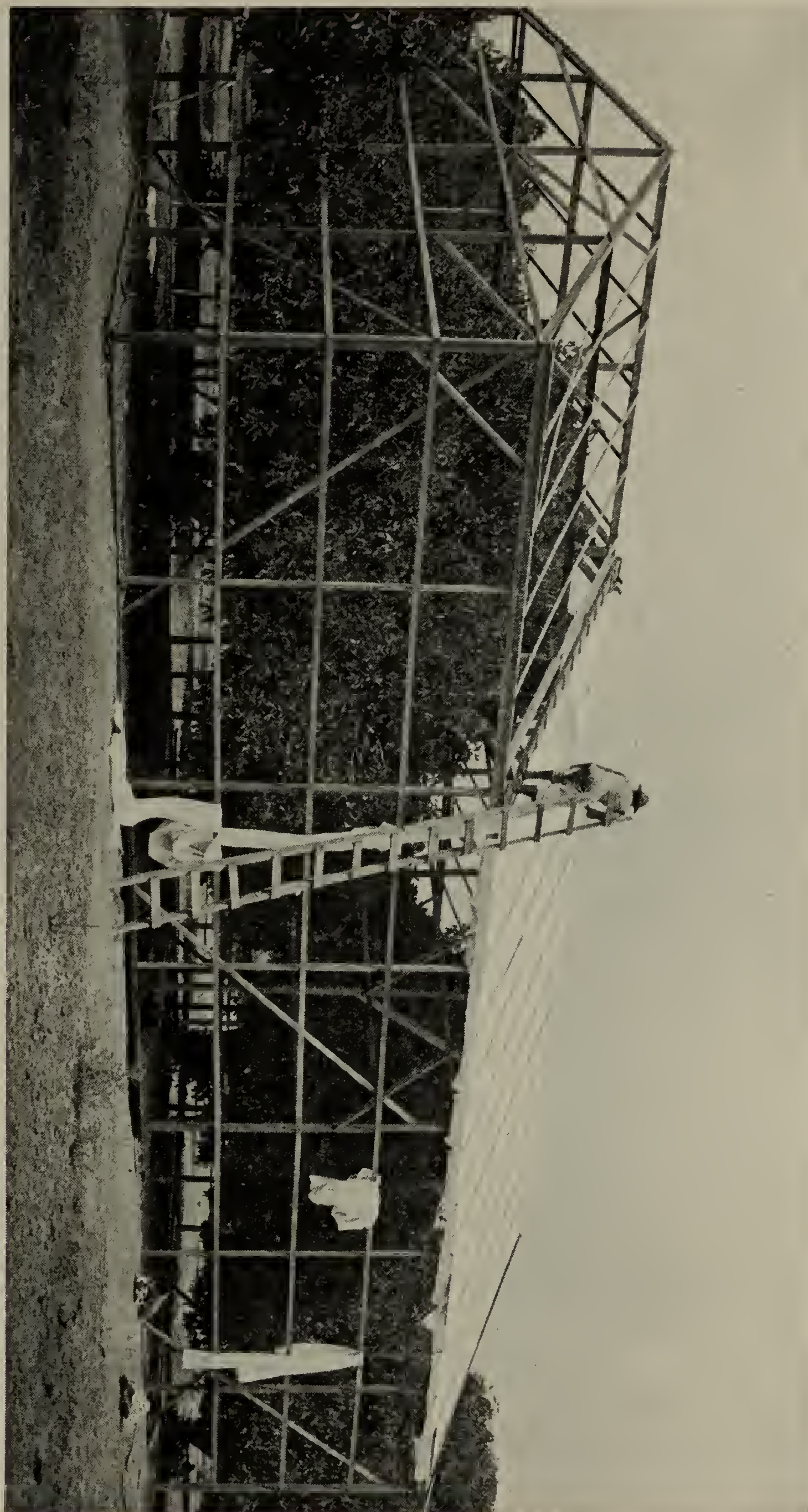

Fig. 17.—Building cloth tent over large Adriatic fig trees to exclude insects. A large amount of splitting developed on these trees, but no souring. (From Bulletin 387.)

Fig. 18.—Dried-fruit beetles issuing from decaying orange, covered with disease germs and ready to attack figs. (From Bulletin 387.)

Caldis (1927) in a study preliminary to his investigation of another fig disease, endosepsis, corroborated the work of Phillips, Smith, and Smith in regard to the flora of Adriatic figs at different stages of development. His results are summarized in table 2.

TABLE 2

VARIETIES, LOCALITIES, AND NUMBERS OF PARTHENOCARPIC FIGS EXAMINED IN DETERMINING THE FLORA OF THE FIG RECEPTACLE (STAGES 1–3)

	Crop	Sacramento	Modesto	Fresno	Condition
Adriatic	First	4	10	53	All sterile
	Second	4	15	68	All sterile
Mission	First	3	....	16	All sterile
	Second	....	....	18	All sterile
Kadota	First	....	....	20	All sterile
	Second	....	....	18	All sterile
San Pedro	First	....	....	18	All sterile
White Ishia	First	....	....	4	All sterile
Brown Turkey	First	....	....	4	All sterile
Cordelia	....	10	....	4	All sterile
Miscellaneous	....	5	....	....	All sterile

From: Caldis, Panos D. Etiology and transmission of endosepsis (internal rot) of the fruit of the fig. Hilgardia 2:298 *table 1*, 1927.

Smith and Hansen (1927) describe souring and state that it is "caused by yeast followed by the action of bacteria and molds. It is started by insects, especially the dried fruit beetle, *Carpophilus hemipterus* (L.), entering the figs. It is spread by these and other insects, especially the vinegar fly (*Drosophila ampelophila* (Loew))." Cultures are reported in which it is shown that *Carpophilus hemipterus* (L.) carries yeasts and some of the fungi commonly found in figs (see fig. 19).

Caldis (1930) later investigated the cause and transmission of souring in uncaprified Adriatic figs. He describes the disease as follows:

In souring there is at first a change in the color of the pulp, which from pink becomes colorless and subsequently turns watery. A pink liquid exudes from the eye, dropping on the leaves or jellying at the eye [fig. 15]. Gas bubbles are seen through the pulp and the skin in many cases becomes water-soaked and loses its firmness. The pulp is disintegrated and smells strongly of alcohol and in many cases is found covered by a white scum. The figs begin to shrivel and dry up in this condition and they either drop to the ground or hang on the twig, in the latter case giving rise to what is commonly called 'black neck' figs [fig. 16]. A dead spot or 'eye canker' is often found in the bark at the point of attachment of such figs, as seen in the two twigs in [figure 16]. Fermented figs lose their firmness, sag, and usually the pulp becomes detached from the skin in the neck, which shrivels, dries up, and turns dark. Fig souring is primarily an alcoholic fermentation, but subsequent changes may take place while the fig is attached to the twig, on the ground, or the drying board. The commonest change is the action of acetic bacteria on the alcohol with the production of acetic acid, which is readily discerned by its pungent, strong odor. Ethyl acetate and other esters are probably formed.

This work was done with Adriatic figs in Fresno in 1924 and in Davis in 1925. Caldis obtained a large percentage of sour figs by confining the dried fruit beetle upon the figs on the tree in wire-cloth

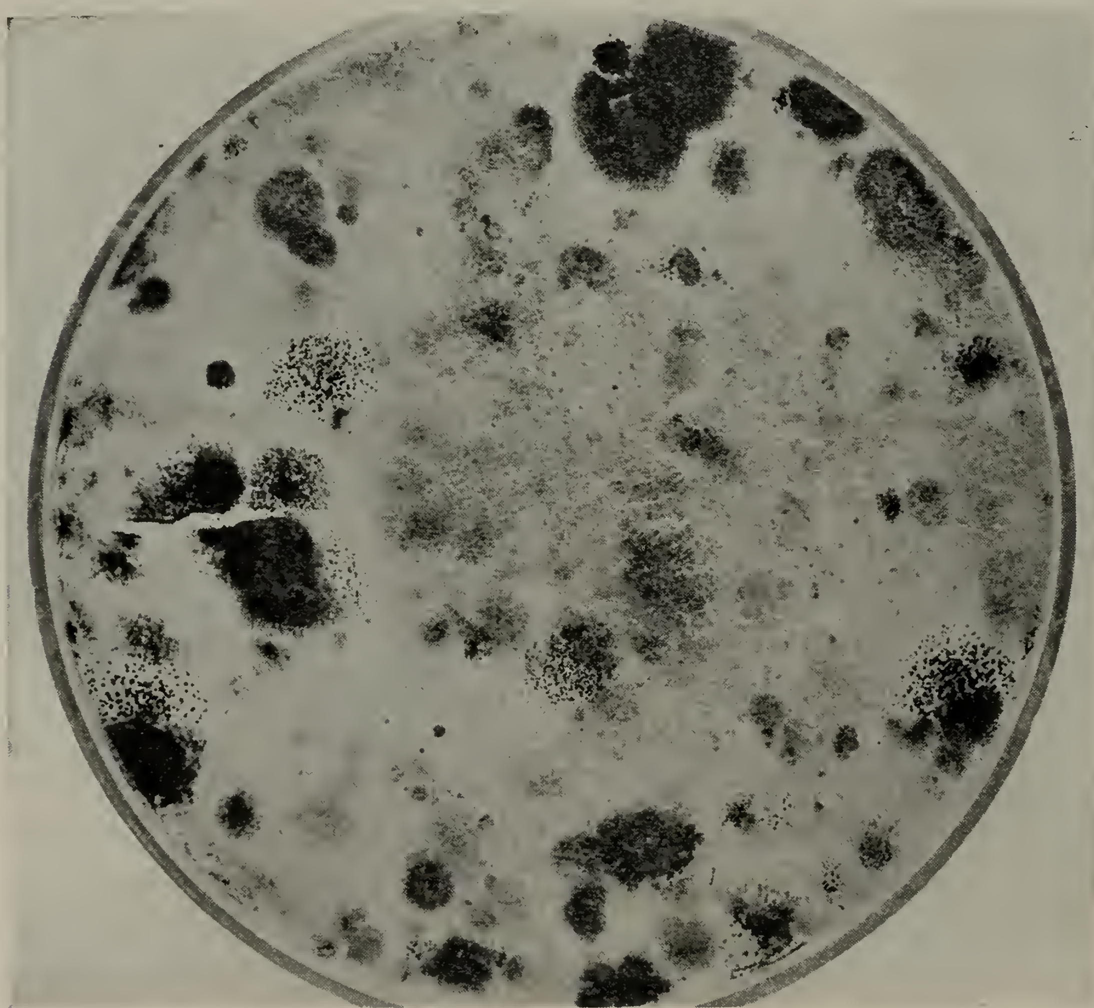

Fig. 19.—Culture plate in which a dried-fruit beetle was placed, resulting in abundant growth of molds, yeast, and bacteria. The black-dot areas are the smut fungus. (From Circular 311.)

cages. The beetles bred and multiplied in the figs during the experiment. In figs which were bagged or caged without beetles no souring developed. Table 3 summarizes Caldis's results.

By culturing sour figs Caldis isolated three prevailing species of yeast, two of which (designated by Caldis as yeast *A* and yeast *C*) produced typical souring when inoculated into ripe figs, while the third type (yeast *E*) produced a different form of disease not of the nature of typical souring. Yeast *A* was said to be of the *Mycoderma* type; yeast *C*, the *Apiculata;* and yeast *E*, a *Torula.* The same yeasts were obtained regularly in cultures from *Carpophilus*. No other insect was mentioned in this work.

For several years Messrs. Perez Simmons and W. D. Reed of the United States Department of Agriculture, Bureau of Entomology, have been located at Fresno carrying on investigations on the life history and control of the dried fruit beetle. No results concerning this work have as yet been published, but several popular addresses have been presented at public meetings concerning the relation of this insect to figs. The possibilities of trapping the beetle have received much attention. It would appear that the practical control of *Carpophilus* in the orchard presents a difficult problem.

TABLE 3

RESULTS OF BAGGING DRIED FRUIT BEETLES ON ADRIATIC FIGS (CALDIS)

	Number of cages or bags	Number of figs	Figs sour	Figs not sour
With beetles—				
Fresno—1924	4	25	19	6
Davis—1925	3	29	9	20
Without beetles—				
Fresno—1924	111	545	0	545
Davis—1925	17	118	0	118

From all the work reported up to this point the following conclusions seem justified:

1. 'Souring' of figs is due to fermentation of the internal saccharine juices caused by specific yeasts.

2. Uncaprified parthenocarpic figs are internally sterile until they have been entered by insects. After this they frequently contain and are infected with yeasts, molds, and bacteria. This time usually coincides with that when the eyes open and the figs begin to ripen.

3. The time of the opening of the eye and softening of the fig is coincident with the first entrance of the omnipresent dried fruit beetle, *Carpophilus hemipterus* (L.). The body of this insect is heavily contaminated with the same microorganisms that occur in the fig.

4. In a limited number of experiments where figs were enclosed with paper, cheese-cloth, or fine-mesh wire screen, excluding *Carpophilus* and equally large insects, souring was prevented. Souring developed when beetles were placed in the bags.

5. It has not been conclusively proved that *Carpophilus* and *Drosophila* are the only insect carriers of infection in parthenocarpic

figs or that all the infection is transmitted by any insect at all, since in the caging and bagging experiments other factors than insect exclusion may have played a part.

Further Aspects of the Problem of Souring.—At the end of ten years of study of the fig problem by members of this division, certain observations affecting the above conclusions on souring are rather outstanding; for instance, it is very evident that the term 'souring' is a loose and indefinite one and may not always indicate specifically the same condition. 'Sour' and 'not sour' may at times have meant nothing more than different degrees of the same thing, and not the absolute presence or absence of a specific infection. Again, several different diseases or infections, some borne by different carriers, may be confused under the term 'souring.' Many figs in an early stage of spoilage or with slight indications of deterioration other than endosepsis have been examined in which no indication of *Carpophilus* or *Drosophila* could be found. This has been true even in the case of whole orchards where there has been a large percentage of bad figs and no beetles were observed. The commercial test-grading of Adriatic figs from such an orchard, as given in table 4, is typical of this. No *Carpophilus* beetles were found in this orchard at the time when the samples were taken, but less than half the figs were free from visible indications of fungus infection.

TABLE 4

Grading of Dried Adriatic Figs from an Orchard in which No Dried Fruit Beetles Were Found

	Good	Passable	Bad	Total
Number of figs	746	433	745	1,924
Per cent	38.8	22.5	38.7	100

The bad figs in this orchard were of a type variously classed as sour or moldy by growers and buyers, but it is impossible to identify the trouble specifically. Many of them showed visible mold or were affected with a deteriorated condition which is sometimes referred to as 'dry rot.'

Another similar case is presented by a condition which occurs abundantly in Calimyrnas and probably also in Adriatics, in many dried figs which appear entirely normal on the outside and pass as good figs. This is a slight dryness and 'seediness' of the meat accompanied by a faintly sour or disagreeable odor. It is only a question

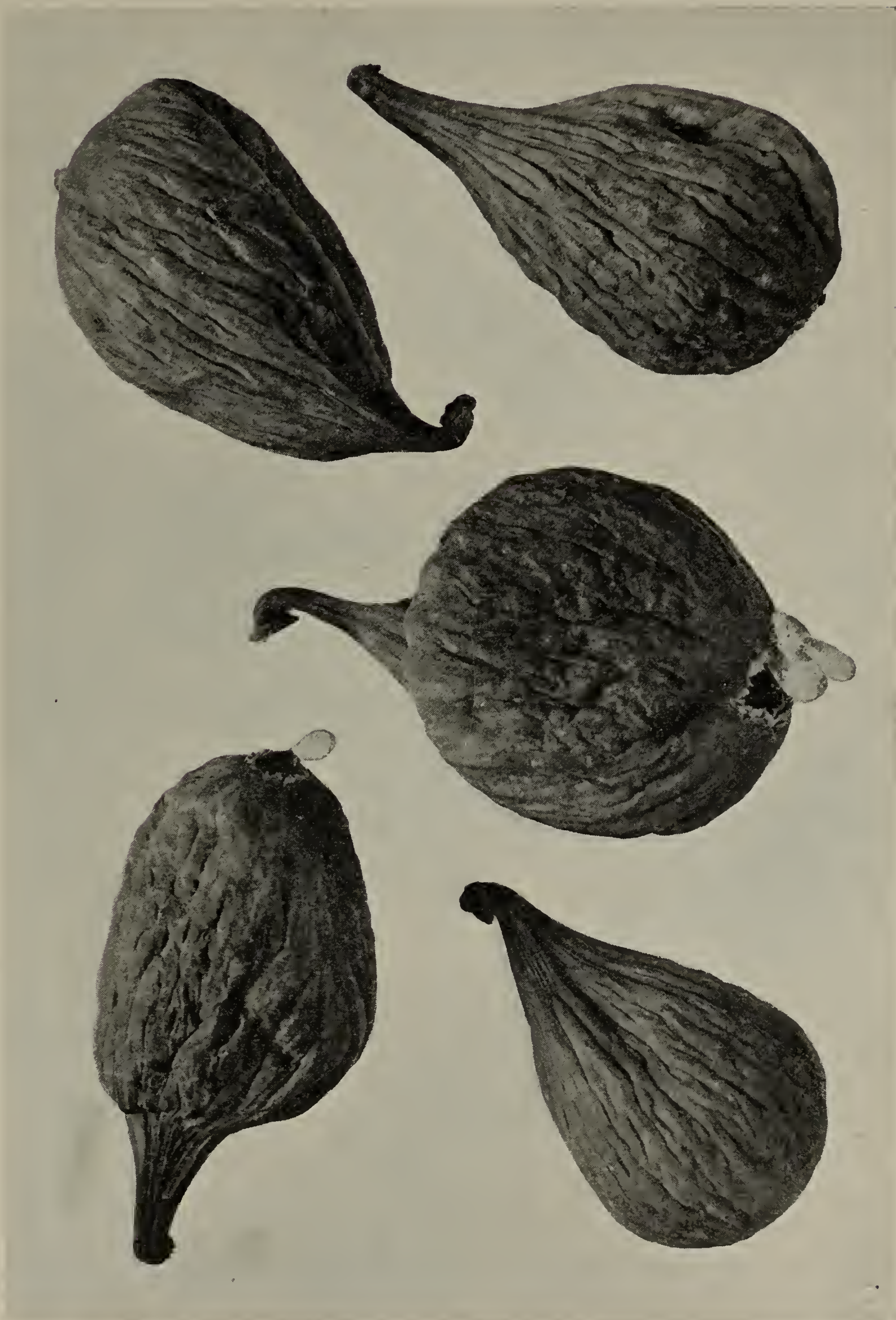

Fig. 20.—Dried Calimyrna figs of practically normal appearance but internally slightly affected with 'dry rot.' (From Hilgardia, Vol. 2, No. 7.)

of degree between figs of this sort and those which are entirely bad and contain nothing but dry seeds. Often there is a large percentage of these which pass commercial grading and are only very slightly 'off' in texture and flavor and show no evidence of having harbored insects. It is a common idea that figs like these gradually deteriorate in storage by a slow breaking-down or dry rot of the pulp and change in flavor. Figures 20 and 21 show the external and internal appearance of such figs. These pictures are from Caldis' paper on endosepsis and are supposed to represent figs slightly affected with that disease. There is some doubt, however, whether all such figs are thus affected, or if so, whether the endosepsis fungus is the cause of the gradual deterioration of the dried fruit. The evidence shows that this fungus does not persist in dried figs but dies out when they beome thoroughly desiccated.

TABLE 5

RESULTS OF CULTURES FROM DRIED CALIMYRNA FIGS

Number of figs	Number of cultures	Commercial quality	Actual condition	Results of cultures
5	5	Passable	Sound but slightly bad odor	Yeast in all
2	4	Passable	Sound but slightly bad odor	Yeast in all
1	1	Passable	Sound but slightly bad odor	Yeast
1	2	Passable	Perfect appearance, very slight sour odor	Yeast in both
1	2	Passable	A perfect fig in appearance, odor and flavor	Yeast in both

Bearing on this point, table 5 gives the result of culture tests from sound-appearing, freshly dried, commercially passable Calimyrna figs. These were all of perfectly normal external appearance with no visible trace of insect infestation. The first three lots had a very dry seedy look on the inside and a slight but distinct sour, disagreeable odor. The fourth was a large fine fig of perfect appearance but with a very slightly peculiar odor, while the fifth appeared to be an absolutely perfect fig in every way. Where two cultures were made from a fig, one was from the flesh just beneath the eye and the other from a point in the flesh near the stem end. The cultures were made on potato-dextrose agar. The yeast obtained was in every case a small round, white form appearing identical with Caldis' yeast *E*.

In studying this matter further another set of cultures was made as follows:

From a lot of dried Calimyrna figs there was selected (1) 10 of the most perfect in color, texture, odor, and taste; (2) 10 of the commercially passable type just mentioned above, showing good color, almost perfect texture (slight seediness), but a faint trace of sour

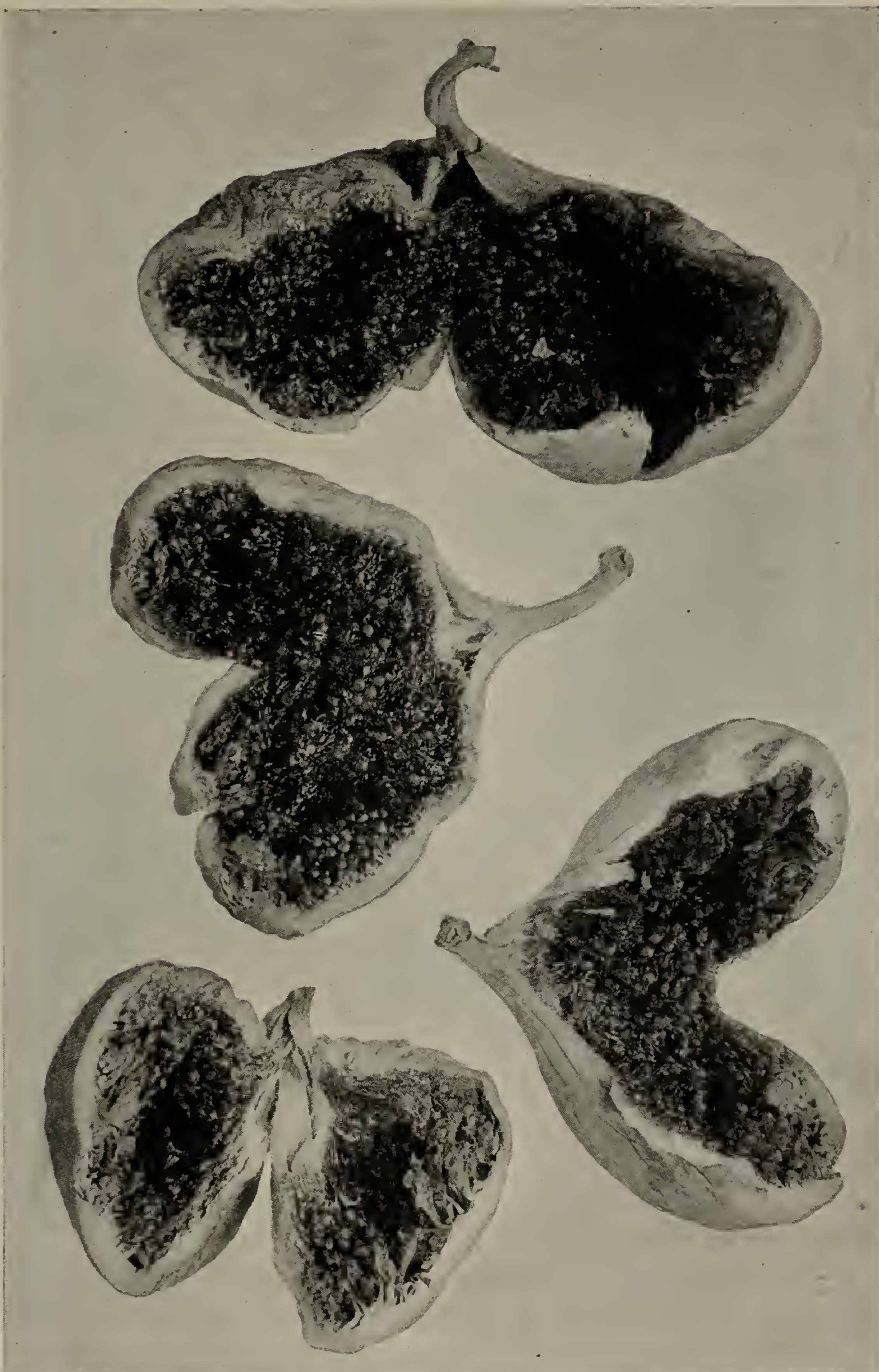

Fig. 21.—Interior of dried figs shown in figure 20, affected with 'dry rot.' The pulp is dry and seedy and has a peculiar flavor. In such figs there is no sign of wet, gassy fermentation or of the dried fruit beetle. Cultures yield a small, round, white yeast. (From Hilgardia, Vol. 2, No. 7.)

odor; (3) 10 worthless culls, showing pronounced pink end and internal browning and characteristic odor of endosepis like the figs in figure 33. All had been in a warm room about a month longer than those in the last lot and were rather overdry.

The endosepsis fungus, *Fusarium moniliforme,* was not found in any of the cultures. As the figs in lot 3 were typically affected with this disease it would appear that this fungus dies out rather quickly in the dried fig. Seven of the perfect figs in lot 1, and four of the slightly sour ones in lot 2 gave sterile cultures, indicating that either they had never been infected or the organisms had died. The fact that even among the bad figs in lot 3, two gave no growth in culture indicates that sterility in the dried state is not a safe criterion of the original condition of the fig.

TABLE 6

RESULTS OF CULTURES FROM DRIED CALIMYRNA FIGS

Number of figs	Number of cultures	Commercial quality	Actual condition	Results of cultures
10	10	Passable	Perfect	1 dark mold, 1 yeast, 1 red bacterium, 7 clear
10	10	Passable	Perfect appearance, very slight sour odor	1 *Aspergillus niger*, 5 mold or yeast, 4 clear
10	10	Culls	Typical endosepsis	1 *Aspergillus niger*, 5 yeast, 2 mold, 2 clear

Considering all these facts concerning the presence of microorganisms in many dried figs where there is no evidence of the *Carpophilus* beetle or other known insects, it appears that there may still be an open question of fundamental importance concerning the mode of infection. There is the possibility on the one hand that practically all figs become unavoidably infected with air-borne microorganisms during the ripening period. This has been suggested by Coit in the quotation on page 22. In contrast to this is the conclusion reached by Pierce (1893), Phillips, Smith, and Smith (1925), and Caldis (1930), that infection is limited almost entirely to insect transmission. If this idea is correct then it would seem important to look further than *Carpophilus* and *Drosophila* for such carriers.

During the progress of these investigations a continuous search has been made for insects of possible importance as agents of disease transmission. Numerous miscellaneous species of Hemiptera, Coleoptera, and other orders may be disregarded so far as any major significance is concerned. It seems safe to conclude that no insect of a size readily visible to the naked eye has been overlooked unless it be one of peculiarly obscure habits.

Thrips.—Caldis (1927, p. 319) made the following observations on caprifigs: "The larva of an unidentified species of thrips may later enter the cavity [after the eye opens]. Plates were poured repeatedly from blanks and edible figs in order to determine the presence of the thrips larva and its effect on the flora of the fig. Of 95 uncaprified figs examined, the larva was found only in two and the flora of such figs was never found to parallel the flora of caprified figs. Most of the figs were sterile. Occasionally several types of green fungi that bear no relation to the disease [endosepsis] were obtained." In considerable more, unpublished work, Caldis found thrips more or less common in figs from certain localities and especially in caprifig blanks (uncaprified), and concluded that they might be the carriers of certain molds and yeasts. Since parthenocarpic uncaprified figs were never observed by him to be affected with endosepsis, he did not consider thrips as carriers of this disease.

In our own work considerable attention has been paid to this matter, since thrips have at times been found abundantly in figs, passing in and out of the fruit freely. No one species was exclusively concerned but several have been found, mostly forms common to various other plants. The following is quoted from an article by Hansen (1929):

> In May, 1928, the writer collected several thousand uncaprified, hard green figs of four varieties: Calimyrna, Adriatic, Kadota, and Mission, from various parts of California. These figs were cut into halves and examined with a hand lens for evidence of insect invasion, mutilated and discolored floral parts, insect excreta, or the insects themselves. Slightly in excess of 20 per cent of the figs examined were found to be infested with thrips, specimens of which were identified by Mr. Dudley Moulton of San Francisco as *Thrips tabaci* Lindl. and *Frankliniella* sp., probably *F. californicus* Moulton.

In 1929 species of thrips were found in figs as follows: *Frankliniella tritici* (Fitch) and *F. tritici* var. *californicus* (Moulton) at Davis, Loomis, Orosi, Sacramento, and Fresno, and *Thrips bremneri* (Moulton), *Liothrips ilex* (Moulton) at Davis. These were identified by Mr. S. F. Bailey of the Division of Entomology, University of California. During the late summer and fall of 1929 the bean thrips, *Heliothrips fasciatus* Perg., was very common in figs throughout the San Joaquin Valley and occurred likewise as a serious pest on cotton and other hosts growing close to or in the fig orchards.

Concerning the cryptogamic flora of thrips-infested figs, Hansen in the article just quoted reported as follows:

> The interior of 200 of the figs showing evidence of insect invasion, and 10 showing no such evidence, were cultured individually on nutrient media to deter-

mine their cryptogamic flora. Each of the 200 thrips-infested figs yielded one or more of the following organisms: various species of bacteria, *Rhizopus* spp., *Aspergillus* spp., *Penicillium* spp., *Fusarium* spp., *Verticillium* spp., *Spicaria* sp., *Hormodendrum* spp., and a number of yeasts. The 10 figs showing no evidence of insect invasion yielded no cryptogamic flora in culture. The above results show that when green, hard figs are entered by thrips, they become inoculated with organisms capable of producing various decays and fermentations in the ripening fruit. Though the 1928 season was especially favorable for thrips, the comparatively high percentage of green, hard figs found infested would indicate that infection from this source alone is sufficiently great to cause the growers considerable loss. It is also possible that the early start of decay and fermentation in thrips-infested figs, giving rise to odors very attractive to *C. hemipterus* and *D. ampelophila,* is partly responsible for the appearance of these insects in the orchards at the time when figs begin to mature.

Further culturing of thrips taken from figs has repeatedly given the same results, namely, that they carry an abundant flora of yeasts, bacteria, and mold fungi. Figure 22 shows cultures from thrips. In a few instances the endosepsis fungus, *Fusarium moniliforme,* and the red bacterium which accompanies it so regularly in connection with blastophaga, have been found in such cultures. There is no positive evidence, however, that thrips are of any importance in the transmission of endosepsis, and it may be that in the few cases mentioned above they picked up the characteristic organism in figs which had previously been infected by blastophaga.

In the orchard described on page 30, where more than 50 per cent of the figs were moldy or slightly bad, thrips were abundant and no *Carpophilus* beetles were found. In 1929 a number of cases occurred in the San Joaquin Valley where fig orchards showed abnormally high percentages of moldy or smutty figs with no indications of sufficient infestations of beetles to account for this. In one case in particular sheep were pastured in the orchard and all the bad figs were kept very closely picked up by this means, thus affording little chance for breeding of scavenger insects. In this orchard, however, there was an unusually high percentage of moldy figs and thrips were abundant, as was the case in all the other orchards mentioned. The thrips yielded in culture the same flora found in the figs. These and many similar instances point to the importance of knowing more about the rôle played by thrips in the transmission of fig diseases.

The Fig Mite (*Eriophyes fici* Ewing).—This blister mite of almost microscopic size was first discovered by E. H. Smith (Essig and Smith, 1922) in work on fig smut, and has proved to be very common in both capri and edible figs. It was named by Ewing (see Essig, 1922) and is described by Essig (1926) as follows:

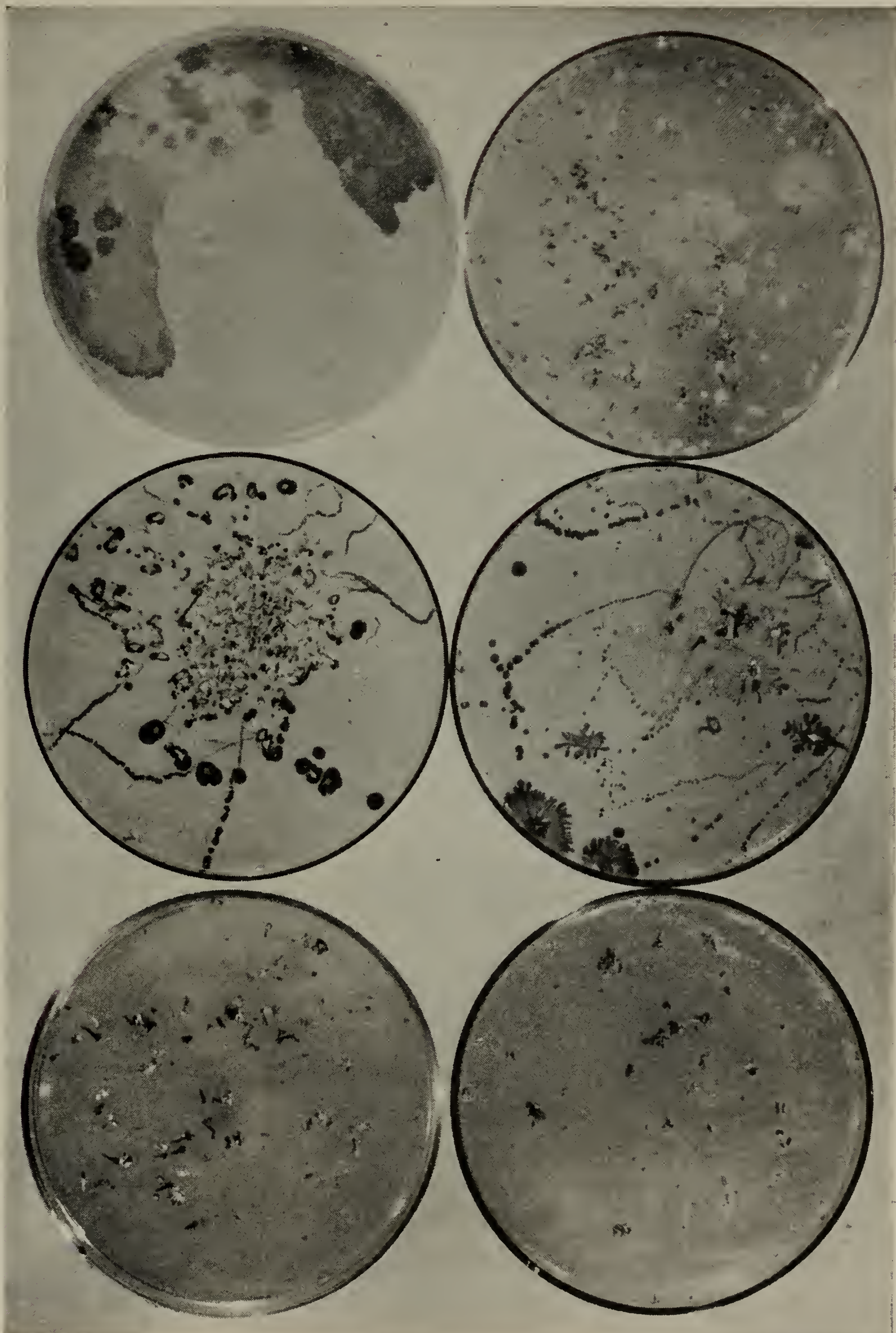

Fig. 22.—Cultures of thrips from blank caprifigs, showing variety of molds, yeasts, and bacteria which may be carried into edible figs and cause spoilage.

The fig mite, *Eriophyes fici* Ewing, is a minute, white, elongated mite which overwinters in the buds and the fruit of the caprifigs and works in the fruit of edible figs during the summer. All the common varieties except the Black Mission were found infested, the mites causing a faint russeting of the interior. As the fruit ripens the mites work out and often concentrate under the scales at the opening. As yet we can attribute no damage to them. They occur in the fig-growing districts of the San Joaquin Valley, California, and must have been introduced from Europe with nursery stock.

Phillips, Smith, and Smith paid considerable attention to the possible importance of this mite as a carrier of infection in figs. The same statement applies to the work of Caldis and that of the writers. According to unpublished notes of all these investigators the fig mite is not an important carrier of infection. Cultures from figs showing

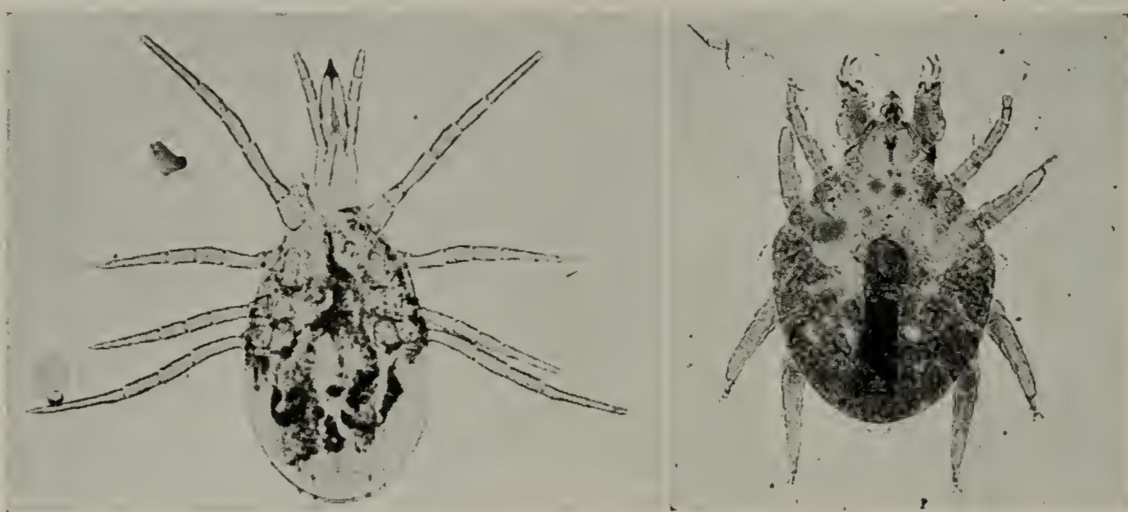

Fig. 23.—Predaceous mites found in mamme figs. *A, Sejus pomi* Parrott (× 50). *B,* Unidentified species (× 50).

the reddish-brown florets which indicate the presence of mites gave no more microorganisms than those which contained no mites. Such figs in fact were usually sterile until entered by other insects. Apparently the life history of this mite is such as to render improbable its carrying pathogenic organisms into the figs.

Predaceous Mites in Figs.—Figure 23 shows two mites which, with still a third species, have been found in caprifigs in considerable abundance. Specimens of the one marked *A* have been sent to Mr. H. E. Ewing, who has provisionally identified it as *Sejus pomi* Parrott (Parrott *et al.*, 1906, and Ewing, 1914). The other two species have not yet been identified.

The comparative abundance of thrips and mites in mamme figs is shown in table 7.

Table 8 shows further results of examining mamme figs for insects.

TABLE 7

HAND LENS EXAMINATION OF MAMME FIGS FOR INSECTS, JANUARY, 1930

Fig No.	Thrips	Preda-ceous mites	*Eriophyes fici**	Fig No.	Thrips	Preda-ceous mites	*Eriophyes fici**	Fig No.	Thrips	Preda-ceous mites	*Eriophyes fici**
1	4	3	+	21	0	0	0	41	0	0	+
2	0	1	+	22	0	0	+	42	1	0	0
3	0	0	+	23	0	1	+	43	0	0	+
4	0	0	+	24	0	0	0	44	0	0	0
5	0	2	+	25	0	0	+	45	0	0	+
6	0	0	0	26	0	0	0	46	0	1	+
7	0	0	0	27	0	2	+	47	0	1	+
8	0	0	+	28	0	1	+	48	1	0	0
9	0	0	+	29	1	0	0	49	0	0	0
10	0	0	+	30	0	1	+	50	0	0	0
11	0	0	+	31	0	2	+	51	0	0	+
12	0	0	0	32	2	0	0	52	0	2	+
13	0	0	0	33	0	0	+	53	0	0	+
14	0	0	+	34	0	0	+	54	0	0	0
15	1	0	+	35	0	1	+	55	0	0	+
16	0	0	+	36	0	2	+	56	4	1	+
17	1	1	+	37	0	0	0	57	0	0	0
18	0	0	0	38	0	0	0	58	0	1	+
19	0	0	+	39	0	0	0	59	0	0	+
20	2	1	+	40	0	0	+				

* + = present.

TABLE 8

INSECT POPULATION OF MAMME FIGS, JANUARY–FEBRUARY, 1930, SHOWING NUMBER AND PERCENTAGE OF FIGS INFESTED WITH EACH

Locality	Thrips		Predaceous mites		Fig mite		No insects		Total	
	Num-ber	Per cent	Num-ber	Per cent	Num-ber	Per cent	Num-ber	Per cent	Num-ber	Per cent
Loomis	4	1.9	29	14.1	108	52.4	65	31.6	206	100
Davis	28	5.5	48	9.4	270	52.8	165	32.3	511	100
Sacramento	4	4 0	11	11.0	15	15.0	70	70.0	100	100
Merced	0	0	6	9.4	38	59.4	20	31.2	64	100
Fresno	21	10.7	64	32.6	56	28.5	55	28.2	196	100

The predaceous mites pass freely from fig to fig, apparently preying on the fig mite. How abundant they are in edible figs has not yet been determined. That their bodies are contaminated with pathogenic organisms is shown in table 9.

TABLE 9

CULTURES OF PREDACEOUS MITES TAKEN FROM MAMME FIGS, 1930

No. of culture	*Fusarium moniliforme*	*Aspergillus*	*Hormodendrum*	Bacteria-like fungus	Yeast-like fungus	Yeast	Bacteria	*Spicaria*
1	0	+	+	+	+	+	+	0
2	+	+	+	+	0	0	+	0
3	0	0	0	+	0	0	0	0
4	0	0	+	+	+	0	+	0
5	0	0	+	+	0	0	0	0
6	+	0	+	+	0	+	0	0
7	0	0	+	+	0	0	0	0
8	0	0	0	+	0	0	+	0
9	0	0	+	+	+	0	+	+
10	0	0	+	+	0	0	+	0
11	0	0	+	+	+	0	+	0
12	+	0	+	+	0	0	+	0
13	+	0	+	+	0	0	+	0
14	0	0	0	+	0	0	+	0
15	0	0	0	+	0	0	+	0
16	0	0	0	+	0	0	+	0
17	0	0	0	0	0	0	0	0
18	0	+	+	0	0	+	+	0
19	0	+	+	+	+	0	0	0
20	0	0	0	0	0	0	0	0
21	0	....	+	0	0	0	+	0

SPLITTING

In much of the writing about fig diseases the term 'splitting and souring' is used in a manner which assumes *a priori* that these phenomena are necessarily concomitant and due to a common cause. This is a very natural assumption, since split figs are usually attacked by swarms of scavenger insects and thereby become infected with the usual microorganisms.

Condit (1918) discusses the behavior of different varieties of figs as to splitting and also suggests the possibility of selecting individual trees which are free from this trouble. Regarding the cause of splitting he makes the following statements (1919):

If the water supply is sufficient and regular and atmospheric conditions are favorable, the fig increases in size gradually and reaches maturity without splitting. Late or irregular irrigation or any condition which brings about an abnormal supply of moisture increases the amount of water in the fruit, the cells swell due to the imbibition of moisture, and fruits that are solid-fleshed split open, since there is no room for inside expansion. Damp, cloudy, or foggy weather, during which time the humidity is high, reduces the transpiration from the leaves, and this in turn increases the amount of water in the fruit, resulting in practically the same conditions to cause splitting as have just been described. The humidity increases and the proportion of split figs increases from Merced County north toward the Bay region.

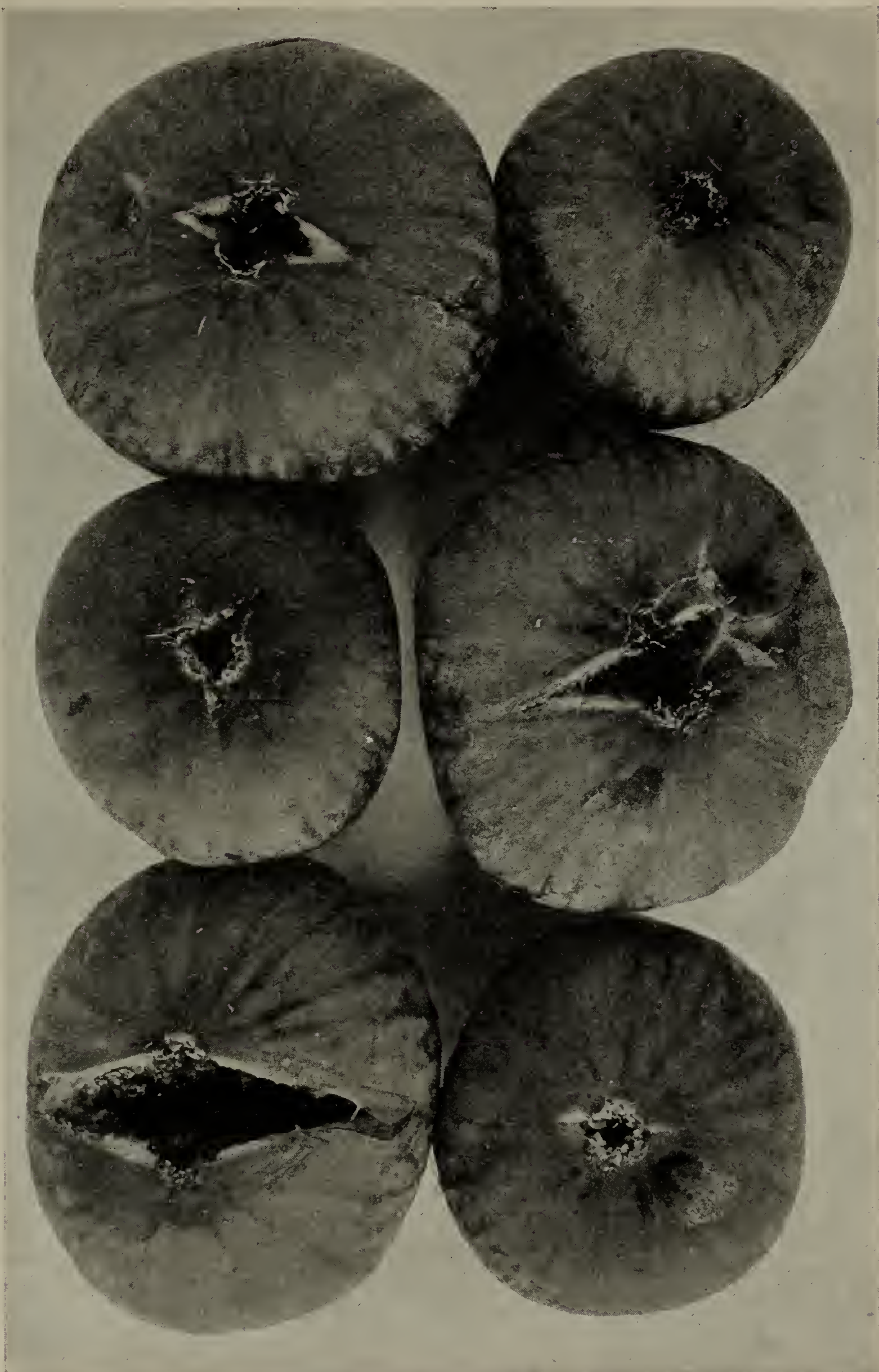

Fig. 24.—Calimyrna figs showing first stages of splitting. Also affected with endosepsis. (From Hilgardia, Vol. 2, No. 7.)

Coit (1921) makes the following statement: "It is evident that splitting is a purely physical phenomenon due to the inherent weakness of the Smyrna fig and its inability to withstand the turgor arising from excessive sap pressure. High sap pressure in the fig is caused by failure of the leaves to evaporate the water as fast as it is taken in by the roots. In normal weather, splitting occurs at night when low temperatures, high humidity, and lack of sunlight greatly reduces the evaporation from the leaves." No data have been published to support this conclusion, although a considerable amount of evidence was obtained by Coit and J. C. Johnston upon this point. It is borne out by the experiment of Phillips, Smith, and Smith (1925), in which fig trees were enclosed in a cheese-cloth cover (fig. 17), where it is stated that: "A fact of interest was the splitting of a large number of figs under the tent while outside no splitting was noticed in this orchard. . . . . The temperature in the tent was somewhat lower than outside and the humidity greater. Condensed moisture on the fruit and foilage was frequently noticed under the tent." The conclusion from this experiment would be that splitting is governed by atmospheric humidity rather than by soil moisture.

They state further, "The most striking result of this experiment was that no souring occurred in either tent although it was abundant on all the neighboring trees on the outside." This demonstrates that splitting and souring do not necessarily accompany each other or result primarily from the same cause.

The universal occurrence of splitting in the Calimyrna crop of Stanislaus County after September 1, 1930, contrasted with the comparative freedom from this trouble in Merced County, thirty miles south, lends weight to the idea that climatic conditions are responsible for splitting. In both these districts many orchards were comparatively free from endosepsis and at the time of the examination made in August 27–28, 1930, and referred to on page 70, the figs were nearly 100 per cent sound. A month later practically every ripe fig in the Stanislaus County orchards was in the condition shown in figure 25, whereas in Merced County there was still very little splitting. Lower temperature and greater humidity in the more northern district seemed to be the most obvious explanation of this difference.

Splitting is ruinous to figs, both in itself and also on account of the fermentation and molding which are introduced by insects which swarm into the exposed flesh. In certain districts, apparently from climatic reasons, a large proportion of the Calimyrna figs start to split every year about the first of September or the latter part of

Fig. 25.—Calimyrna figs ruined by splitting. (Upper photo by Condit.)

August. This attracts swarms of dried fruit beetles and vinegar flies. Soft, wet decay, fermentation, and souring follow, and for the remainder of the season the figs are a complete loss. No treatment or control method can be conceived which would prevent this if the splitting of the figs is really due to atmospheric humidity. The production of good figs is physically impossible under such conditions and no reasonable hope can be held out that fig growing (at least of susceptible varieties like the Calimyrna and Adriatic) can ever be made a successful industry.

MOLD

A common defect in dried figs is that called mold, where the inside flesh of the fig is more or less completely destroyed and discolored and shows visible fungus growth. Molds of various colors—white, black, green, brown, and yellow—are of common occurrence. That such molds start to develop in figs when they are still on the tree is shown throughout all the work reported on in this publication. The fact that all the fig-entering insects (*Carpophilus, Drosophila,* thrips, mites, etc.) discussed in connection with various diseases carry spores of many different molds (*Aspergillus, Hormodendrum, Cladosporium, Rhizopus,* etc.), as well as those of more specific pathogenes, has been well demonstrated. It therefore seems logical to assume that infection with these molds is brought about by insects. In cases where no dried fruit beetle can be found, it is a general rule that figs with mold (including the black smut, *Aspergillus*) may be abundant, but the wet, dripping, soft, gassy type of fermentation or souring does not develop. The relation of mold to sunburn will be discussed in the next paragraph.

SUNBURN

In the interior valleys figs are often injured by high temperatures, as shown in figure 26. The end or side of the fig is killed and becomes dry and hard. This is a decided injury to the quality of the dried fig. Those which are burned in the end are called 'round heads' because the dry, hard end does not soften in drying but remains round and hard. Those which are so badly burned as to kill practically the whole fig become hollow and dry and are called 'puff balls.' Beside the direct injury from the dry, dead tissue in sunburned figs, more loss is caused by the fact that a high percentage of them become infected internally with molds, which further lowers the grade.

Sufficient irrigation offers the only possibility of preventing sunburn and the mold which follows it. On stunted trees in shallow soil in a hot climate it is unavoidable.

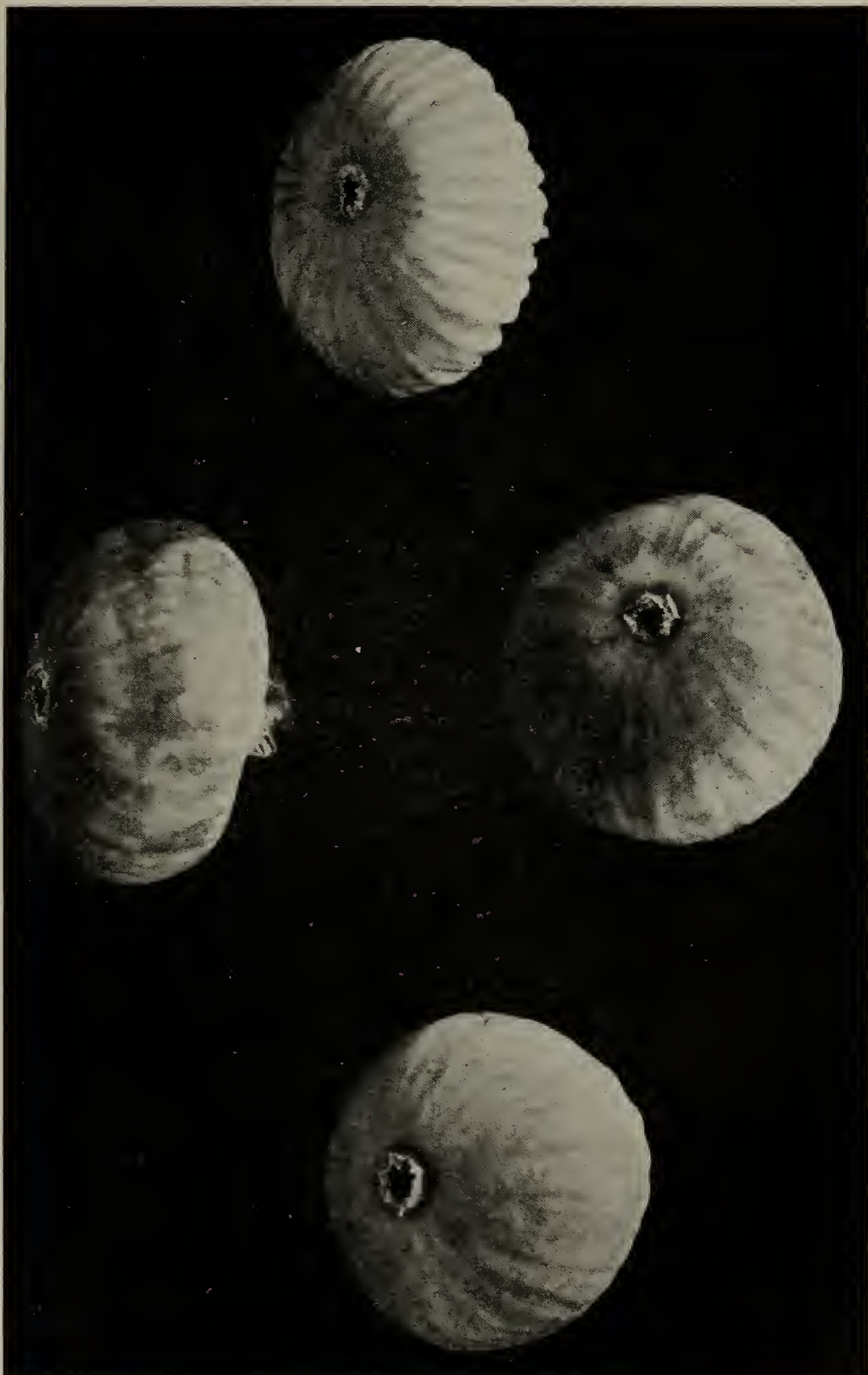

Fig. 26.—Figs injured by sunburn, caused by high temperature and drought. This injures the figs and also causes them to mold on the inside.

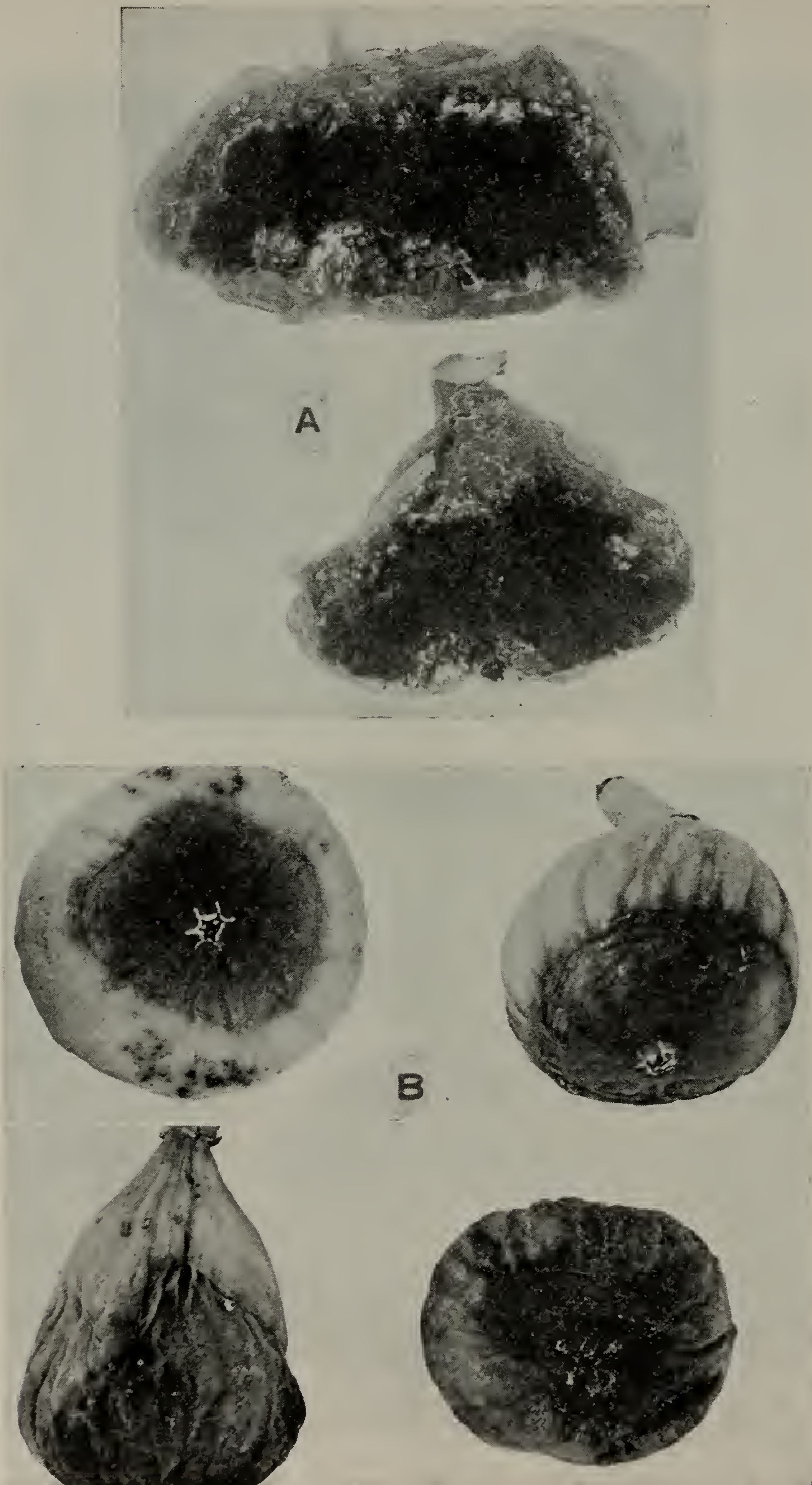

Fig. 27.—Fig smut. *A*, Interior, mature figs. *B*, Exterior fresh figs on tree. (From Bulletin 387.)

SMUT

The so-called 'fig smut' is a characteristic infection with one of the many molds which infest the ripening fig fruit. This is the common black fungus, *Aspergillus niger* v. Tieg. (figures 28, 29). The disease was described in Europe in 1867 (Reichardt) and in California in 1918 (Hodgson). Phillips, Smith, and Smith (1925) who investigated the disease thoroughly, describe it as follows:

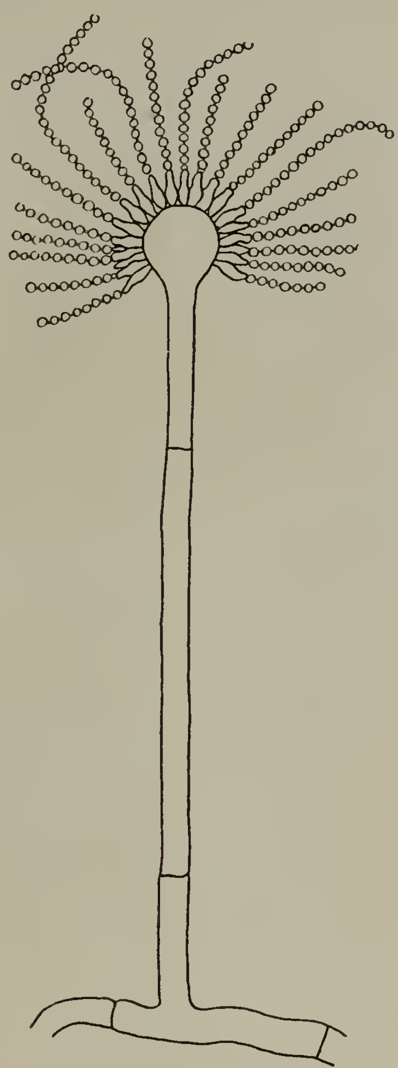

Fig. 28.—Typical spore head of the smut fungus, *Aspergillus* (much enlarged). (From Bulletin 387.)

Typical smut in dried figs occurs as a black, powdery mass in the pulp of the fruit [fig. 27]. This mass is composed of fungus spores. On squeezing such fruits the spores shoot out for a considerable distance from the eye in a black cloud, while fruits less affected show dark or yellowish spots in the pulp with no spores. The skin of many of the badly smutted figs has a dark, translucent appearance by which they are easily picked out, but others, especially those with pulp only slightly affected, show no external evidence of disease, and so reach the market. It is only on tearing open such figs that the smut is discovered. Tests have shown that smutty figs are not injurious when eaten, but the appearance of such figs is disgusting, and the finding of one in a package is often enough to cause the whole lot to be thrown away and the purchaser to hesitate before again buying California dried figs. The discovery of a smutty fig in the preserved, fresh fruit by cutting into it with a spoon and seeing the inky contents run out into the clear syrup, is even more disgusting. This has a serious effect on consumption, although the number of smutty figs occurring either in packages of the dried fruit or in the preserved products is extremely small and the actual loss of material is insignificant.

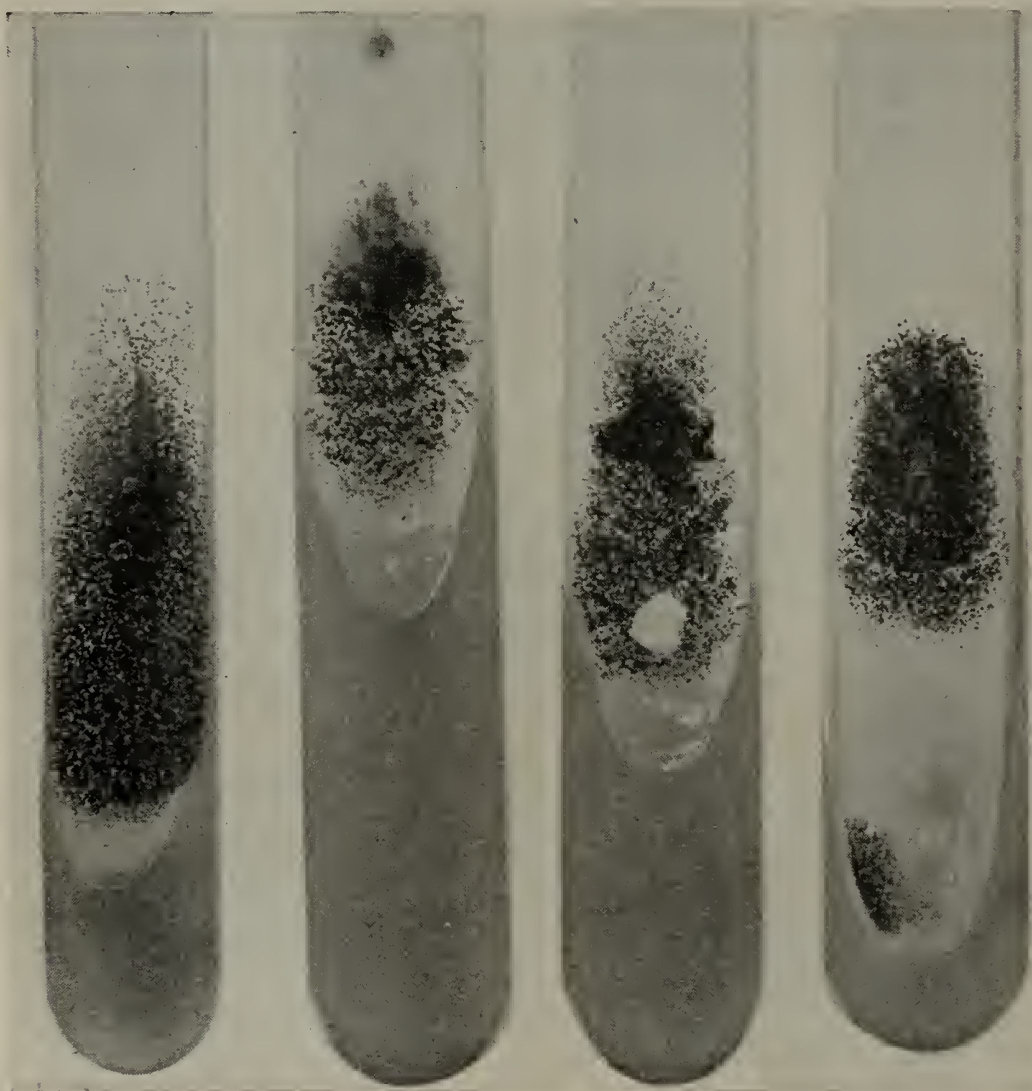

Fig. 29.—Cultures of fig smut fungus, made from pulp of figs of type 5 (natural size). (From bulletin 387.)

Phillips, Smith, and Smith showed that infection occurs while the figs are still on the tree but not until the eye opens at about stages 4–6 (see figs. 3, 4, 5). Previous to this stage they found the interior of uncaprified figs to be sterile. These investigators believed that the infection is spread largely by the *Carpophilus* beetle, which they found breeds commonly in the fig districts on all sorts of decayed vegetable matter (see fig. 18). The specific fungus concerned was found to be abundant on such material and also on the bodies of the insects, both before and after they entered the figs (fig. 19). It was therefore concluded that the control of smut would depend largely upon sanitary measures to eradicate the breeding material of the beetle.

The more recent work on souring relative to the thrips problem has shown that this insect is also a frequent carrier of smut spores and may be an important agent in transmitting this disease.

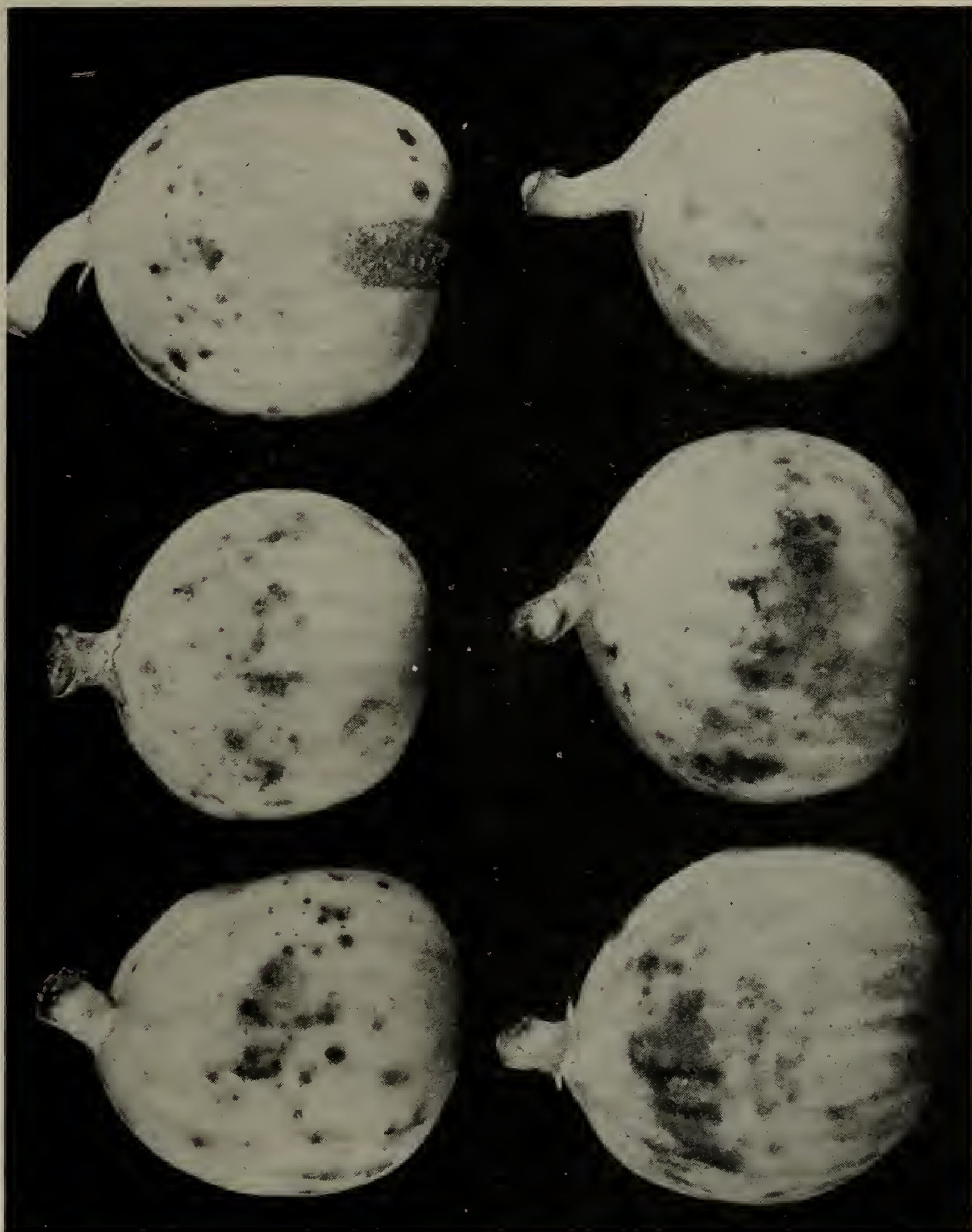

Fig. 30.—'Mildew' or 'black spot' of the Kadota fig, a fungus infection which develops after early fall rains and spoils the fruit for canning.

SURFACE SPOTTING OF FIGS

Figure 30 shows the so-called 'mildew' or 'black spot' of the Kadota fig, which sometimes disfigures a considerable amount of fruit and spoils it for canning purposes. This condition develops after summer rains or periods of high humidity which sometimes occur in

August or September in the San Joaquin Valley. If there is a good deal of moisture, considerable spotting may develop on the figs while they are still on the tree. Besides this, much fruit becomes affected while in boxes in transit to the cannery. At certain times during the season almost all figs of the white varieties will develop this spotting if they are confined in a moist chamber.

Cultures of a fungus, a species of *Alternaria*, have been obtained from affected figs and typical spots have been produced by inoculating Kadota figs with this fungus.

To prevent the spotting of the figs while on the tree, spraying with a fungicide immediately after rain would be necessary. Bordeaux mixture could not be used because the dried residue would disfigure the fruit. Sulfur in any form is undesirable because it is liable to affect the cans in which the figs are packed. The so-called ammoniacal copper carbonate spray, which is a clear solution, might be tried, and may be prepared as follows:

Copper carbonate	6 oz.
Ammonia	3 pints
Water	50 gals.

First dilute the ammonia with about five times its volume of water and dissolve the copper carbonate in this. It is better to leave a little of the carbonate undissolved than to have an excess of ammonia. Then add the remainder of the water. The commercial spray material called Borco may be substituted for this material, being of a similar nature.

Dense-topped Kadota trees having the fruit covered with a mass of foliage are more likely to develop this trouble, and on such trees it would be difficult and expensive to cover the figs with spray. A change in the system of pruning might be necessary in certain districts if the spotting of the fruit becomes a common thing. To prevent the figs from spotting while in transit to the cannery, they should be kept as dry as possible and should not remain in lug boxes any longer than necessary. A process of dipping the figs in a weak fungicidal solution might be developed, but this would complicate handling and add to the expense. Great care would be necessary not to do anything which would interfere with the canning process.

Figure 31 shows another surface spot which was common in Calimyrna figs in 1929. This developed where figs were in close contact with one another, growing in clusters. A brown mold, another species of *Alternaria* or similar fungus, was present in these spots and appeared to be the cause. The injury was superficial, never penetrating through the outer wall of the fig.

It is to be hoped that this spot will not develop sufficient importance to require control treatment.

Fig. 31.—'Contact spot' of Calimyrna figs, caused by fungus development at points where closely-clustered figs touch each other.

ENDOSEPSIS

During the earlier work on fig-spoilage diseases by Coit in 1920 and Phillips, Smith, and Smith in 1920–22, mention was occasionally made of a 'new' fig disease affecting the Calimyrna variety. This disease was variously referred to as 'pink rot,' 'brown rot,' 'soft rot,' and 'internal rot.' Caldis described it as follows:

The disease manifests itself internally as soon as the figs begin to ripen. In severe cases, even before the pulp sweetens and just as soon as the stalks and the sepals of the individual florets swell and begin to color, brown streaks may be seen running down the flower stalks almost to the meat. As the fig ripens such streaks develop into spots, yellow-brown in color, and may involve a number of flowers. In most cases these colored spots are first found in the pulp near the eye of the fig, but any other part or parts of the pulp may develop this symptom according to the locus of infection. In very early stages, just as the fig begins to sweeten, these spots stand out very clearly against the bright-colored healthy pulp. [Figure 32] shows six figs, five of which are at the same stage of maturity and alike in external appearance, firm, and bright green, just at the stage when figs are picked for canning or for fresh shipment. From their external appearance all five could be taken for sound ripe figs. Fruit *a* represents a healthy fig at this stage of maturity. The pulp should be bright amber to pink, with a small amount of sweet juice in the cavity. Fruits *b, c, d,* and *e* show the endosepsis symptoms at different stages of development. In fruit *b* the brown includes almost the entire mass of flowers in the vicinity of the eye, in the third fruit the browning includes three-quarters of the pulp, in the fourth all but few flowers at the stem end are involved, and in the fifth the entire pulp is disintegrated. Such pulp is slightly watery and is easily pulled away from the meat. Until this last stage is reached, and even later, there is almost no external sign of this diseased condition of the pulp.

When the fig softens and begins to dry, a water-soaking of the skin appears in indefinite areas, mostly around the eye in a circular spot, or extending down the sides to the neck of the fig. This water-soaking gradually assumes a bright pink or purple color and the epidermis of the fig may easily be rubbed off on such water-soaked spots [fig. 24]. The fig may dry in this condition and fruit *f* in [figure 32] and the fruits in [figure 33] represent such dried figs. These pink spots should not be confused with the pink spots produced by *Aspergillus niger* van Tiegh., the black-smut organism of the fig, as described by Phillips, Smith, and Smith. In the case of the internal rot the spots are not very wet and the margins are not shrunk and have not the tendency to be easily detached from the rest of the skin as in the black-smut spots. In the internal rot they appear as normal skin except in color. It is not always, however, that such colored spots appear on the decaying figs. Under favorable weather conditions the figs dry before they reach the stage of external symptoms, and undoubtedly even before the entire pulp is decayed. In many cases only a small water-soaked ring appears around the eye and a drop of liquid is exuded, varying in color from clear to caramel. This exudate is never in sufficiently large quantities to drip and soil the foliage or solidify in long hanging drops, as is the case in souring. [Caldis, 1927.]

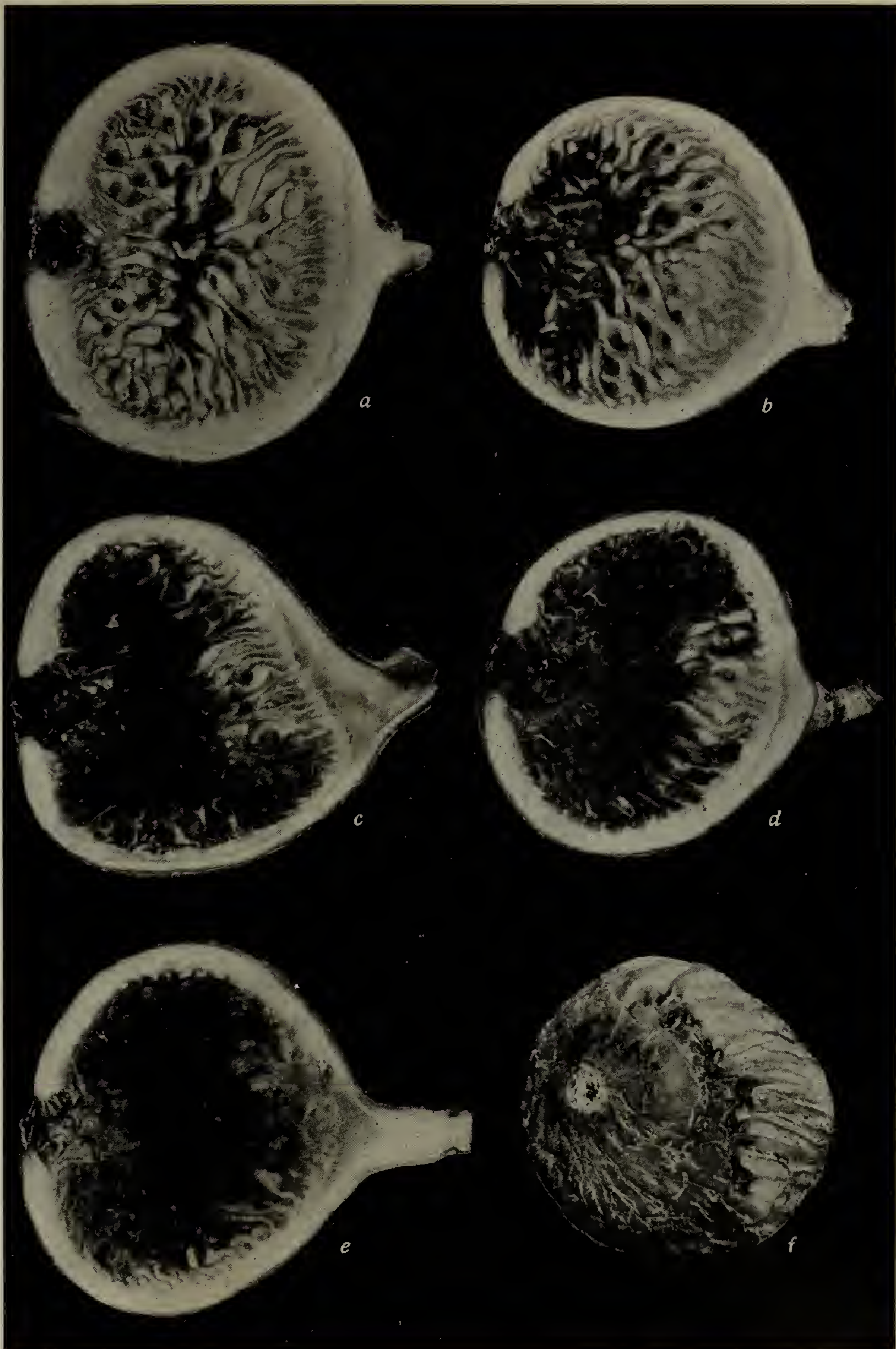

Fig. 32.—Calimyrna figs at stage of maturity ready for picking for fresh shipment or canning, showing progressive internal symptoms of endosepsis. External appearance normal in the first five. *a*, Normal fig. *b*, Flowers around the eye diseased. *c*, Three-fourths of the pulp diseased. *d*, Seven-eighths of the pulp diseased. *e*, Entire pulp diseased. *f*, External symptoms, meat invaded. (From Hilgardia, Vol. 2, No. 7.)

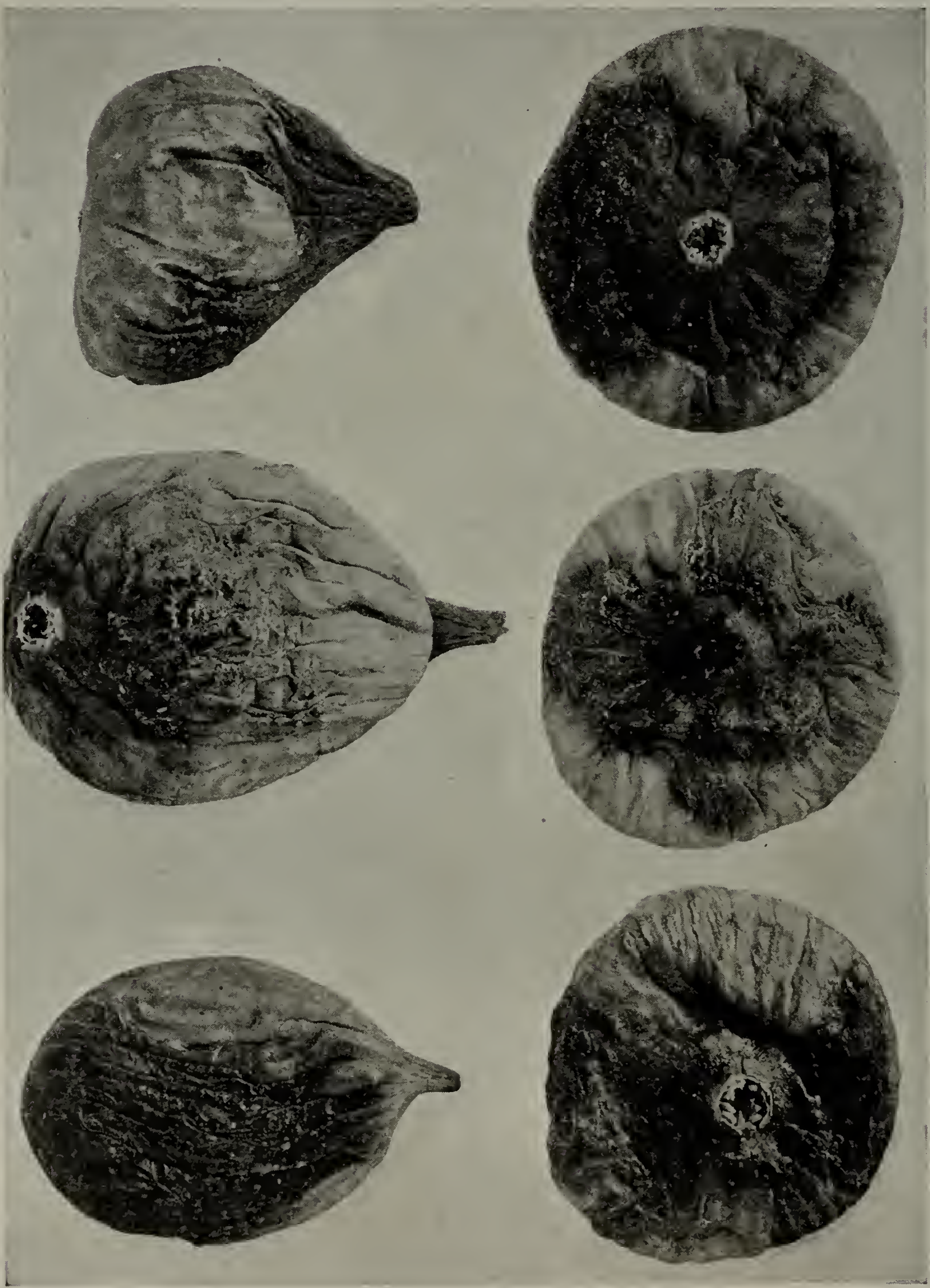

Fig. 33.—Dried Calimyrna figs showing external symptoms of endosepsis. The dark watersoaked spots are pink, red, or purple in color. Notice the small drop of gum at the eye of one fig. (From Hilgardia, Vol. 2, No. 7.)

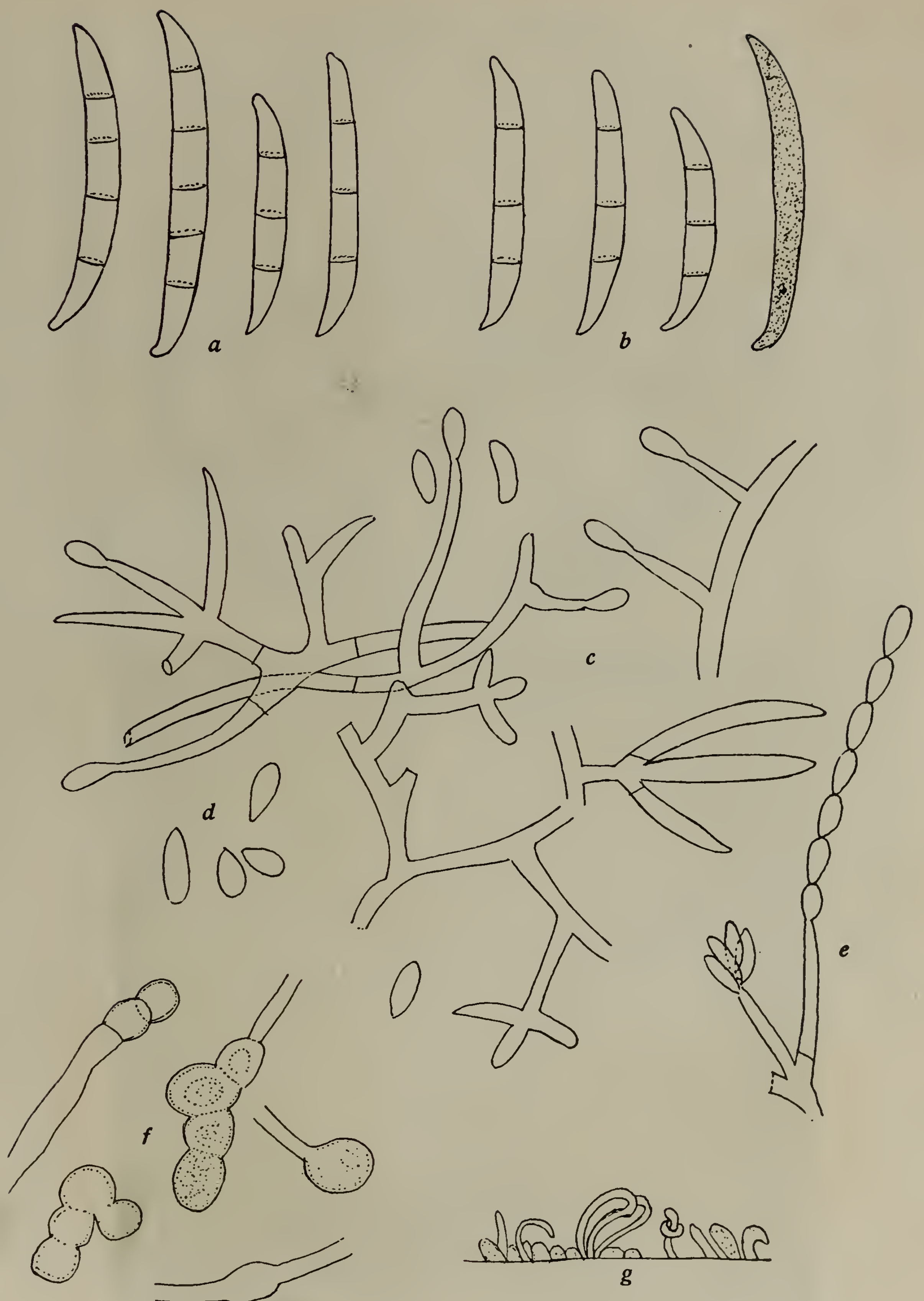

Fig. 34.—*Fusarium moniliforme* var. *fici* n. var. *a*, Macroconidia from sporodochium on autoclaved cornmeal (× 782). *b*, Macroconidia from sporodochium on blackberry stem (× 782). *c*, Conidiophores and microconidia. *d*, Microconidia. *e*, Microconidia in chains and loose heads. *f*, Pseudochlamydospores (× 782). *g*, Sporodochia on autoclaved cornmeal. (From Hilgardia, Vol. 2, No. 7.)

A

B

C

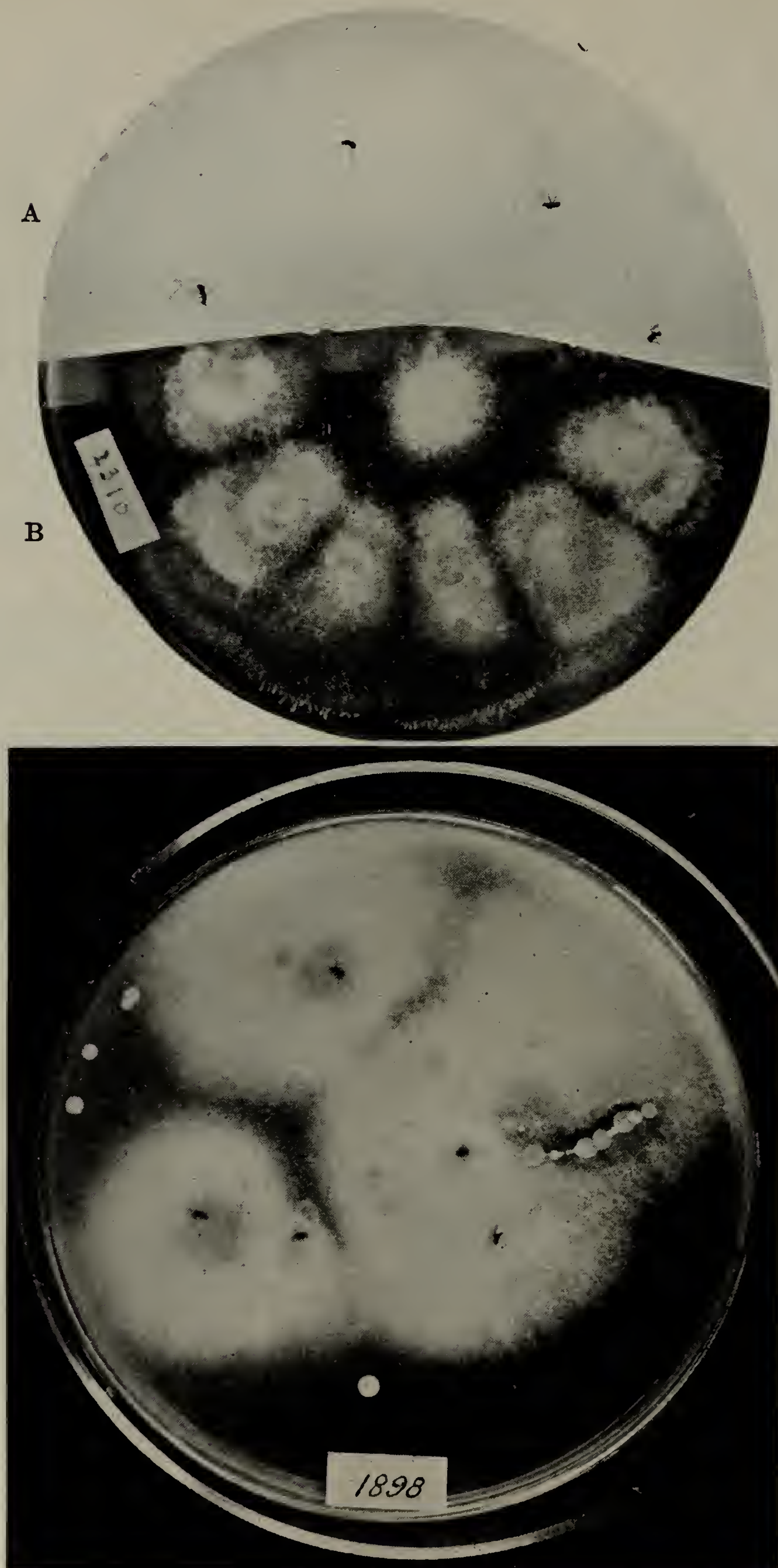

Fig. 35.—Culture plates showing, *A,* a section of a plate with insects from disinfected mamme fig, with no fungus growth (the blastophaga on the left shows a slight development of bacteria); *B* and *C,* the growth of endosepsis fungus from blastophagas from untreated figs. (From Circular 311.)

Boncquet (1921), in a newspaper article, discussed what, at least in part, was probably this disease and described as its cause a fungus which he calls *Cylindrotrichum fici.* The meagre description of this fungus suggests that it is the same organism which Caldis later described as *Fusarium moniliforme* var. *fici,* and proved to be the cause of endosepsis.

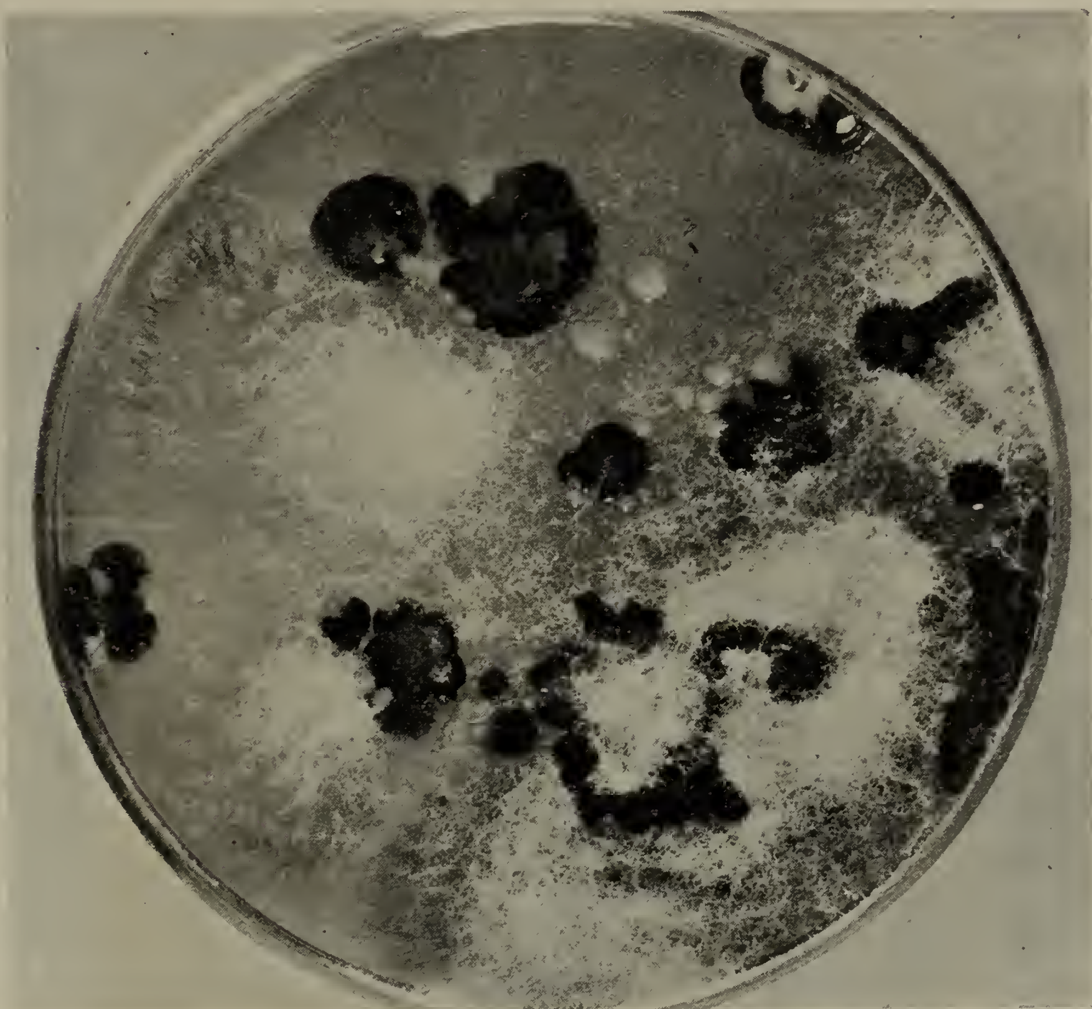

Fig. 36.—Typical flora of a caprified fig, showing the three characteristic organisms. (From Hilgardia, Vol. 2, No. 7.)

Caldis (1925, 1927) in 1922, 1923, 1924, and 1925, thoroughly investigated this trouble, naming it endosepsis and establishing the fact that it is caused by the specific fungus just mentioned (fig. 34). He found that this fungus occurs almost universally in caprifigs and is transmitted from fig to fig by the indispensable pollinating insect, blastophaga (fig. 35). The organism first establishes itself on the dead stigmas of the florets, in the pollen of the profichi, and finally fills the caprifigs entirely with a white mold when they are old and spent. He states:

The fungus overwinters along with the blastophaga in the mamme fig. In April the adult females carry the spores of the fungus into the profichi where they germinate and grow on the stigma of the gall flowers and the body of the dead insect. In June the adult females come out of the profichi carrying spores of the fungus on their bodies. Some of these females enter Calimyrnas and infect them, others enter mammoni caprifigs, where they carry the infection and lay their eggs. The blastophaga coming out of the mammoni transmit the infection to the mamme in September and the cycle is completed.

Caldis also found two forms of bacteria constantly associated with caprified figs and on the bodies of the blastophaga.

Plate cultures from the pulp of a diseased fig which has not been exposed to the atmosphere always yield a typical growth or rather a group growth, which consists almost exclusively of the fungus mentioned and of a cream-colored and a bright red bacterium. This association has been found to be remarkably constant. It may be said also that both bacteria have been obtained from figs irrespective of disease symptoms, and in all stages of maturity, but not previous to caprification.

Figure 36 shows the typical flora of caprified figs and blastophaga.

No pathogenic significance was found to be attached to the bacteria mentioned, but their constant association with the blastophaga and with the interior of caprified figs has been frequently corroborated by the present writers.

Caldis attempted to find fungus-free individual caprifigs from which clean colonies of blastophaga might be built up, but the latter has never been successfully accomplished.

Control of Endosepsis by Disinfection of Caprifigs.—Hansen (1927, 1928) in 1926 conceived an entirely new idea in the control of endosepsis, namely, that of treating the interior of the caprifigs with a fungicide in such a manner as to destroy the fungus on the exposed floral parts and surface tissues without injuring the blastophaga in the galls or destroying the caprifigs themselves.

Injection Method.—The first work was described (Hansen, 1927, p. 199) as follows:

When the writer took over the control problem in July, 1926, it occurred to him that it might be possible to apply to the interior of the caprifig a fungicide which would be strong enough to kill the fungus without injuring either the fig itself or the insects still in the galls. In order to test out this possibility the following experiment was carried out: A large number of caprifigs (mammoni) were treated internally with the following fungicides: mercuric chloride, 0.05 per cent; formaldehyde, 0.2 per cent; mercurochrome, 0.1 per cent; Semesan, 0.2 per cent; and commercial lime sulfur, 5.0 per cent. Injections were made with a hypodermic syringe through the eye of the fig not less than three weeks after the fig had been caprified so that the insects would be either in the larval or pupal stage and therefore well down in the center of the gall. Treatment with the above-mentioned fungicides had apparently no adverse effect on either the figs or the blastophaga, as the figs matured normally and the insects emerged at the proper time.

Treated figs were removed from the trees and cultured on nutrient media at intervals of three weeks after treatment up to the time of maturity when the emerging blastophaga were caught and also cultured. An equal number of untreated figs and blastophaga from untreated figs were cultured as checks. The following results were obtained: All the treated figs and the insects emerged from them were found to be free from *Fusarium moniliforme* Sheld. var. *fici* Cald.; all the untreated figs and the insects emerged from them were found to be 100 per cent infected with the fungus.

Dipping Method.—Further experience suggested a modification of this method (Hansen, 1928).

Notwithstanding the effectiveness of the injection method, it was found to have some very serious limitations that make it undesirable for use on a large scale. The operation requires considerable skill and very great care, making it a slow and tedious affair. Because of internal structure (solid center) most varieties of caprifigs cannot be treated by this method. To be effective, injection must be done over a short period of time, preferably within six or eight week after the figs have been caprified, and finally, when injecting a large number of figs on a tree, a few might easily be overlooked and left untreated to start infection over again.

On account of these difficulties the dipping method was developed in 1927. This consisted in gathering the mamme figs from the trees when they were mature and ready to discharge the blastophaga, splitting them in two, and dipping them in the fungicide. Although complete sterilization could not be effected in this manner, the development of the endosepsis fungus could be retarded for several days, giving time to hang the pieces of mamme figs in the trees and allow the blastophaga to function without contamination. This method was tried on an orchard scale and proved successful and practical.

Methods Used in State-wide Endosepsis Clean-up of 1928.—In 1928, on account of the almost total loss from endosepsis of the Calimyrna crop of 1927 and the promising results of the control method just described, a demand arose for concerted action to attempt to control this disease simultaneously over the whole interior valley, or in fact in all parts of California where Calimyrna figs are grown. This effort had the almost unanimous support of the fig industry and was shared by the California Peach and Fig Growers, Inc., the California Dried Fruit Association, State Department of Agriculture, County Horticultural Commissioners, Agricultural Extension Service, and the Agricultural Experiment Station.

In order to accomplish the desired result of state-wide control it appeared, in light of the difficulties already mentioned, that neither the injection nor the dipping method could hope to succeed; the former on account of the slow and laborious nature of the operation; the latter because of the impossibility of leaving all the mamme figs on the trees until the insects begin to emerge and the uncertainty of getting the dipped caprifigs removed from the trees at the end of a four-day period.

Fig. 37.—Dipping split mamme figs for use in insectary method of obtaining clean blastophagas. Insectary containing incubators in the background. Photo by Clifford Clower, California State Department of Agriculture.

During the campaign of 1928 practically all the mamme figs in California, amounting to about 60 tons, were removed from the trees during the months of February and March under the supervision of the various County Horticultural Commissioners. These figs were shipped to a central insectary at Fresno and placed in storage in a cool warehouse in fruit lug boxes. Considerable difficulty was experienced in keeping these figs in good condition on account of mold and decay which attacked them very seriously. This was found to be preventable to a large extent by sorting the mamme figs very carefully before storage and removing all bruised, defective, or partly frozen ones. It has long been known that mamme figs may be gathered even as early as December and stored through the winter without destroying the insects or seriously hindering their normal development. The principal problem involved is that of the proper degree of humidity and temperature in storage to preserve the insects and figs in good condition and keep the latter from rotting.

Fig. 38.—Interior of insectary, showing steam-heated incubators in which the mamme figs were placed after splitting and dipping, with glass tubes in which blastophagas were collected. Photo by Clifford Clower, California State Department of Agriculture.

The figs were removed from storage as wanted and preheated in a small room for 24 hours at 85° F to stimulate the insects; they were then split and dipped for 15 minutes in 0.2 per cent Semesan (fig. 37), then placed in steam-heated incubators from which the blastophaga emerged into 1 by 8 inch glass test tubes (fig. 38). In this state (fig. 39) the insects were distributed to the orchardists, using care to keep the tubes cool and dark. When used for caprifying the profichi, the tubes were opened and hung on the branches or the insects were shaken out into shallow fruit baskets placed in the caprifig trees. More than 100,000 tubes containing 500 blastophaga each were distributed in 1928.

This method had the advantage of permitting scientific exactitude in testing the blastophaga for the endosepsis fungus and keeping the mamme figs, with all danger of reinfection, entirely away from the trees. It had the disadvantage that when caprification was practiced these delicate, sensitive insects had to be put out into the open without the protection afforded by the cavity of the fig during the normal automatic adjustment between climatic conditions, the maturity and emergence of the blastophaga, and the receptivity of the profichi. Thus it frequently happened that after the insects were liberated, weather conditions became unfavorable for them to function. More knowledge of the technique of handling the blastophaga to keep them in a vigorous condition would improve this situation.

Shortage of Crop.—The most outstanding feature of the whole situation in 1928 and the one which had probably the most immediate influence upon the grower was the fact that the final number of tubes ordered was from five to ten times greater than the original estimates. This resulted in a rushing and upsetting of the plan and schedule of the campaign and a large deficiency in filling the total orders. This again resulted in a short crop of profichi, a short crop of Calimyrnas, and disappointment to many growers. Regrettable as this was, it was not in itself a serious factor in the broad question of finding a permanent method of handling the fig situation, particularly in view of the fact that in many cases the total crop of *good* figs was greater in 1928 than it had been in 1927.

Going over the campaign in detail, the facts given in the following paragraphs stand out as having affected the final result:

Removal of Mamme Figs.—It is almost unbelievably difficult to remove all the mamme figs from a tree. This being true even under the most favorable circumstances, it is easy to understand what happened in cases where the owner was rather indifferent or where he was actually hostile and opposed to the removal of his mamme figs. Comparatively few trees were stripped of absolutely every mamme fig, even where the intentions were of the best. Many more were left through carelessness, while in the orchards of 'conscientious objectors' it is even possible that some trees were not stripped at all or very indifferently.

Disinfection of Mamme Figs.—Numerous tests showed that when carefully and properly performed, the dipping process retarded the fungus in the mamme figs so that the blastophaga emerged in a clean condition. It would be rash to say that this was 100 per cent perfect in every batch treated during the height of the rush and confusion of the campaign.

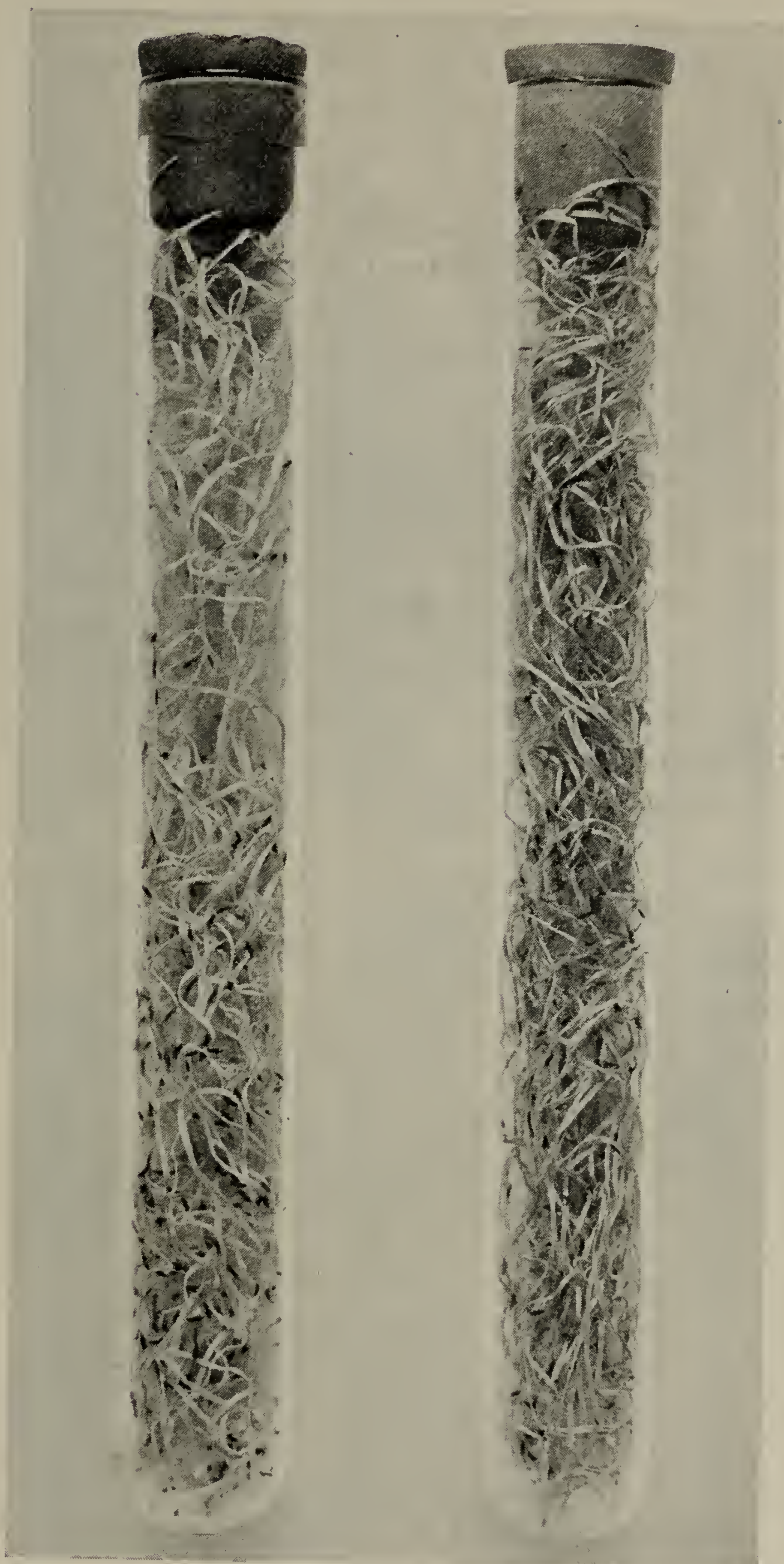

Fig. 39.—Clean blastophaga in glass vials as used in insectary method to caprify profichi crop. (From Circular 311.)

Caprification of the Profichi.—Much variation in results developed from varying conditions at the time the insects were put out in the trees to caprify the profichi crop. In some cases a normal number of figs was set by the number of insects contained in a tube. Again the condition of the weather or that of the insects or that of the profichi was such that not much caprification was obtained from the tubed insects. Meantime the condition discussed above existed, namely, that some mamme figs were left on many trees. It was impossible in a great many cases to say positively that certain trees were caprified entirely with tubes, even though tubes of insects were placed in the trees. More profichi may have been set by the insects from even a very few mamme figs left in the tree than those from the limited number of tubes which were used. Doubtless many profichi, also, which had been caprified by tubed insects, were entered and infected by blastophaga from untreated mamme figs. It was rumored that some growers purposely left a considerable number of mamme figs on their trees and that others picked the mammes but did not send them to the insectary. These were stored at home and were later used without disinfection, or, in a few cases, the owner dipped them himself, apparently with considerable success. Some growers conscientiously removed their mamme figs and depended solely upon the tubes of blastophaga which were regularly allotted to them. A few were able to obtain extra tubes and correspondingly more insects. Some used mamme figs which had not been disinfected. Thus the actual condition of the profichi was more or less uncertain in most cases.

Caprification of Edible Crop.—The profichi were used in the customary manner except that where a shortage existed they were in some cases distributed more sparsely than usual. In other instances they were concentrated on a limited number of trees and no attempt was made to caprify the whole orchard. The setting of the edible crop was governed mainly by the number of profichi used, which varied greatly. Some growers used only the profichi which resulted from the number of tubes of blastophaga which they were able to obtain. This, in practically every case, was much less than the amount ordinarily used. Many bought extra profichi, some claiming to have been caprified by clean insects, some frankly 'bootleg' of untreated or unknown origin.

Results of the Campaign of 1928.—Only a very general statement can be made on the results of the season's campaign, on account of the uncertainties just described. In only a very few cases could one determine with absolute certainty what the condition of the profichi was, and without such information it is useless to draw any positive conclusions from the condition of the Calimyrnas. The 'bootleg' profichi, those caprified by tube insects, and those from mamme figs left on the trees, were all mixed together in many orchards. According to fairly extensive observations, in cases where all the mamme figs had been removed and all the profichi caprified with insectary blastophaga, the grower obtained from 5 to 15 per cent of a normal crop of Calimyrnas. Where extra profichi were obtained, the size of the crop increased accordingly up to a point in a few orchards of practically a normal yield. As a general rule any orchard which bore much over 15 per cent of a normal crop could safely be assumed to have been caprified with extra (and usually untreated) profichi figs.

The quality of Calimyrnas in practically every case varied directly with the condition of the profichi according to their source, so far as could be determined. In general, the Calimyrnas were better in 1928 than in 1927 or 1926 regardless of the profichi used. This may have been due in part to light caprification, and in part to a season less favorable to endosepsis. Beyond this, however, it was plainly apparent and generally admitted that the light crops which were known to have come almost entirely from tube insects were practically 100 per cent clean of endosepsis, while in the few normal Calimyrna crops which had been obtained by the use of 'bootleg' profichi or those which came from trees that were not completely stripped of the mamme crop a large amount of rot developed. Certainly the districts or orchards where the clean-up was followed most conscientiously had the cleanest Calimyrna figs they had had for many years, and a great deal more rot developed where the campaign was opposed.

Endosepsis Clean-up of 1929.—At the end of the season of 1928 the sentiment prevailing among the fig growers of the San Joaquin Valley was almost 100 per cent in favor of the idea that control of endosepsis depends upon the use of profichi which have been freed of the causative fungus. The idea of an enforced clean-up, however, especially by a method dependent upon sending the caprifigs away for treatment to a more or less distant point, had many opponents. The use of the dipping method by individual growers as practiced in 1927 had from the first attained much popularity. Its one serious drawback had been the necessity of allowing the mamme figs to remain on the trees until the blastophaga began to emerge, thus incurring considerable danger of infection of the profichi by early-escaping insects. The discovery in connection with the insectary method that the mamme figs could be gathered early and kept in storage for a considerable time, and the insects then be caused to emerge at any desired time by the application of heat, removed this objection and greatly increased the possibilities of the general voluntary use of the dipping method by individual growers.

TABLE 10

CULTURES OF 1929 MAMME FIGS TO DETERMINE PERCENTAGE INFECTED WITH ENDOSEPSIS

One sample (usually 10 figs) represents one tree.

County	Number of figs cultured	Number of samples	Number of figs infected	Per cent figs infected	Number of samples infected
Stanislaus:					
Hansen*	421	36	153	36.34	34
Merced:					
Hansen	1,500	192	341	22.73	118
Scott†	439	44	96	21.80	35
Total	1,939	236	437	22.50	153
Madera:					
Hansen	50	3	7	14.00	3
Fresno:					
Hansen	1,546	157	181	13.26	86
Scott	417	7	42	10.07	4
Total	1,963	164	223	11.31	90
Tulare:					
Hansen	260	24	17	6.54‡	9
Scott	309	24	28	9.06	16
Total	569	48	45	7.90	25
Various Counties:					
Hansen	70	5	19	27.14	5
Scott	15	1	1	6.60	1
Total	85	6	20	23.53	6
Entire State:					
Hansen	3,847	417	718	18.66	255
Scott	1,180	76	167	14.15	56
Total	5,027	493	885	17.60	311

* Experiment Station.

† State Department of Agriculture.

‡ Most of these figs were from the caprifig orchard of the California Peach and Fig Growers, Inc., at East Orosi, where very thorough clean-up was practised in 1928.

An important factor in the prospective program for 1929 was the question of the condition of the caprifigs in the winter of 1928–29, following the 1928 clean-up. It would seem that some lessening of the amount of endosepsis infection in the caprifigs should have followed that extensive campaign. In order to test this, growers were invited to send samples of mamme figs and profichi during the spring of 1929, either to the Experiment Station or the State Department of Agriculture, for a culture test to determine the percentage of figs infected. The method adopted was to pick 10 figs from each caprifig tree to be tested. In the laboratory each fig was split open and the interior mass of galls and florets was scooped out with a sterile knife into a sterile

TABLE 11

THE FLORA OF CAPRIFIED MALE FIGS FROM COMMERCIAL ORCHARDS IN CALIFORNIA DURING THE YEARS 1922, 1923, 1924, AND 1925

	Number of figs examined	Per cent *F. moniliforme* var. *fici*	Per cent red bacterium	Per cent white bacterium	Per cent green fungi	Per cent Torula yeast	Per cent sterile figs
Mamme 1922 and 1923:							
Sacramento Section	52	30.7	13.4	61.5	....	11.5	19.2
Modesto	45	35.5	40.0	35.6	2.22	2.22	20.0
Merced	22	54.6	63.6	59.0	4.55	4.55	9.08
Fresno	29	31.0	44.8	34.5	3.45	3.45	17.2
Reedley	49	32.6	61.2	28.6	18.4	18.18	2.04
Tulare	24	41.7	70.8	62.4	4.17	....	16.6
	221						
Profichi 1923:							
Modesto	63	46.0	68.3	44.4	12.7	....	4.76
Merced	45	51.1	82.1	40.0	6.66	....	4.45
Fresno	115	40.9	65.2	18.3	10.4	....	13.9
Reedley	46	52.2	78.2	21.7	4.35	....	....
Tulare	54	46.3	92.5	38.9	3.70	....	7.41
	323						
Profichi 1924:							
Modesto	16	50.0	43.8	68.7	25.0	12.5	6.25
Fresno	43	69.8	67.4	67.4	....	....	....
Reedley	47	51.1	80.8	51.0	4.25	8.50	....
Tulare	44	25.0	43.2	51.0	....	....	6.81
Southern California	70	17.1	....	....	....	11.40	10.00
Mammoni 1924:							
Sacramento	79	55.6	....	....	....	....	....
Modesto	12	58.3	41.7	....	....	....	....
Fresno	5	100.0	....	....	....	....	....
Reedley	7	28.6	....	100.0	....	....	....
Southern California	5	60.0	....	....	....	....	....
Mamme 1924:							
Sacramento	500	59.4	....	....	....	....	....
Modesto	64	45.3	20.3	23.4	....	....	....

From: Caldis, Panos D. Etiology and transmission of endosepsis (internal rot) of the fruit of the fig. Hilgardia **2**:312. *table 4*. 1927.

petri dish. A tube of melted nutrient agar was then poured over the fig tissue and allowed to harden. The plates were then observed for growth of the endosepsis fungus. The cultures were made by Messrs. C. E. Scott of the State Department of Agriculture and H. N. Hansen of the Experiment Station, the former of whom has kindly furnished us his figures for publication in the accompanying table (table 10). These figs were mostly from trees on which an attempt at clean-up had been made in 1928. Much variation in percentage of infection will be noted, but in general the improvement over conditions existing previous to 1928 (see table 11) is very marked.

On the basis of this work it was hoped that such testing might make it possible to decide whether a given lot of mamme figs required treatment or might be used without dipping if they showed a low percentage of endosepsis. In practice, however, this did not work out satisfactorily because a high percentage of disease in the Calimyrna crop sometimes developed from a low-testing lot of mamme figs. Apparently the fungus builds up so rapidly in the profichi that an infection of, say, 10 per cent in the mamme may be sufficient to cause a high percentage of loss in the edible crop. It is noticeable, however, in comparing the amount of endosepsis found in 1929 (table 10) with the figures for profichi given by Caldis (table 11) for 1923 and 1924, that the amount of infection had been greatly reduced.

During February a series of demonstrations of the dipping method was held by the Agricultural Extension Service throughout the San Joaquin Valley. The principal effort at fig improvement in 1929 was made in Merced County. In the other counties only a few individual growers made any effort to treat their caprifigs. In Merced, under the leadership of County Agricultural Commissioner Dooley P. Wheeler and a committee of local growers, a clean-up area was formed including about 1,500 acres of Calimyrna figs in a territory of four square miles, representing the holdings of thirty growers. In another large similar fig area immediately adjoining no treatment was attempted, thus furnishing a check on the results of the effort.

The methods adopted varied somewhat in the different portions of the clean-up district or even in the same orchard, so that the results of the season's work cannot be analyzed too critically. In general, however, the mamme figs were removed from the trees as late as possible before any blastophaga emerged, which meant sometime during March. It was then necessary to store the figs for a time, which was done in open boxes in a cool, moist room or in some cases buried in sand or sawdust. When the insects were needed for caprifying the profichi crop, many growers made an attempt to preincubate the mamme figs in order to force the emergence of the blastophaga. They were kept, for instance, in a small, warm room like a bathroom for 24 hours or in a chicken incubator. The figs were then split into two or four parts and soaked for 10 minutes or longer in Semesan solution, the strengths used varying from 1 ounce to 8 gallons to 1 ounce to 4 gallons. The pieces were then hung in the trees in various containers, left for four days and then removed and either destroyed or dipped and used again. Some lots were dipped and put out a third time, the plan being never to leave them in the trees for more than four days and finally to destroy them. The details as well as the thoroughness of the above described procedure varied considerably in individual cases.

On account of a shortage of profichi due to severe frost in April, the growers of the Merced County clean-up area purchased the crop of the caprifig orchard belonging to the California Peach and Fig Growers, Inc., situated near East Orosi. This orchard, consisting of about 50 acres of the principal varieties of caprifigs, had been very carefully stripped of the mamme crop in 1928 and recaprified entirely with the insectary blastophaga in glass tubes. In order to increase the setting of profichi the Merced growers used a considerable quantity of their own mamme figs in the Orosi grove. These were all split and dipped in the usual manner. The mamme crop of the Orosi trees was not gathered and dipped because the tests had shown such a low percentage of endosepsis in them.

Outside of Merced County the principal efforts made in 1929 to prevent endosepsis by treatment of mamme figs were, so far as known to us, those of several growers in Stanislaus County and a few in Fresno and Tulare counties. Most of the others depended on the low percentage of infection in the mamme crop resulting from the 1928 clean-up to carry them through or left the whole matter entirely to chance.

Results of Endosepsis Control of 1929.—The positive results of the efforts made in 1929 to control endosepsis by the dipping method were in almost every case pronounced and easily recognized. Late in August a trip was made through the fig districts of the San Joaquin Valley and the Calimyrna figs, which were just beginning to drop, were tested in a number of representative orchards in the following manner: All the figs on the ground under a number of trees were picked up and thrown together in one pile and thoroughly mixed. From these 100 figs were picked out at random. At this time endosepsis was the only disease present in most cases and the number of figs in the sample which showed the typical pink ends, brown flesh, and characteristic odor was counted. The following results were obtained:

TABLE 12

AMOUNT OF ENDOSEPSIS IN TREATED AND UNTREATED CALIMYRNA FIG ORCHARDS, AUGUST 26–29, 1929

County	Orchard	Mamme figs dipped (?)	Per cent endosepsis
Merced	A	Yes	0
	B	Yes	2
	C	Partly	14
	D	Yes	0
	E	Yes	2
	F	Yes	4
	G	Partly	8
	H	Partly	18
	I	No	32
	J	No	40
Fresno	K	Yes	0
	L	No	40
	M	No	60
Tulare	N	No	60
	O	No	50
	P	Yes	5
	Q	No	50

In Merced County arrangements were made through Mr. Wheeler to carry out a test of the dried Calimyrna figs from within and without the clean-up area on a considerable scale. The test was made by gathering from the drying trays in about seventy different orchards composite samples of 200 figs each at three different times during the harvest season (August 20–October 23), early, middle, and late. Half of each sample (100 figs) was sent to the University and the other half to Mr. B. J. Howard of the Office of Food, Drug, and Insecticide Administration, United States Department of Agriculture, who was temporarily stationed at Fresno. Most of the samples were taken by Mr. T. D. Southward under Mr. Howard's instructions.

The samples sent to Mr. Howard were graded by him by his official methods for commercial fig testing (Howard, 1929). According to this classification dried figs are graded into the following seven classes: insect-infested, moldy (including smut), endosepsis, sour, filthy (including bird-pecked), worthless, and passable. The examination is made with the naked eye or a low-power magnifier and purports to be simply a commercial grading and not a scientific diagnosis of specific diseases. In doubtful or border-line cases commercial quality governs, rather than strict pathological analysis.

In the cases of the samples sent to the University an attempt was made to identify as accurately as possible the presence of all kinds and degrees of infection regardless of commercial standards. It was found that such diagnosis cannot be made in dried figs on account of the dying out of certain organisms and the appearance or increase of others as the fig dries; consequently, the results given here will be based entirely upon the commercial grading made by Mr. Howard.

Table 13 summarizes the results of Mr. Howard's examination of 161 samples from seventy different orchards, grouped according to the treatment given for the disinfection of the mamme figs which were used for caprifying the profichi. Acknowledgment is due to Mr. Howard and Mr. Dooley Wheeler for these figures. Four classes are distinguished comprising (1) orchards in the clean-up area where all the growers applied the methods to the best of their ability; (2) individual clean-up orchards where neighboring orchards were not treated; (3) partly treated orchards where some of the caprifigs were disinfected and some not; (4) orchards in which no clean-up was attempted.

TABLE 13

AVERAGE OF RESULTS OF FIG TESTS, MERCED COUNTY, 1929, BY B. J. HOWARD

District	Number of samples	Per cent insect infested	Per cent mold and smut	Per cent endo-sepsis	Per cent sour	Per cent filthy	Per cent worthless	Per cent total bad	Per cent total passable
1	79	6.8	10.9	6.45	3.33	3.5	1.0	32.08	67.92
2	27	9.8	15.6	16.5	4.3	3.3	1.0	50.5	49.5
3	31	7.7	9.9	14.9	4.9	4.8	0.2	42.47	57.53
4	24	11.5	10.1	19.7	3.7	4.8	0.9	50.7	49.3

It will be observed that the figs from district 1, where complete clean-up was attempted, averaged only about one-third as much endosepsis as those of district 4, where no attempt at clean-up was made. The other districts showed only a slight improvement from partial or individual clean-up efforts. It will further be noted that endosepsis clean-up brought about no significant reduction in other diseases.

CONTROL OF ENDOSEPSIS: GENERAL DISCUSSION

Location of Caprifig Trees.—From every point of view, it is evident that the present practice of interplanting caprifig trees in the fig orchard is extremely undesirable in relation to the prevention of endosepsis. Failure or partial success in any of the steps about to be discussed in the process of handling the caprifigs leaves a source of continuous contamination in the midst of the edible figs. With the noncaprified varieties (Mission, Adriatic, Kadota), caprifig trees close by are an unqualified nuisance and should not be tolerated if they can possibly be dispensed with. In Calimyrnas it is often noticeable that there is more endosepsis (also more splitting) in Calimyrna trees close to caprifig trees than otherwise. This is due mainly to two reasons: First, the figs on such trees are overcaprified, and if there is a small percentage of endosepsis among the profichi the total amount of infection will be that much greater. Second, the percentage of infection

Fig. 40.—Old, spent, moldy mamme fig and fresh profichi. From mamme figs like this, blastophagas emerge over a long period and carry endosepsis infection into the profichi and thence to the edible figs.

in the caprifigs keeps increasing in the old, spent mamme (if not removed), the late profichi, and in the mammoni (fig. 40). Blastophagas keep on coming out of these and going into the succeeding crops, and also entering the edible figs all summer, even up to the time when they are nearly ripe. Thus there is a continuous danger of infection all through the season, long after caprification has been finished. Large numbers of blastophagas have actually been found entering Calimyrna figs that were beginning to soften as late as September 1, and carrying in endosepsis spores at a time when the figs were very easily infected.

Another objection to caprifig trees in the Calimyrna orchard arises in years when the caprifigs are seriously injured by frost. At such times the trees may be covered with mamme figs like those shown in figure 41. These figs are not worth gathering for dipping and caprifying the profichi, but if left on the trees they become overgrown with

Fig. 41.—Frozen, moldy mamme figs, which are worthless for dipping and caprifying, but which must all be removed and destroyed to prevent the escape of many fungus-contaminated blastophagas—an argument against planting caprifig trees in the Calimyrna orchard.

endosepsis fungus and other molds and from them emerge many heavily contaminated blastophaga. It is a difficult and expensive task to remove all these worthless and dangerous mamme figs from the trees, but when they are in the fig orchard there is no alternative if clean fruit is to be produced.

If the practice of growing caprifig trees in Calimyrna orchards is to be abandoned, the question naturally arises, where should they be planted? The small grower having not over 10 or 20 acres of land in his entire ranch would do well to have no caprifig trees at all but depend upon buying his profichi from a clean source. On a large place the caprifig trees should be as far as possible from the fig orchard.

The possibility of planting comparatively large, completely isolated blocks of caprifig trees in frost-free places where they can be grown, pruned, shaped, and handled in the best possible manner for the production of clean profichi by the methods of annual stripping and dipping of the mamme crop suggests itself more and more strongly if this clean-up method continues. The caprifig orchard planted several years ago by the California Peach and Fig Growers, Inc., near East Orosi is fairly well adapted to such a purpose (fig. 42). This is a solid planting of about 50 acres of caprifigs of different varieties in an almost frostless location. Groups of fig growers in various localities might well consider establishing such plantings at convenient, isolated points where the most careful methods could be

Fig. 42.—Caprifig orchard of the California Peach and Fig Growers, Inc., located in the foothills of Tulare County, California, near East Orosi.

applied for producing clean profichi figs. In such a case, it is possible that arrangements could be made for testing and certifying the caprifigs under state authority.

It has been suggested that for the production of clean caprifigs two well-separated plantings of trees be maintained, one (*A*) for mamme figs, and the other (*B*) for profichi. In orchard *B* the mamme figs would be entirely removed and destroyed early in the winter. In orchard *A* the mamme figs would be allowed to reach full maturity on the tree and could then be harvested, treated, and used for caprifying the profichi in B.

If such plantings were made, the caprifig trees now growing in the Calimyrna orchards could be top-worked to the edible variety.

Varieties of Caprifigs.—There are in California caprifigs of a number of named varieties, each having certain desirable or undesirable qualities, such as those relating to the size of the different crops, size of the individual figs and the number of insects produced, time of maturity, and other features. Adaptability to harvesting and dipping of the mamme crop now becomes a factor of importance in this connection. The subject is too new to permit any critical judgment of the different varieties from this point of view. It may be said, however, that a variety with large, open mamme figs, like the upper ones in figure 43, is better adapted to splitting and dipping than one with small, solid figs like the lower ones in this figure.

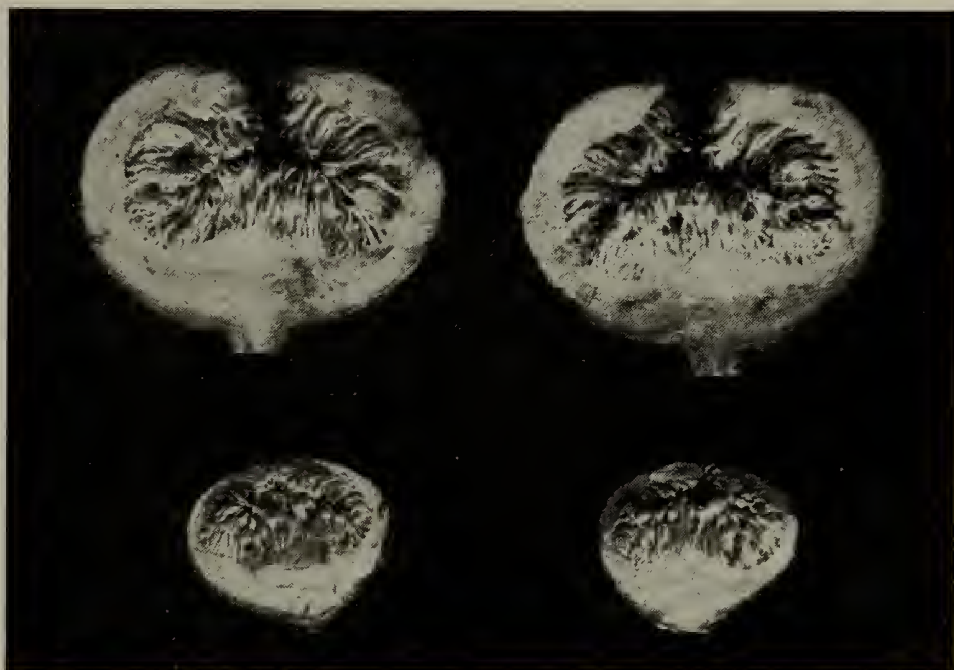

Fig. 43.—Mamme figs of two varieties, showing the internal structure and its relation to injection or dipping in a fungicide. The larger variety has a more open center and is better adapted to treatment than the small, solid figs below.

Complete Removal of Mamme Figs Necessary.—One of the greatest obstacles to the success of this method is the difficulty of getting off all the mamme figs from the trees. The reasons for this are well understood by anyone who has ever tried it. The trees are often large while the figs are small and inconspicuous. With ordinary hired help the task is absolutely hopeless, but even the owner himself seldom does a complete job except by going over the trees again and again in different lights and from different angles. Growers sometimes think that if they gather and treat most of the caprifigs, a few left on the trees will not do any harm; but they can make no greater mistake than this. A mamme fig which is removed from the tree and split and dipped is put back into the tree for only a few days and probably produces but a comparatively small percentage of blastophaga. A fig which stays in the tree, on the other hand, keeps discharging insects over a much longer period, has no loss of insects from artificial storage, splitting, dipping, drying, etc., and may during the caprifying season produce enough contaminated insects to infect a large number of profichi, each of which in turn may multiply the dissemination of endosepsis by many fold in the Calimyrnas (see fig. 40).

About the most difficult situation in this respect is presented by large, unpruned, brushy caprifig trees, from which it is physically impossible to get all the mamme figs (fig. 7). In the case of a great many such trees enough figs are left after the tree is supposed to have been stripped to set a large number of profichi, most of which are infected. For this reason pruning caprifig trees to a low spreading form and cutting the tops of large ones is advisable.

To insure the control of endosepsis a systematic method of cleaning all mamme figs from the trees must be practiced. A good method is to go over the trees limb by limb, clearing all the figs from one branch before going to another. In Merced County, where removal of mamme figs has become a regular practice, the following method has been developed: A canvas sheet is first spread on the ground, covering the space beneath the tree. A gang of men then proceed to remove all the mamme figs in sight, pulling them off by hand and also using wire hooks mounted on light poles. Following the main crew an experienced inspector then goes over the tree with the utmost care, and usually finds a surprisingly large number of figs. After that, in organized districts, other inspectors follow (and still detect an occasional mamme fig) until no more can be found. Care must be taken to pick up all figs from the ground after the canvas is lifted.

Time of Removing Mamme Figs from Trees.—Tests have been made of removing the mamme figs at different times from December to April. It has been shown in the past that it is possible to gather and store the figs through the winter, in order to avoid frost damage. In relation to endosepsis control there are two main considerations about this, and these conflict with each other. First, it is desirable to leave the figs on the trees just as late as possible in order to develop and preserve the insects normally up to the time of caprifying the profichi. Second, the mamme figs must all be removed before any insects begin to come out and enter the profichi. Theoretically it would be best to leave the mamme on until just as the first blastophaga begin to emerge. Practically it cannot be timed as closely as this because it takes considerable time to go over a number of caprifig trees and to treat the figs. All mammes should have been harvested in an average season by about March 20 in Merced and Stanislaus counties and by March 15 in Fresno and Tulare counties. As a general rule, where there is any considerable number of trees to go over, the work should be started about March 1. Unless harvesting of mamme figs is entirely finished before any insects come out and enter the profichi, the object of the operation will be defeated.

Storing and Handling Mamme Figs.—After the mamme figs are picked from the tree they must be stored in some way to keep them in normal condition until it is time to use them. First, they should be carefully sorted and all frozen, bruised, moldy, or defective figs removed and destroyed. The good ones may then be kept for some time in boxes in a well-ventilated room or cellar. The storage temperature should be as nearly as possibly the same as that outdoors. For longer storage it is better to bury the mamme figs in dry sawdust. They should be stored and handled as far away as possible from the caprifig trees and in a tight room to prevent the escape of the blastophaga.

Disposal of Surplus Mamme Figs.—All surplus, defective, or worthless mamme figs should be destroyed by burning or by some other certain method and not left where there is any chance of the blastophaga emerging and reaching the profichi. Caprifigs remain viable for a long time when lying on the ground in the winter time and no chance of infection from this source should be taken when attempting to clean up endosepsis.

Time for Dipping and Caprifying.—This should be governed by the condition of the profichi and must be determined by personal judgment rather than by any fixed standard. The size of the figs is not a safe criterion, but a certain odor or fragrance is characteristic of the receptive condition of the profichi. The condition of the mamme figs and that of the insects is also important. Under natural conditions the blastophaga do not all emerge from the mamme figs and enter the profichi at the same time, but the process is an intermittent one, scattered over many days or even weeks. When the first profichi seem to be receptive, therefore, the mamme figs should be sorted over and some of the most mature ones selected for use. This is determined by the softness of the fig and possibly the emergence of the first male blastophagas from the galls.

Incubation of Mamme Figs.—Various attempts have been made to stimulate the emergence of the blastophaga at a given time by keeping the caprifigs at a fairly high temperature, say 75° to 80° F for 24 hours or more just before splitting and dipping them. It has frequently been demonstrated that the desired result can be attained by this method; as to whether it is necessary there is some difference of opinion. On the whole it is perhaps true that in the past the insects have been hurried too much and many blastophaga have been wasted by too early emergence. On the other hand, it should be remembered that the dipped mamme figs are left in the trees for only a few days and the insects must emerge promptly if at all. The best method may be, therefore, to wait until a large proportion of the profichi are fully receptive and then warm the mamme figs for 24 hours and use a warm solution for dipping. Several successive applications of mamme figs are better than one application.

Dipping and Caprifying.—The following directions may be followed: Make a small cut into the fig, right through the eye, and break the two halves apart. Do not cut all the way through the fig, for by doing so many insects are killed and the sterilization process is interfered with. Some prefer to split the figs into quarters, leaving them attached together at the stem end, but the penetration of the solution is not as good with this method, and the interior of the fig retains moisture which favors the growth of the endosepsis fungus and other molds.

Now submerge the figs in a solution of Semesan, 1 ounce to 4 gallons of water, squeezing them gently to separate the galls and allow the fungicide to reach every part of the cavity. Let the figs remain submerged for about 15 minutes and while they are submerged squeeze them gently from time to time to eliminate any air pockets that may have formed among the galls. The dipping process may be improved by using two containers of the solution, first submerging the cut figs in one and then, as they are squeezed, transferring to the other. In this way every fig is sure to be squeezed. Five thousand figs may be sterilized in 4 gallons of the fungicide, after which it should be replaced by a fresh solution. If the solution is made with warm water and the temperature kept up to 75° or 80° F the activities of the insects will be considerably hastened. A vacuum dipping apparatus would seem desirable in order to draw out the air bubbles in the figs and obtain complete penetration of the solution among the galls. In such a method, however, caution must be used not to drown or asphyxiate the blastophaga. Figure 44 shows an experimental outfit which has been used for this purpose, consisting of an electrically-driven air pump and a vacuum chamber. The solution is placed in the latter, the cut figs are added, then the lid is clamped on and the exhaust is run as long as desired. The tendency is for too much moisture to be absorbed by the tissue of the fig, leaving it in a saturated, soggy condition.

After the figs have been treated, drain off excess solution and dry them as quickly and thoroughly as possible. This is important because the endosepsis fungus develops in moist figs much faster than in dry ones.

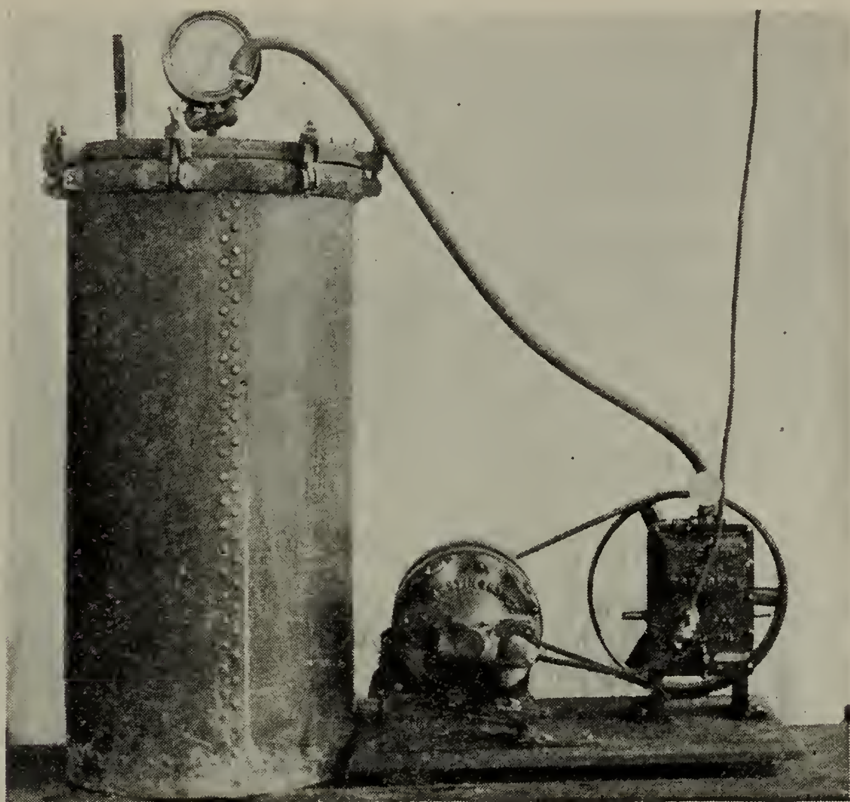

Fig. 44.—Vacuum dipping apparatus for treating mamme figs, consisting of exhaust pump, motor, and dipping chamber.

The cut mamme figs are then placed in the caprifig trees for caprifying the profichi. It has been recommended that they be put into tin cans or paper sacks to avoid excessive evaporation, furnish protection for the blastophaga, and distribute the mamme figs over the tree in several containers rather than all in one place. Figure 45 shows a popular method, putting two open-topped paper sacks containing cut and dipped mamme figs into a fruit basket and hanging one or more of these in the tree. In other cases the sacks were hung directly in the tree without the baskets.

The figs must be taken out of the trees and either destroyed or retreated within four days, in order to keep the endosepsis fungus and other molds from developing on the surface of the cut pieces. The drier the figs are the longer they can stay in the trees without redipping. It is often the case that at the end of four or five days the blastophaga are just emerging abundantly and caprification is seriously interfered with, and many insects lost by dipping the mamme figs again at such a time. Nevertheless, the endosepsis fungus is equally active and much infection of the profichi may result if the dipping is not repeated. More blastophaga sometimes emerge after the second dipping than the first, especially if hot water is used. After a second four-day period the mamme figs should again be removed and

Fig. 45.—Method of caprifying caprifig tree for setting profichi crop by hanging fruit basket containing two paper sacks of treated mamme figs. Box on ground illustrates another method.

destroyed, unless there is a great shortage and a third dipping seems worth while. No mamme figs should ever remain in the trees more than four or five days, for the fungus will gradually develop on them and a few straggling, late-emerging blastophagas may pick up the spores and contaminate a large number of profichi. It is very desirable that a method be developed of more permanently sterilizing the mamme figs so that they may stay in the trees longer without redipping. The possibility of using a dry, powdered fungicide in dust form rather than a liquid is being investigated.

Figures 45 and 46 illustrate a method which has recently come into vogue of putting large quantities of dipped mamme figs into flats or lug boxes and placing these on the ground under the caprifig trees. If one has plenty of mamme figs and the insects are active, a box needs to stay only a short time under one tree to caprify all the receptive profichi and they may be frequently moved from tree to tree or redipped.

Fig. 46.—Caprifying profichi crop of caprifigs by exposing a large number of treated mamme figs in a box on the ground. This makes it easier to gather up the figs for redipping. See page 81.

Use of Untreated Caprifigs.—Many growers, after making a great effort to clean up their caprifigs, have made the fatal mistake of bringing in a lot of untreated mamme figs at the last minute, for fear of not having enough. In this connection it should again be emphasized that an untreated caprifig may produce many more blastophaga than one which has been picked early, split, and dipped, and even a very few untreated mamme figs may contaminate almost every profichi on the tree.

Caprification of Calimyrna Crop.—This is done in the usual manner, with profichi which were set by blastophagas from the treated mamme figs. The smallest possible number of profichi should be used, scattered over the tree rather than all in one container. Light caprification, even without any treatment, produces less endosepsis than an overabundance of insects. A light, clean crop is better than a heavy setting of rotten figs. Here again, as with the mamme figs, if an effort at cleaning up is being made, no profichi from untreated trees should be used to supplement the others, even though there is some shortage.

Fig. 47.—Box of split and dipped mamme figs used as in figure 46. Note blastophagas on surface of the figs. Quartering the figs in this manner is not as effective as splitting them into separate pieces; the solution does not penetrate as well and the inside of the fig holds the moisture too long.

How Often Must Clean-up for Endosepsis be Practiced?—The evidence at present indicates that removing and treating the mamme figs every year is the only way to ensure control of endosepsis. It was thought at first that by testing the mamme figs to determine the percentage of infection, those which showed a low count, say less than 10 per cent, might be used without treatment. Apparently, however, the fungus builds up so rapidly in the profichi that this is not safe.

Individual Versus District Clean-up of Endosepsis.—The question is often asked whether an individual grower can produce clean figs even though his neighbors do nothing. This question is well answered in the data given in table 13. A comparison between the amount of endosepsis which developed in orchards in districts 1 and 2, where the clean-up of individual orchards was the same, shows the poor results obtained by treating orchards in which nothing was done in those surrounding them. It is absolutely necessary that entire districts be handled uniformly in order to obtain good results. It will also be found much more satisfactory if all the growers in the district can be induced to do the work voluntarily than if any of them must be driven to it by force. There must, however, be some central, legalized authority to direct and inspect the work if it is to progress satisfactorily.

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