JOURNAL OF AGRICULTURAL RESEARCH

VOL. 54 WASHINGTON, D. C., JANUARY 1, 1937 No. 1

SWEET ORANGE FRUIT SCAB CAUSED BY ELSINOË AUSTRALIS [1]

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INTRODUCTION

A study of the sweet orange fruit scab, caused by *Elsinoë australis* Bitancourt and Jenkins (*5*),[3] as yet identified only in South America, is reported in this paper. The sour orange scab,[4] caused by *Elsinoë fawcetti* Bitancourt and Jenkins (*4*), and the Australian citrus scab, caused by *Sphaceloma fawcetti scabiosa* (McAlp. and Tryon) Jenkins (*23*), are almost never found (*23*, *40*) on the sweet orange (*Citrus sinensis* Osbeck), and when present do little or no damage.

Inasmuch as *Sphaceloma perseae* Jenkins (*22*), the causal fungus of scab of avocado (*Persea americana* Mill.), is morphologically similar to the conidial stage of *Elsinoë fawcetti*, having at first been confused with it, this organism was included in most of the comparisons of *E. australis* with *E. fawcetti*. The comparisons served to demonstrate that *E. australis* is also distinct from *S. perseae*, and they confirmed the conclusion (*22*) that *S. perseae* and *E. fawcetti* are two different species. Only a brief report of the comparisons with *S. perseae* is given.

Experiments on the control of sweet orange fruit scab have not been included in the present study. Wright and Moreira (*41*), however, have shown by a series of spraying experiments that the disease can be controlled by essentially the same methods as those employed for sour orange scab.

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[1] Received for publication Apr. 27, 1936; issued February, 1937. Cooperative investigation by the Bureau of Plant Industry, U. S. Department of Agriculture, and the Instituto Biologico de São Paulo. The authors in the beginning undertook these studies independently, and each has made separate contributions on the general subject (*2*, *3*, *21*).[3] The cooperative study of the problem was begun in 1933, and from October 1935 to June 1936 at the invitation of the instituto Biologico, the junior author worked at São Paulo in direct cooperation with the senior author. Since this paper was written the perfect stage of the fungus herein discussed has been found. This discovery led to a change of the title "Sweet Orange Fruit Scab Caused by *Sphaceloma fawcetti viscose*", originally proposed to the present form. A related paper (JENKINS, A. E., and BITANCOURT, A. A., DOENÇAS DAS PLANTAS POR FUNGOS DOS GENEROS ELSINOË E SPHACELOMA. Rodriguésia. In press.) gives a synopsis of all the known species of *Elsinoë* and *Sphaceloma*.

[2] The authors are indebted to J. M. Toledo, of the Instituto Biologico, for the color drawings shown in pl. 1, *A* and *B*, and to J. Marion Shull, of the U. S. Department of Agriculture, for those in pl. 1, *C* to *L*, and in pl. 8. These plates were furnished by the Instituto Biologico. Many of the photographs were made by members of the Instituto Biologico, namely, J. G. Carneiro, A. Federman, B. U. Mazza, and the senior author.

[3] Reference is made by number (italic) to Literature Cited, p. 16.

[4] In the United States the disease caused by *Elsinoë fawcetti* is called citrus scab, but in this discussion the term "sour orange scab" is used as a matter of convenience to distinguish this disease from those caused by *E. australis* and *S. fawcetti scabiosa*. The choice of the name seems appropriate, since *E. fawcetti* was first observed on the sour orange (*Citrus aurantium* L.), which it attacks virulently.

SPECIES AND VARIETIES OF CITRUS AFFECTED

In São Paulo the sweet orange varieties thus far observed to be affected by the sweet orange fruit scab are the following: Bahia Navel,[5] Pera, Sabará, Selecta, São Sebastião, Santos, Lima, and Mangaratiba. Artificial inoculations show that the Abacaxi variety also is susceptible.

In Tucumán, Argentina, Müller[6] has observed the disease on the following varieties: Ruby Blood, Sweet Mediterranean, Valencia, and Criolla.

Other kinds of citrus known to be affected by the sweet orange fruit scab in São Paulo are the tangerine of Brazil (*Citrus nobilis* var.), tangerona (*Citrus nobilis* × *sinensis*) a sweet lime known as lima da Persia (*C. aurantifolia* Sw.), a sour lime known as limão seda (*C. aurantifolia*), laranja cravo (*Citrus* sp., probably a variety of *C. nobilis* Lour.), and a pointed-leaf papeda (*C. hystrix* DC.). These last two are subject also to sour orange scab. In Argentina, according to G. L. Fawcett (*15*), the fruit scab slightly affects sour orange and mandarin (possibly the same as the variety called tangerine in Brazil).

THE DISEASE

HISTORICAL REVIEW AND GEOGRAPHIC RANGE

Sweet orange fruit scab, as the disease under discussion is designated in this paper, was previously referred to in related papers by the authors as navel orange scab (*21*) and as scab or verrucosis of sweet orange and tangerine (*3*).

In South America sweet orange fruit scab is known to occur in Argentina, Paraguay, Uruguay (apparently), and Brazil. The present knowledge of the distribution of the disease is based on the records detailed below rather than on a planned survey. During the past several years scabbed sweet oranges (including the navel), from Brazil and Argentina, have occasionally been intercepted at seaports of the United States by inspectors of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

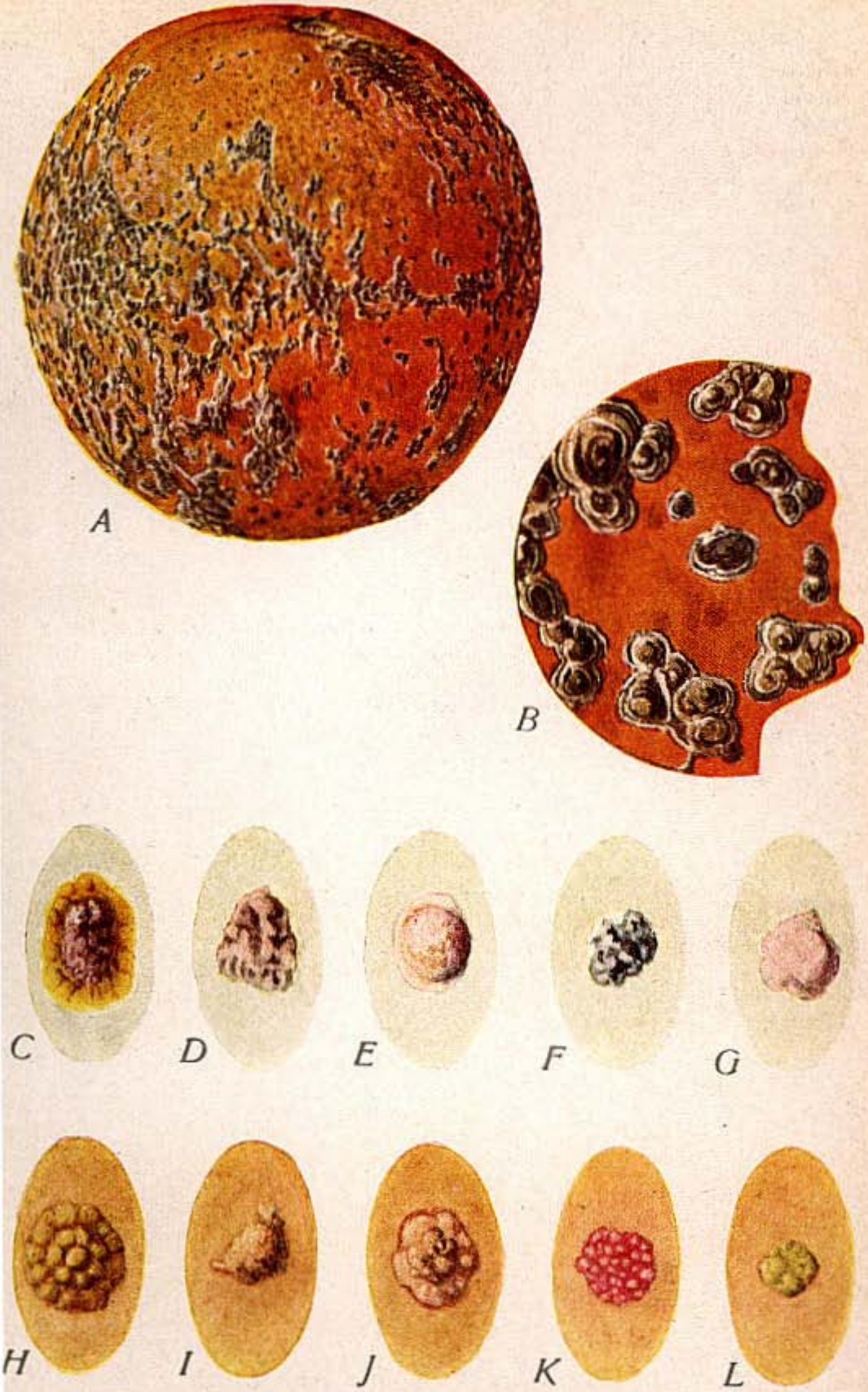
The earliest record of sweet orange fruit scab is from Paraguay in 1882. This antedates by about 40 years the first records of sour orange scab in South America. These records of sour orange scab are from Argentina (*14*), Paraguay (*36*), and Brazil (*29*).

[5] In the present paper, as in a previous one (*21, footnote 2*), the varietal name Bahia Navel refers to the variety of *Citrus sinensis* that is the original source of the Washington Navel orange in the United States. As is also explained in the article just cited, "From plants of the Bahia variety that were introduced into the United States, the late William Saunders, landscape gardener and superintendent of gardens and grounds of the United States Department of Agriculture, budded the 2 trees that were introduced into California in 1873 and from which developed (*13*) what may be termed the 'Washington Selection' of this variety, now known as the Washington Navel." For the botanical classification of the citrus hosts referred to in the article the authors have consulted Swingle (*37*), who is at present engaged in revising and amplifying the treatise cited.

[6] Letter of May 6, 1935, to H. S. Fawcett, Citrus Experiment Station, University of California, Riverside, Calif., from A. S. Müller, Escola Superior de Agricultura e Veterinaria de Minas Geraes, Brazil, descriptive of his trip to Argentina, February 1935.

EXPLANATORY LEGEND FOR PLATE 1

A, Ripe sweet orange affected by the fruit scab (× 1). *B*, Enlargement of lesions (× 8). *C–G*, potato-dextrose agar, parallel cultures of *Elsinoë australis*, *E. fawcetti*, and *S. perseae*: *C*, *E. australis*, convolute type of growth (strain 345); *D* and *E*, *E. fawcetti*; *D*, convolute type (strain 8); *E*, pulvinate type (strain 71): *F* and *G*, *S. perseae*: *F*, convolute type (strain 21); *G*, pulvinate type (strain 363). *H–L*, Same strains on wort agar. (All × 1.) Cultures *C–G*, approximately 3 weeks old; *H–L*, 4 weeks old.



FOR EXPLANATORY LEGEND SEE OPPOSITE PAGE.

Comp. Melhoramentos de S. Paulo (Brazil)

In Argentina

G. L. Fawcett, in reporting (1920) the existence of sour orange scab in Tucumán (*14*), stated that the sweet orange is very resistant, although the fruits are sometimes affected. Later (*15*) he noted that the scab of lemon and the scab of sweet orange, as he called the two diseases, differ in regard to their host plants, as well as, apparently, their causal organisms, although in general they are very similar and are controlled by similar methods. More recently he stated[7] that the sweet orange fruit scab was present in Tucumán before the sour orange scab was introduced and that he[8] first observed sweet orange scab there in 1915.

In February and March 1927 Kisliuk[9] reported the finding of scab and scale on oranges from Corrientes, Argentina, in the retail markets of Buenos Aires. A specimen of scabbed fruit collected in February 1927 is in the mycological collections of the Bureau of Plant Industry, and is typical of sweet orange fruit scab. Scabbed sweet orange fruits from Bella Vista, Corrientes, 1934, were contributed by León Grodsinsky, of the Ministerio de Agricultura, Buenos Aires. Marchionatto in 1934 (*27*) reported that in Argentina "citrus scab has been observed extensively during the present year on various citrus fruits (oranges, mandarins, and grapefruit) in citrus growing districts of the coast." In part the disease referred to was probably sweet orange fruit scab. In the letter by Müller[10] already cited he stated that he had spent the month of February traveling through widely separated parts of Argentina (including Tucumán), and that what impressed him most in citrus diseases was the abundance of sweet orange fruit scab; wherever he saw orange trees these were affected by scab, whereas the sour orange scab was comparatively rare.

In Paraguay and Uruguay

In Paraguay and Uruguay, in 1920, Spegazzini (*36*), describing symptoms, evidently those of sour orange scab, on leaves of lime (*Citrus aurantifolia*), stated that growers there had informed him that the disease also attacks shaddocks, sweet oranges, and lemons, but that he had not had an opportunity to confirm these statements at first hand. There is, of course, the probability that the disease of sweet orange was the sweet orange fruit scab. On several occasions mention has been made (*20, 21, 26*) of the mycological specimen showing what are now considered to be typical lesions of sweet orange fruit scab, collected at Villa Rica, Paraguay, in 1882 by Balansa[11] (B. Balansa Pl. du Paraguay no. 3543).

The scab of sweet orange which Girardi (*17*) reported in 1922 as having been present in Paraguay in a mild form for 30 years is possibly the sweet orange fruit scab. Girardi stated that the small isolated or grouped lesions of the disease had been confused by some with certain scale insects.

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[7] Letter to H. S. Fawcett, dated Dec. 20, 1931.

[8] Letter to H. S. Fawcett, dated Nov. 17, 1933.

[9] Kisliuk, M., Jr. Report of fruit fly survey—Argentina. U. S. Dept. Agr., Bur. Ent. and Plant Quarantine. pp. 4–5, 20. 1927. (Unpublished.)

[10] See footnote 6.

[11] As recently noted by Vellard (*38*), Balansa, whose grandsons are living in the region of Villa Rica, introduced into Paraguay the distillation of petitgrain oil, which is obtained from sour orange (*Citrus aurantium*).

In Uruguay, with respect apparently to sweet orange fruit scab, Girardi reported further that the disease was alarmingly prevalent, there being no orange groves entirely free from it. He added that if the disease has not been given the importance it deserves it is because growers have believed it to be due to adverse conditions of locality or weather.

In Brazil

In Brazil sweet orange fruit scab is known to occur in the States of São Paulo, where are grown about 60 percent of the Brazilian oranges that are exported, Rio Grande do Sul, Minas Geraes, Rio de Janeiro

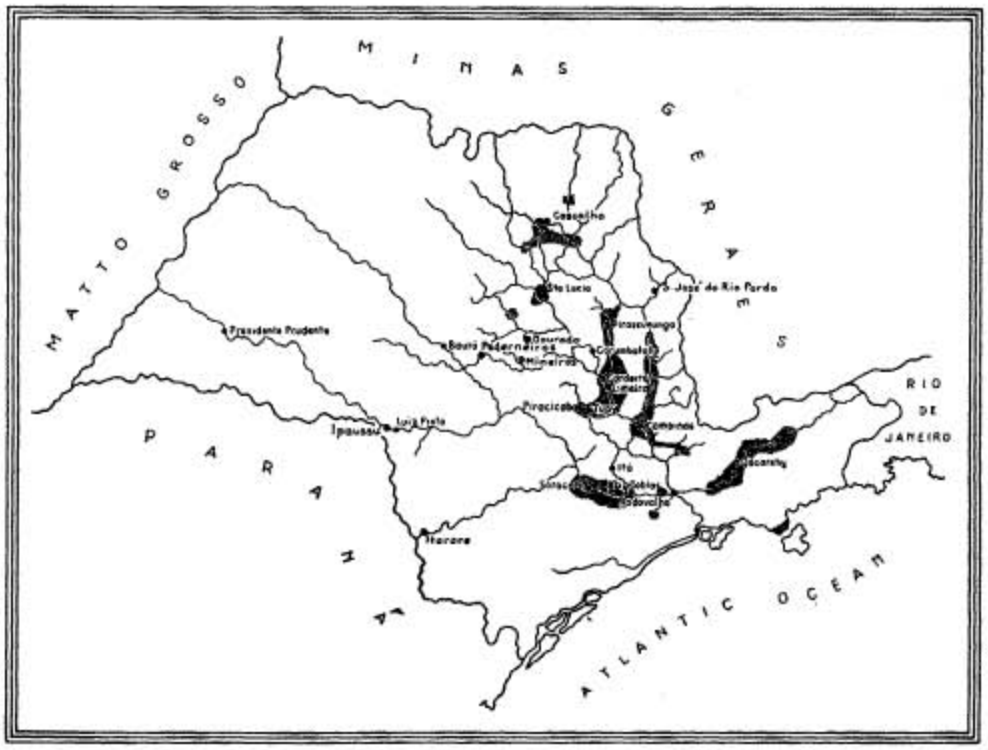


FIGURE 1.—Map of the State of São Paulo, Brazil, showing location of neighboring States. Shaded areas indicate the orange-growing districts of São Paulo and names of places show localities where sweet orange fruit scab is definitely known to occur. Recent distribution not indicated on the map includes the following localities: Caraguatatuba, Cravinhos, and Torrinha (apparently).

and in the Districto Federal. Unverified reports indicate that it may also be present in the States of Matto Grosso and Paraná (fig. 1).[12]

In the light of present knowledge it is believed that Noack's (*31*) description of scab (Grind) on fruits and young twigs of various kinds of oranges (an verschieden Orangensorten) in São Paulo (1900) may have been sweet orange fruit scab.

In São Paulo sweet orange fruit scab came definitely to the attention of citrus growers about 1931, and since that time it has come to be regarded as an important disease (*2, 3, 9, 21, 41*). At first it was observed only in a few localities, but, by 1934, it had been found to occur abundantly in the most important commercial citrus-growing districts (*41*). Carvalho (*9*) stated in 1932 that severely diseased

[12] It was previously assumed (*21*), from Bondar's (*7*) account of citrus scab in Brazil, that in the State of Bahia the sweet orange is affected by scab. More recent inquiries, however, indicate that this interpretation may not be correct. Sweet orange fruit scab had not been distinguished from sour orange scab when Bondar's paper was written, and in a personal conference with the authors on Oct. 29, 1935, Bondar expressed uncertainty as to whether the sweet orange fruit scab is found in Bahia. O. H. Leonardos, of the Estação Experimental de Citricultura, Alagoinhas, Bahia, on Aug. 19, 1935, wrote that as yet the sweet orange fruit scab is not known in Bahia.

sweet oranges of various varieties had been received from Limeira, Sorocaba, and Piracicaba. The first critical studies of the disease which demonstrated it to be separable from sour orange scab are those of the present authors. (See footnote 1.)

Authority for the occurrence of the disease in Rio Grande do Sul is based upon a herbarium specimen collected near Borges de Medeiros Instituto, Porto Alegre, in March 1923, by E. Bruck. The specimen (no. 1745, Secção de Phytopathologia do Instituto de Biologia Vegetal, Rio de Janeiro) was later identified by E. Rangel as *Sphaceloma fawcetti* Jenkins, as the sour orange scab fungus was designated in 1925 (*19*). A note on the label of the specimen states that the characters observed are those of the pseudocanker of Costa Rica. According to Smith (*35, p. 62 and legends to figs. 45 and 46*), the pseudocanker of Costa Rica is the same as sour orange scab. The following statement, translated from the Portuguese (*34*), is indicative of the prevalence of the sweet orange fruit scab in 1936 in the vicinity of Porto Alegre:

In our almost daily inspection of the packing houses of this region we find that a great majority of the fruits unsuitable for exportation is rejected owing to the presence of "spots" caused by the fungus disease known by the common name of verrucosis or scab. A large percentage of the fruits rejected in these packing houses is made up of oranges showing this disease.

The record of the occurrence of the disease in Minas Geraes is based on a few fruits of the Bahia Navel from Jacutinga, collected on August 8, 1934 (*28*), and deposited in the mycological herbarium of the Escola Superior de Agricultura e Medicina Veterinaria de Minas Geraes. A specimen from this collection was observed by the authors in January 1936.

In the Districto Federal, at Campo Grande, the disease was recently (1935) observed on the Pera and Selecta sweet oranges in two or three orchards. It has since been found (1936) in numerous other places not only in Campo Grande, but also in Nova Iguassú and São Gonçalo in the State of Rio de Janeiro. According to quarantine officers there are now more than 60 groves in this general region where the disease has been identified. In a grove at Inhoahyba, Districto Federal, there is an abundance of sweet orange fruit scab. On a tree of the Selecta variety leaves as well as fruits were heavily scabbed.

ECONOMIC IMPORTANCE

Sweet orange fruit scab apparently does not affect the general health of the sweet orange. Severely diseased fruits often reach normal size, but the rind is greatly disfigured. There is apparently no loss in the flavor of the fruit. This partly explains why citrus growers in Brazil paid little attention to scab while their oranges were produced for local consumption or for exportation on a small scale to Argentina and Uruguay. Upon the exportation of oranges to Europe (beginning in about 1929), however, a series of Federal regulations was inaugurated in order to prevent the shipment of low-grade fruit. The fruit scab then began to be a matter of serious concern to citrus growers in São Paulo. In some groves from 50 to 60 percent of the fruit was blemished by the disease, some of it

severely, and in numerous other groves as much as one-third of the crop was unfit for export (*41*). Fortunately, however, as shown experimentally, the disease can be controlled (*41*), and this has since been demonstrated under commercial conditions by the results of spraying in a number of orchards.

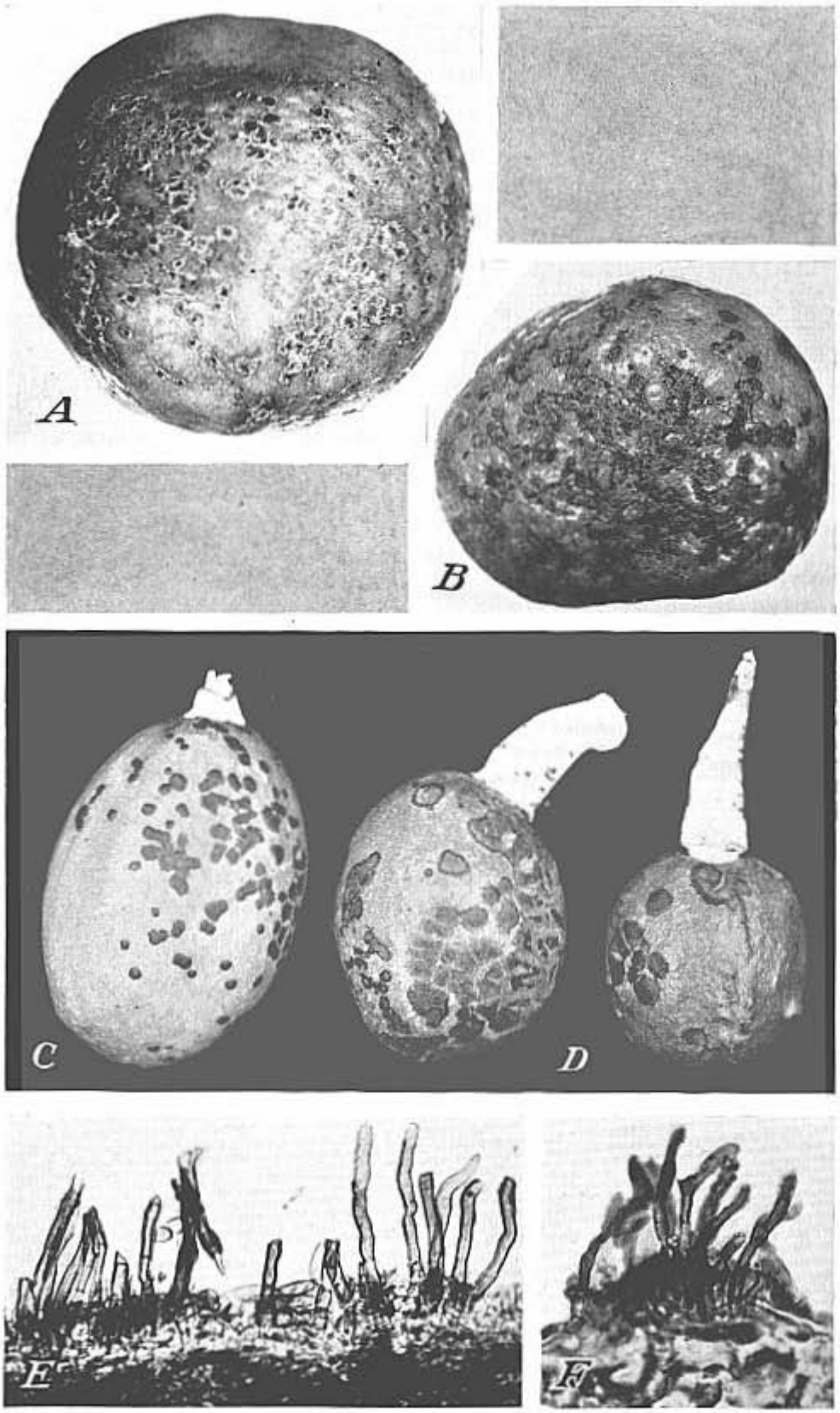
SYMPTOMATOLOGY

Morphologic Symptoms

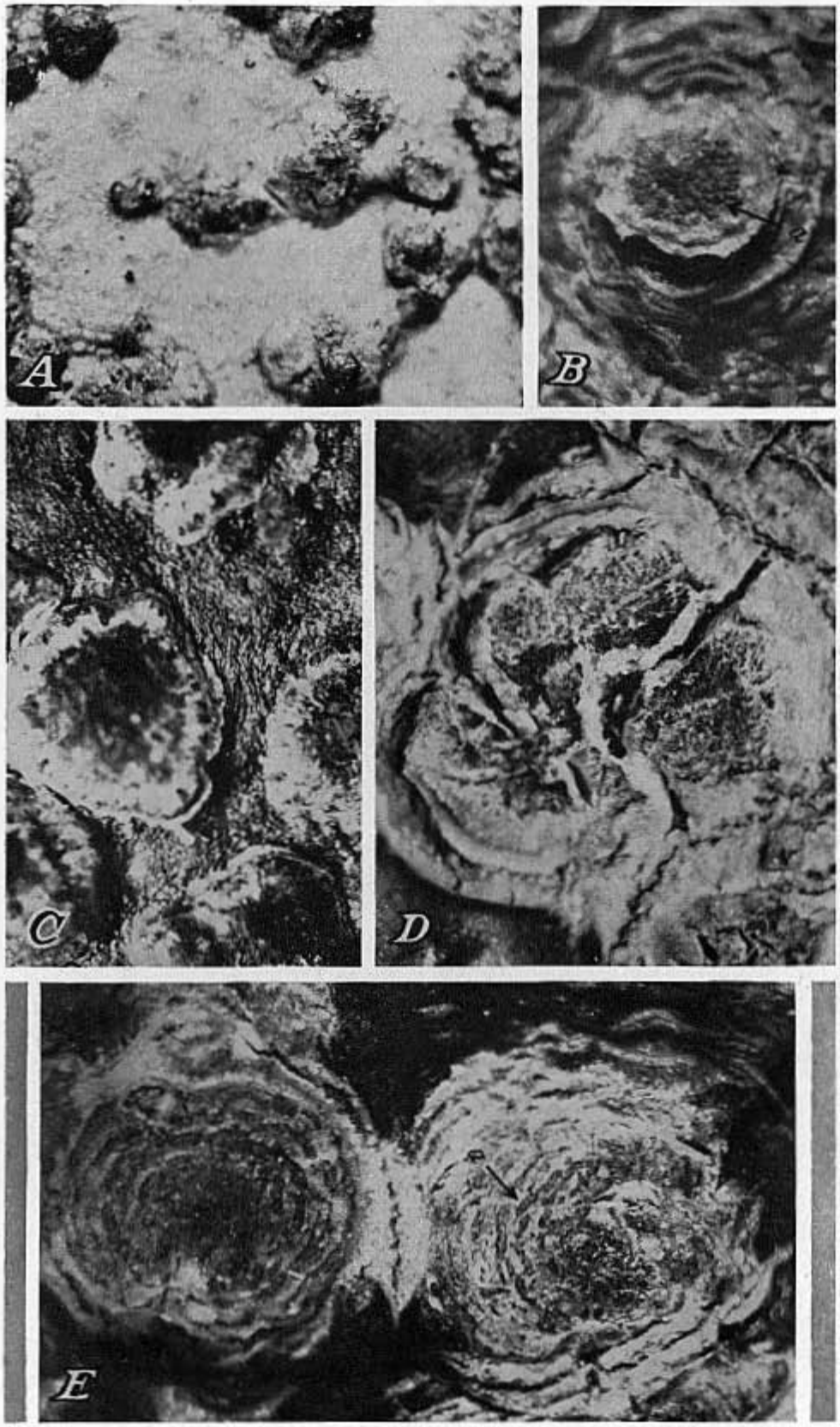
The symptoms of sweet orange fruit scab detailed below are more or less supplementary to those previously given by one of the authors (*2*, *3*). So far as observed in South America, sweet orange fruit scab affects mostly the fruits, while sour orange scab attacks leaves and young twigs as well. Lesions on leaves of sweet orange are so rare that it has been the belief for some time that the leaves are entirely free from the disease, and this opinion was expressed by G. L. Fawcett (*15*) and by Honey (cited in *21*). As a result of a very thorough examination of a navel orange grove in Limeira, however, during one of the most severe attacks of the disease yet noted, a number of mildly scabbed leaves were found in the inner part of the tree. In general, leaves of the outer part of the crown, and, in fact, more than 90 percent of the leaves of severely diseased trees, do not show lesions at all. Although from the standpoint of symptoms the leaves may be considered as generally scab-free, leaf infection is not to be disregarded, for doubtless even a few lesions may play an important role as hold-over scabs.

ON FRUITS

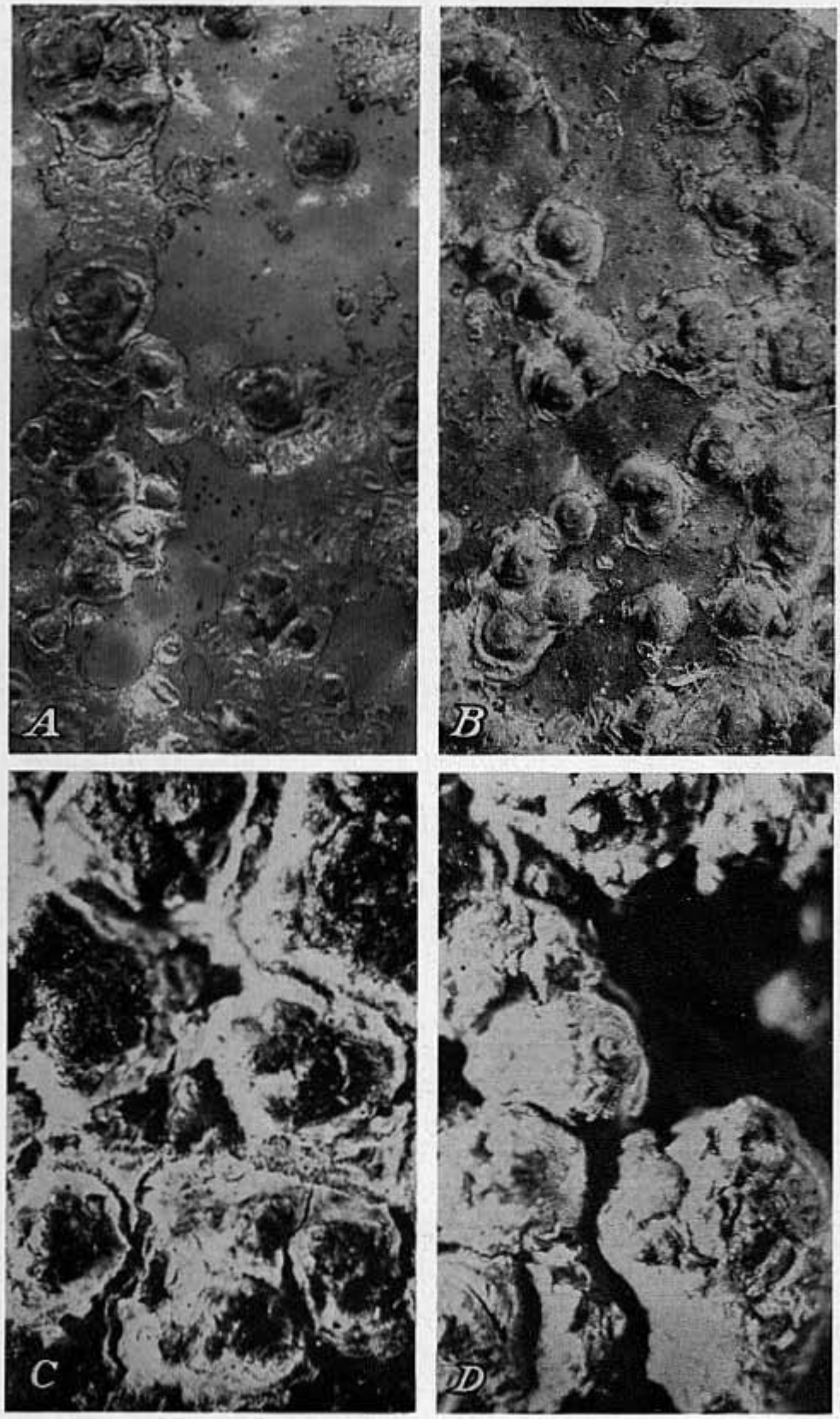
Lesions of sweet orange fruit scab on young fruits may cause an appreciable deformation of the rind, which is usually protuberant or swollen where the lesions appear. These deformations gradually disappear as the fruit increases in diameter, and mature fruit has the normal spherical shape. The surface, however, is sometimes slightly depressed at the points where lesions are large and coalescent (see pl. 12, *C*). In general appearance the lesions (pl. 1, *A* and *B*; pl. 2, *A* and *B*) are similar to those of sour orange scab. Upon careful examination, however, it is possible to discern certain appreciable differences to be explained presently. Individual lesions of the sweet orange fruit scab consist of pustules of corky tissue, which are round to irregular, raised, and usually slightly convex (pl. 3, *A*) measuring from 2 to 6 mm in diameter. The larger lesions (pl. 3, *B–D*) are more flattened and may be traversed by more or less deep furrows which result from the rupture of the corky tissues. In some cases a circular fissure (pl. 3, *B*) surrounds the central part of the lesion and this part may be detached with comparative ease, leaving in its place a slightly depressed scar covered with a silvery pellicle. This same pellicle sometimes surrounds more extensive lesions or covers the areas between them to a greater or less extent (pl. 4, *A*). On severely infected fruits the lesions are frequently large and confluent and cover extensive areas (*2*, *fig. 44*), rendering the fruit too unsightly for export, as previously mentioned. In some cases the smaller and more numerous lesions resulting from secondary infection may be distinguished from the primary lesions, which they surround on the same fruit (*2*, *fig. 47*).



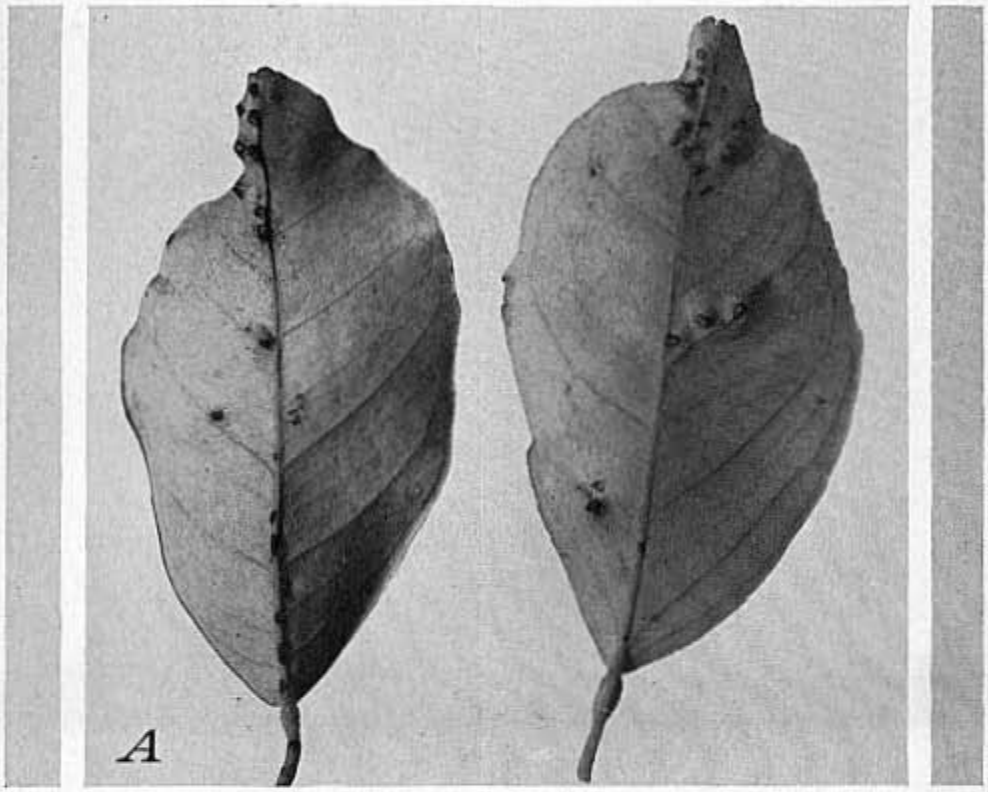
A and *B*, Lesions of sweet orange fruit scab on tangerine from a market in São Paulo (× 1). *C* and *D*, Young avocado fruits of the Guatemalan race from Limeira, São Paulo, affected by avocado scab: *C*, Linda variety; *D*, Winslow variety (× 1). *E*, Conidiophores of *Sphaceloma perseae* from avocado leaf (× 450). *F*, Conidiophores of *E. fawcetti* from a lemon leaf (× 480).

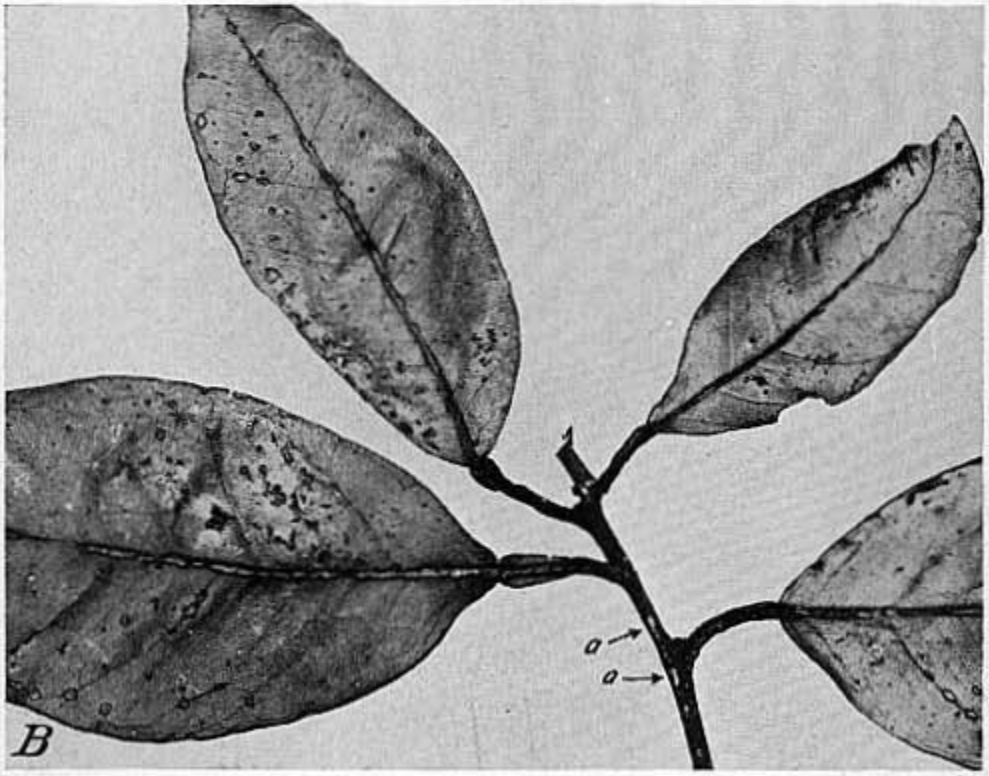


Enlargements of scab lesions of sweet orange fruit scab on (*A*, *C*, and *D*) sweet orange and on (*B* and *E*) tangerine (all × 17); *B*, *a* and *E*, *a*, pustules of the causal fungus.



Lesions of sweet orange scab on (*A*) sweet orange, and lesions of sour orange scab on (*B*) lemon and (*C* and *D*) sour orange. *A* and *B*, × 7½; *C* and *D*, × 17.





A and *B*, Lesions of sweet orange fruit scab on leaves and twig (*B*, *a*) of sweet orange. × 1.

The coloration of the lesions of sweet orange fruit scab is determined on the one hand by the color of the corky tissues and on the other by the conidial pustules of the parasitic fungus. The corky tissues are "light ochraceous buff" [13] to "warm buff." Sometimes there is superimposed on these tissues a reddish tinge, "deep vinaceous" to "eugenia red", which is also noted in the rind surrounding the lesions. The conidial pustules of the causal fungus of the disease, often visible near the center of the lesion, are "warm buff" to "clove brown", and "fuscous-black." In general the lesions, together with the exposed growth of the pathogen, thus exhibit a variety of colors, ranging from buff to black with sometimes a pinkish hue, which can be distinguished without the aid of a hand lens. The dark-colored lesions may resemble lesions of scab of apple (*Malus sylvestris* Mill.) caused by *Venturia inaequalis* (Cke.) Aderh., as noted by Carvalho (*9*).

Comparing the lesions of sweet orange fruit scab on sweet orange (pl. 4, *A*) and tangerine with those of sour orange scab on lemon (*B*) or sour orange (*C* and *D*), it will be seen that the former, as a rule, are more nearly circular, and, particularly on the tangerine (pl. 3, *E*), more flattened and less wrinkled or rough. Fruit lesions of sour orange scab often consist of irregular pustules, on the surfaces of which appear small rounded elevations or wrinkled protuberances (pl. 4, *C* and *D*) not found in sweet orange fruit scab. The corticose tissues in the fruit lesions caused by sour orange scab also seem to be more spongy and less compact than in those caused by sweet orange fruit scab. It was evidently sour orange scab lesions of the type shown in *D*, although much more pronounced, that Spegazzini (*36*) described as "nodules having a granular surface almost like a cauliflower."

Reference to lesions of both sweet orange fruit scab and sour orange scab on a common host, i. e., fruits of laranja cravo, is made in the section entitled "Inoculations."

In plate 2, *C* and *D*, is shown an example of avocado scab, which, as already indicated, is similar to sour orange scab but distinct from both this disease and sweet orange fruit scab.

Symptomatological characters of the scab disease of the remote citrus relative *Hesperethusa crenulata* (Roxb.) Roemer have a certain similarity to those of sweet orange fruit scab (*24*).

ON LEAVES AND TWIGS

On the leaves of sweet orange the lesions are mostly found only on the lower surface, chiefly on the midrib (pl. 5, *A* and *B*). They seldom form protuberant outgrowths as on the fruits, although in very young leaves they sometimes form funnellike pockets (*A*) similar to those produced in sour orange scab. The leaf lesions are smooth, and frequently have a somewhat glossy surface. Their color agrees with that of the fruit lesions, except that they may be bordered by a narrow brown line. The lesions, with the exception of those along the midrib, seldom attain 2 mm in diameter. On pointed-leaf papeda and Selecta orange the leaf lesions may be distributed on both leaf surfaces, as is the case with sour orange scab. In general, as thus far observed, the leaf lesions of sweet orange fruit scab are smaller and less elevated than those of sour orange scab.

[13] The color readings given in quotations are based on Ridgway's Color Standards (*33*).

On the twigs (pl. 5, *B*, *a*) the lesions of sweet orange fruit scab are also comparatively rare and inconspicuous, resembling those on the midrib of the leaves.

Signs

On fruits, on the surface of the lesions as well as within the fissures, there may be seen with the aid of a powerful lens small buff to black projections or pustules (pl. 3, *B*, *a*), the largest of which are about 0.1 mm in diameter. They are sometimes concentrically arranged and more or less continuous (*E*, *a*), or they may be aggregated at the center of the lesion (*B*, *a*) or more or less effuse over the entire central part of the scab (*C*). The projections are the conidial pustules or acervuli and sporodochia of the causal fungus of the fruit scab, referred to on page 7. Signs on leaves are generally inconspicuous, although on pointed-leaf papeda they may be prominent.

The concentric arrangement of fructifications in the case of sour orange scab (*20*, *fig. 2*, *E*) is less evident than in sweet orange fruit scab. The outstanding sign of sour orange scab is of course the Cladosporium-like development of the fungus on the surface of fairly young lesions, and this type of growth has not been observed for the causal fungus of sweet orange fruit scab.

Histologic Symptoms

The hyperplastic nature of the lesions of sweet orange fruit scab (pl. 6, *A*) is generally similar to that of sour orange scab as described by Cunningham (*11*) and as later discussed by Butler (*8*, *p. 181*).

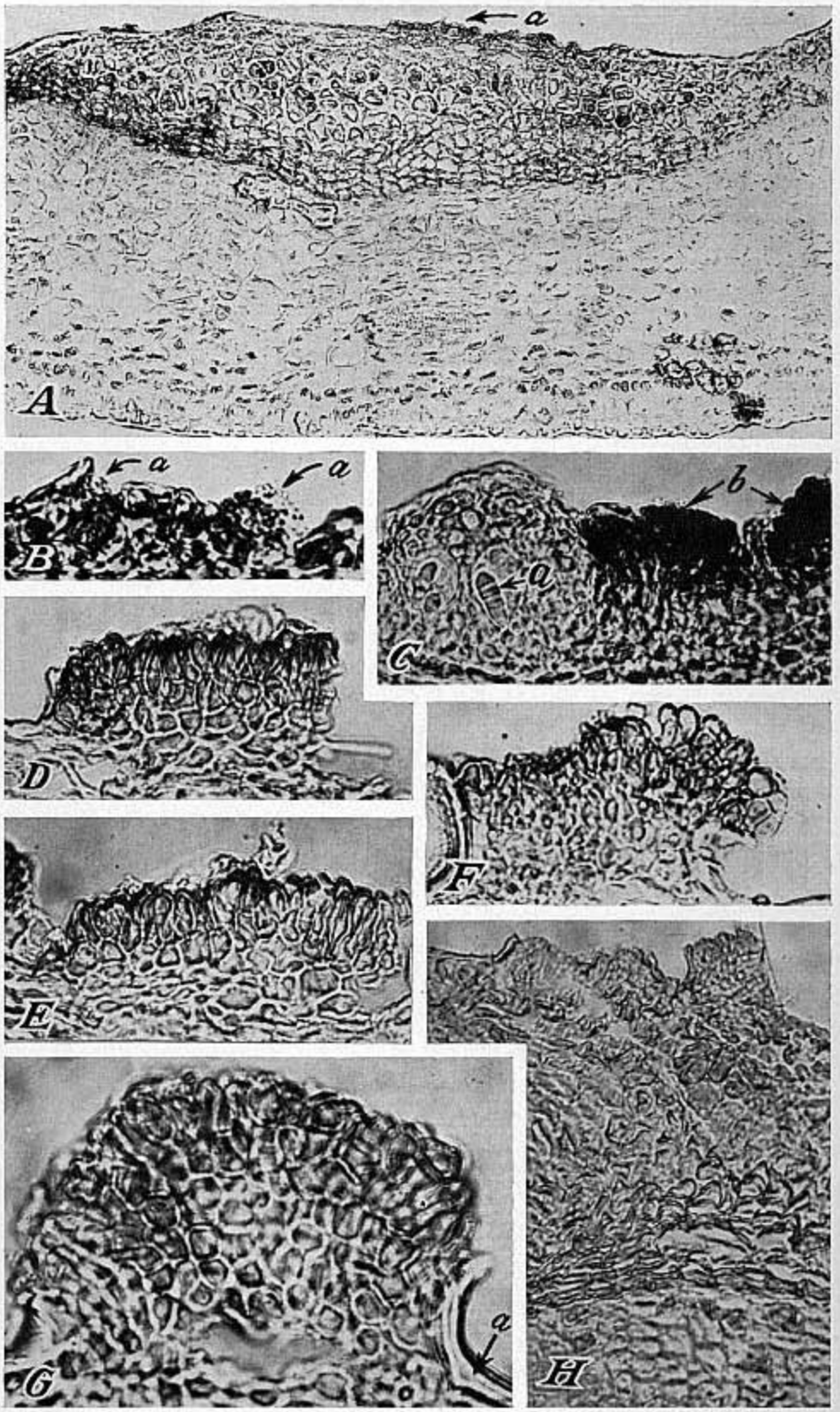
THE CAUSAL FUNGUS

NAME, HISTORY, AND CLASSIFICATION

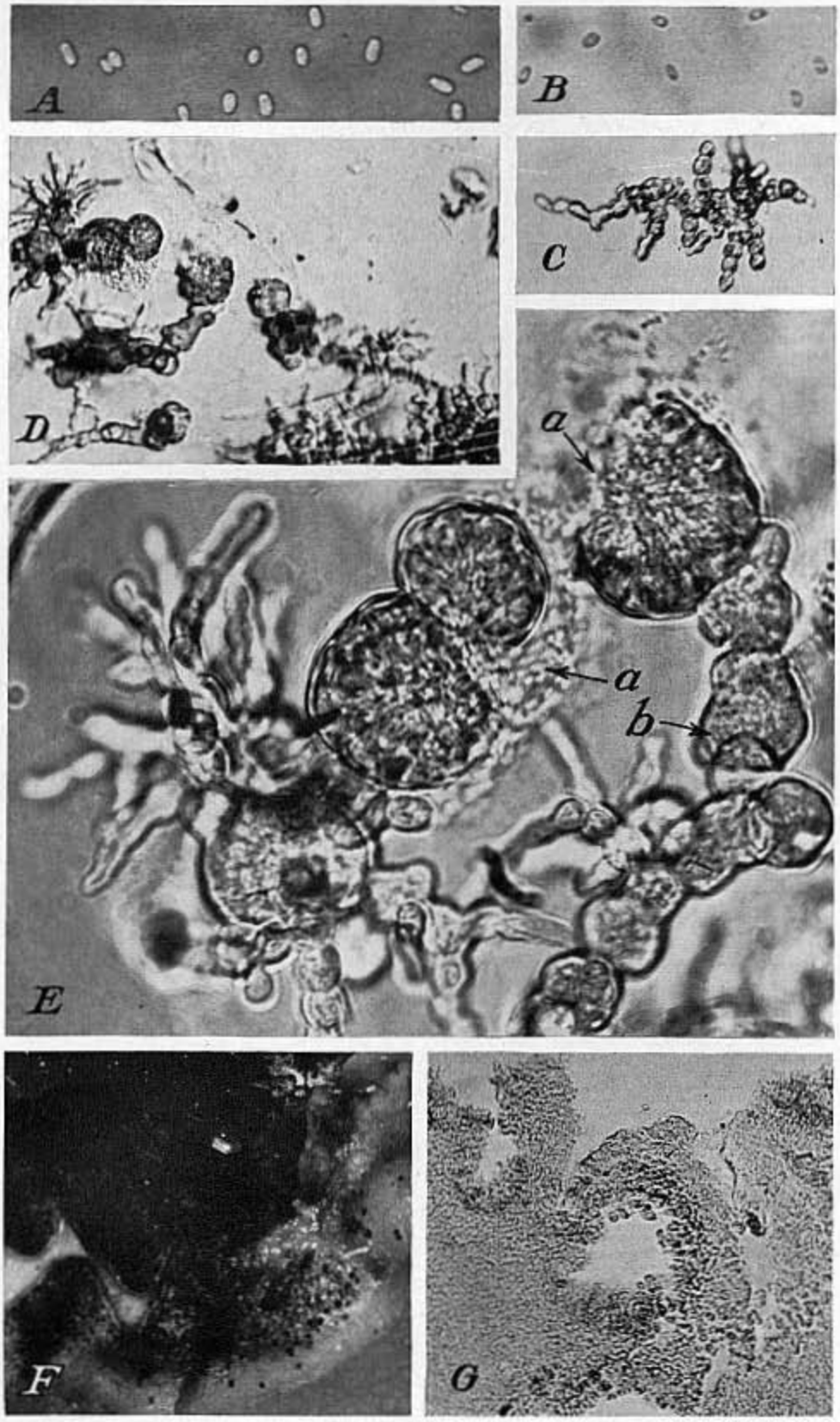
The fungus causing sweet orange fruit scab is the myriangiaceous ascomycete *Elsinoë australis* Bitancourt and Jenkins (*5*), originally described (1933) as *Sphaceloma fawcetti viscosa* Jenkins (*21*). The earliest available record of the fungus is the previously mentioned specimen on rind of sweet orange collected in Paraguay in 1882. The general appearance of this specimen, together with the original label, is shown elsewhere (*26*, *fig. 1*, *A and B*); in plate 6, *H*, are shown acervuli from this material. The perfect stage of the fungus was discovered in July 1936, on scab lesions on a ripe Bahia Navel orange (*5*). In describing this stage as a distinct species it was suggested that the imperfect stage be called *Sphaceloma australis* Bitancourt and Jenkins. In its perfect stage the fungus differs from *Elsinoë fawcetti* in the apparent absence of an epithecium and in having well-developed globose ascomata and longer ascospores. The conidial stage is not characterized by the Cladosporiumlike development of *E. fawcetti* and is more persistent.

MORPHOLOGY

The conidial fructifications of *Elsinoë australis* consist of acervuli and sporodochia (pl. 6, *D–H*) arising from intraepidermal or subepidermal hyphae. Conidia other than the bodies interpreted as microconidia have been uncommon and usually entirely absent on these fructifications as collected in the field and examined in the laboratory. The bodies interpreted as microconidia are usually present on the surface of the acervuli and sporodochia (pl. 6, *B*, *a*). They



A, Section of scab lesion on sweet orange leaf; pustules of causal fungus, *Elsinoë australis*, visible at *a*. × 150. *B*, Enlargement of *A*, *a*, showing ruptured epidermis and masses of microconidia (*a*). × 800. *C*, Ascoma; *a*, 3-septate ascospore in ascus; *b*, conidial layer. × 500 (reproduced from (*4*)). *D–H*, Conidial fructifications of the fungus on rind of (*D–E*) tangerine and (*F–H*) sweet orange. *G*, *a*, outer wall of ruptured epidermis. *D–F*, × 650. *G*, × 870; *H*, section of specimen from Paraguay, collected by Balansa in 1882. × 200.



A and *B*, Conidia of *Elsinoë australis* (*A*) and of *E. fawcetti* (*B*) from culture. × 380. *C–G*, *E. australis*: *C*, germinated conidium on malt agar (× 290); *D*, greatly swollen germinated conidia on potato-dextrose agar, the larger cells filled with microconidia (× 220); *E*, enlargement of *D*, showing conidia (*a*) escaping from ruptured cells and younger hyphal growth (*b*) containing microconidia (× 700); *F*, pycnidialike development in culture (× 5); *G*, section of these structures (× 150).

are hyaline, often refractive, and bacteriumlike in appearance and they stain readily with cotton blue.

In culture the previously reported (*21*) ovoid to oblong-elliptical hyaline conidia of *Elsinoë australis* may be present on the surface of fairly old growth. Those here illustrated, both of *E. australis* (pl. 7, *A*) and of *E. fawcetti* (*B*), were produced from small masses of potato-dextrose agar cultures transplanted to a film of malt agar on a glass slide, the culture having been held for 24 hours in a Petri dish lined with wet filter paper. Numerous germinated conidia or young thalli (*C*) were present in the culture of *E. australis* when it was several days old. In similar potato-dextrose agar cultures, as previously noted (*21, footnote 11*), the cells of greatly swollen germinated conidia (*D*) were filled with microconidia measuring 1μ to 3μ by 0.5μ (*E*, *a* and *b*). In one instance black pycnidialike masses were produced by the fungus grown on potato-dextrose agar slants (pl. 7, *F* and *G*).

The perfect stage of the fungus (pl. 6, *C*) is described (*5*) as follows:

Ascomata globose, sometimes flattened or irregular, occasionally confluent, $40-120\ \mu$ in diam., buff, embedded in the tissues of the perfect stage, erumpent, consisting of a hyaline or slightly yellowish pseudoparenchyma devoid of a well defined epithecium; asci often distributed in the upper part of the ascoma, globose to obclavate, inner wall thickened apically, $15-27\times13-21\ \mu$; ascospores hyaline, variable, straight or more or less curved, $2-4$ celled, often markedly constricted not only at median septum, but also at the other two [septa], sometimes with a longitudinal septum in the upper middle cell, which is frequently slightly larger than the other cells, $12-20\times4-8\ \mu$.

ISOLATIONS AND CULTURAL COMPARISONS

As previously reported (*21*), to assist in the identification of *Elsinoë australis* as found on the Bahia Navel orange, two different isolations were first made, one from the specimen from Sorocaba (strain 345) and one from the specimen from Limeira (strain 356). The two strains were similar in appearance but were separable from the other strains of *E. fawcetti* then at hand. They were also culturally distinct from *S. fawcetti scabiosa*, then not distinguished from the species. The cultures of *E. australis* were particularly distinctive in that they were copiously covered with a clear viscous substance (*21, fig. 1, C and D*).

The cultural growth of *Elsinoë australis* was of the convolute type, and was therefore directly comparable to the convolute growth types of *E. fawcetti* and *S. perseae* rather than to their pulvinate growth types.[14] This is brought out in plate 1, *C* to *G* and *H* to *L*, which also shows *E. australis* to be culturally distinct from *E. fawcetti* and *S. perseae* on both potato-dextrose and wort-agar media.

To obtain further data on the identity of the organism associated with sweet orange fruit scab, additional isolations of this variety and of *E. fawcetti* and *S. perseae* were made from leaves and fruits of their respective suscepts (table 1), and then additional parallel cultural comparisons were made.

Various methods were employed in making the isolations, but for the most part they were made from scrapings of lesions. These were placed in a Petri dish, and the contents of a culture tube containing potato-dextrose or glycerin agar was poured over them. For some of the isolations of *Elsinoë australis* (for example, culture 702A) sections of conidial fructifications similar to those shown in plate 6, *D* to *F*,

[14] The so-called convolute and pulvinate types of growth as produced by *S. fawcetti* and *S. perseae* have been described in related papers (*20, 22, 25*).

were transplanted to the edge of agar slants. The development of the fungus could be observed from the first under a comparatively high magnification. For another isolation a water suspension of conidia was made on a glass slide, allowed to dry, and then a single conidium was transferred to the edge of the slant with a micro-needle.

TABLE 1.—*Isolations of Elsinoë australis and E. fawcetti employed in a parallel cultural comparison on potato-dextrose agar (pl. 9, A–D)*

Arrangement in plate 9, *A–D*	Strain no.[1]	Organism	Source of material from which isolations were made		
			Host plant		Country
			Scientific name	Common name or variety	
A and *B*:					
a	345a	*E. australis*	*Citrus sinensis*	Bahia Navel	Brazil.
b	345	do	do	do	Do.
c	381B	do	do	do	Do.
d	356	do	do	do	Do.
e	375	do	do	Sweet orange	Argentina.
f	379	do	do	do	Brazil.
g	933A	do	*C. nobilis deliciosa*	Tangerine	Do.
h	702A	do	*C. sinensis*	Sweet orange	Do.
C and D:					
a	8	*E. fawcetti*	*C. limonia*	Rough lemon	United States.
b	275	do	do	do	Union of South Africa.
c	376	do	do	do	Brazil.
d	828A	do	*C. aurantium*	Sour orange	Do.
e	259	do	*C. mitis*	Calamondin	Japan.
f	826A	do	*C. grandis*	Grapefruit	Brazil.
g	776A	do	*C. limonia*	Sicilian lemon	Do.
h	806A	do	do	Sweet lemon	Do.
i	745A	do	*Citrus* sp.	Rangpur lime	Do.
j	823A	do	*C. aurantifolia*	Tahiti lime	Do.
k	121B	do	*C. nobilis*	Laranja cravo	Do.

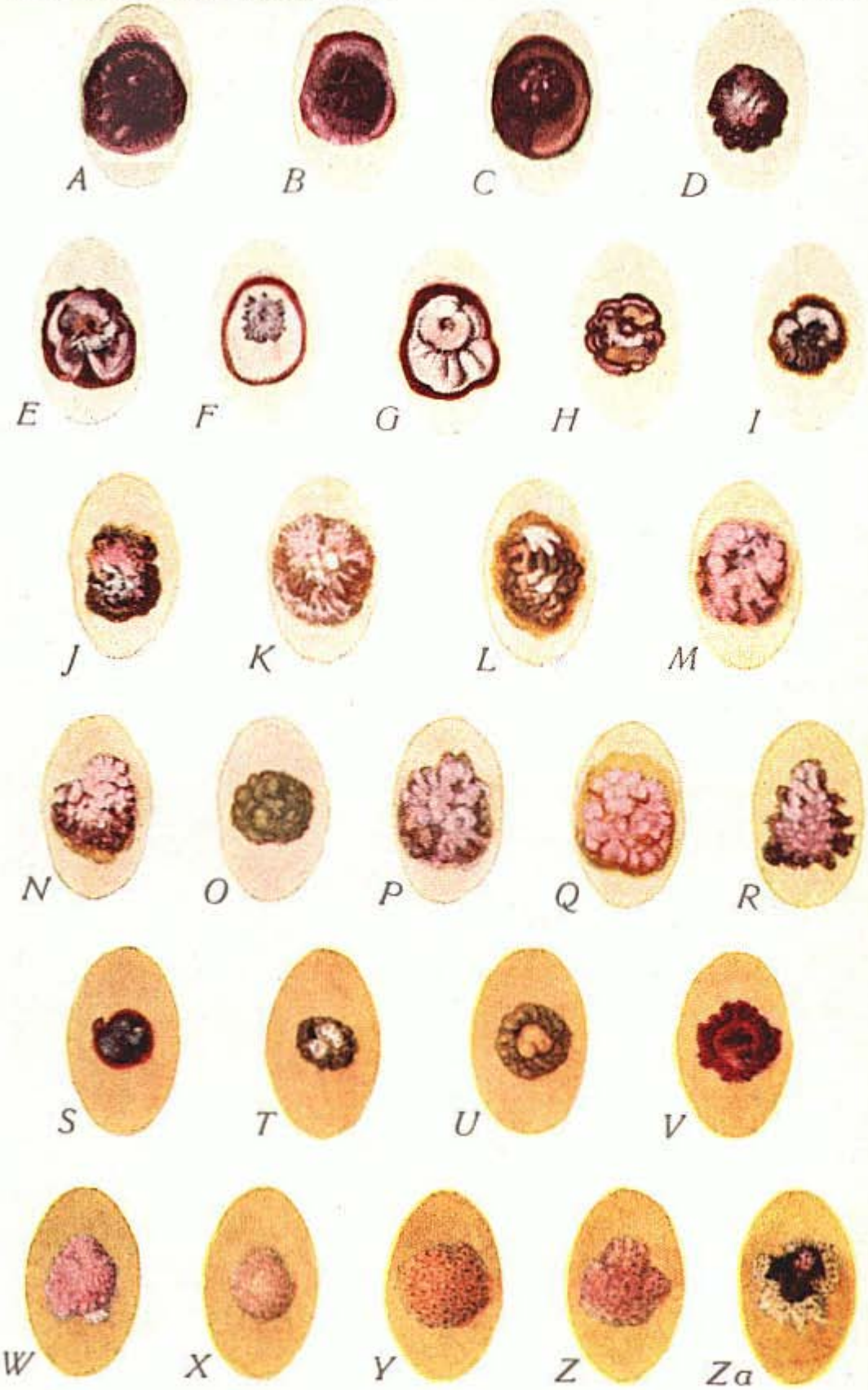
[1] Strain numbers followed by a capital letter are those of the Secção de Phytopathologia do Instituto Biologico de São Paulo, and represent isolations made by the senior author; those not followed by a letter represent other isolations, in the collection of the junior author.

The cultural comparisons shown in plate 8 were made in 1933, when there were available three new isolations of the *Sphaceloma* from citrus scab from South America. Two were of *Elsinoë australis* from common sweet orange (strains 375 and 379) and one of *E. fawcetti* (*21, footnote 11*). These strains (grown on tubes of the size shown in plate 9, *A–D*) are here compared with one of the original strains of *E. australis*, and with *E. fawcetti* and *S. fawcetti scabiosa*. On the three different substrates, malt agar (pl. 8, *A–I*), potato-dextrose agar (*J–R*), and wort agar (*S–Za*), the new strains from sweet orange formed a group with the original strain of *E. australis*, although all three could be distinguished from one another. Strain 379 on potato-dextrose agar (*K*) was more or less intermediate between *E. australis* and *E. fawcetti*. In another comparison of the three strains on potato-dextrose agar they were again separable when grown at room temperature, but similar when grown in a refrigerator (pl. 11, *D–I*).

A parallel cultural comparison, made on March 20, 1934, included representative isolations of all the strains of *Elsinoë australis* (pl. 9,

EXPLANATORY LEGEND FOR PLATE 8

A–I, Month-old cultures on malt-agar test-tube slants, of strains 375 (*A*), 379 (*B*), and 356 (*C*) of *Elsinoë australis* and of strain 376 (*D*) of *E. fawcetti* from São Paulo as compared with strains 8 (*E*) and 71 (*F*) of *E. fawcetti* from Florida, strain 200 (*G*) of *Sphaceloma fawcetti scabiosa* from Australia, strain 259 (*H*) of *E. fawcetti* from Japan, and strain 275 (*I*) of the *Sphaceloma* on citrus from the Union of South Africa. *J–R*, Same strains on potato-dextrose agar. *S–Za*, Same strains on wort agar. (All × 1.)



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Comp. Melhoramentos de S. Paulo (Brazil)

A and *B*) and of *E. fawcetti* (*C* and *D*) then available (table 1). Several strains of *S. perseae* were added to the comparison, but they were readily distinguishable as not of the *E. fawcetti* group and are not reported upon further. The pulvinate strain (345a) of *E. australis* (pl. 9, *A*, *a*, and *B*, *a*) was isolated from strain 345 (*A*, *b* and *B*, *b*). A pulvinate strain (828A) of *E. fawcetti* is shown in plate 9, *C*, *d*, and *D*, *d*. The other strains included in the comparison were of the convolute type of growth. The cultures of *E. fawcetti* were remarkably uniform in appearance (pl. 9, *C*, *a–c*, *e–k* and *D*, *a–c*, *e–k*). They were a bright clear color and generally "vinaceous" to "pinkish vinaceous." In corresponding cultures of *E. australis* the light-colored regions were generally "cinnamon buff", "cinnamon", or "clay color." Strain 375 (*A*, *e*, and *B*, *e*) was, as usual, nearly all black; strain 379 (*A*, *f*, and *B*, *f*) was "pinkish vinaceous."

SALTATIONS

The comparisons just described showed that the strains of *Elsinoë australis* could be divided into two main groups: Group 1, represented by the first two isolations, strains 345 and 356, and by 381B (pl. 9, *A*, *b–d*); and group 2, represented by strains 375, 379, 933A, and 702A (*A*, *e–h*). The existence of these groups was further emphasized by a number of new parallel series with additional new isolations of *E. australis*. These series have also shown that the fungus is so extremely variable that within the two groups many of the isolates may be distinguished from each other. Furthermore, it was soon recognized that within a single isolate there occur variations of the type known as saltations. These are conspicuous in large thalli, and Kolle flasks are convenient for the cultural work with them.

Examples of groups 1 and 2 and of saltations produced from each are here given as representative of variations of *Elsinoë australis* observed on potato-dextrose agar in Kolle flasks.

Strain 381B, representing group 1, is shown in plate 10, *A*. This culture is here distinguished chiefly by the copious mucous covering already mentioned and by the light color of the thallus, "cinnamon buff" to "clay color." There are sometimes embedded in the mucous covering a number of globose bodies (pl. 10, *A*, *a*) of a darker color than the thallus, "sayal brown" to "mikado brown." These are interpreted as secondary thalli probably produced from conidia or detached cells of the primary thallus. In corresponding slant cultures held in an upright position the inoculum for secondary colonies would be carried with the slime to the previously sterile agar surface and there would develop into characteristic thalli. Such secondary growth, produced by strain 375, of group 2, on old cultures of wort and potato-dextrose agar is shown in plate 9, *E* and *F*, respectively, and also by *Elsinoë fawcetti* on potato-dextrose agar in plate 9, *G*.

A saltation isolated from a sector of 381B is characterized by absence of viscosity (pl. 10, *B* and *C*). It is slightly convolute in the central part, and the marginal region is applanate with well-marked concentric zones. The surface is covered with a short white down. The general color is the same as in normal sectors or slightly darker ("light drab") along the radial and concentric zones.

Strain 702A, representing group 2, is convolute and coal black. There are no traces of mucus, and tufts of white down are present on

the surface (pl. 10, *D*, *a*). From this culture has arisen a fan-shaped sector (*D*, *b*) of the pulvinate type of growth. It is concentrically zonate and uniformly covered with a short red down, "Hay's russet" to "dragon's-blood red." A bright-red color, "carmine" and "ox-blood red", is imparted to the medium. A similar, but less pronounced, coloration is produced by the saltation described for group 1.

A further description of variations of this species is published elsewhere (*6*). More or less similar variations may be cited for other organisms, as, for example, those reported by Conant (*10*), Davis (*12*), Hansen (*18*), and Muskatblit (*30*).

In the case of *Elsinoë veneta* (Speg.) Jenkins the decided difference noted between strains isolated by Anderson and Kadow (*1*) and a strain isolated by L. K. Jones [15] is explainable on the basis of what has been referred to here as the convolute and pulvinate types of growth. The strain isolated by Jones was pulvinate in character when first studied by Jenkins (*25*, pl. 1) and it has so remained. Anderson and Kadow (*1*) stated that this strain produced no conidia on corn-meal agar, while the other strains isolated by them produced conidia in abundance. This culture produced some conidia when studied in 1924–25 by Jenkins, but abundant conidial formation was not obtained.

TEMPERATURE RELATIONS IN CULTURE

To obtain data on the temperature relations of *Elsinoë australis*, cultures 381B and 702A, representing groups 1 and 2, respectively, were grown on potato-dextrose, glycerin, and rice agar slants. The cultures were held for 1 month at the following temperatures: 5.5°, 12°, 17.5°, 22°, 26.5°, 31°, 35°, and 39.5° C. The reaction to temperature was the same in all three media. There was no growth at 5.5° and 39.5°, some growth at 12° and 35°, and good growth at 31°. The best growth occurred at 26.5°.

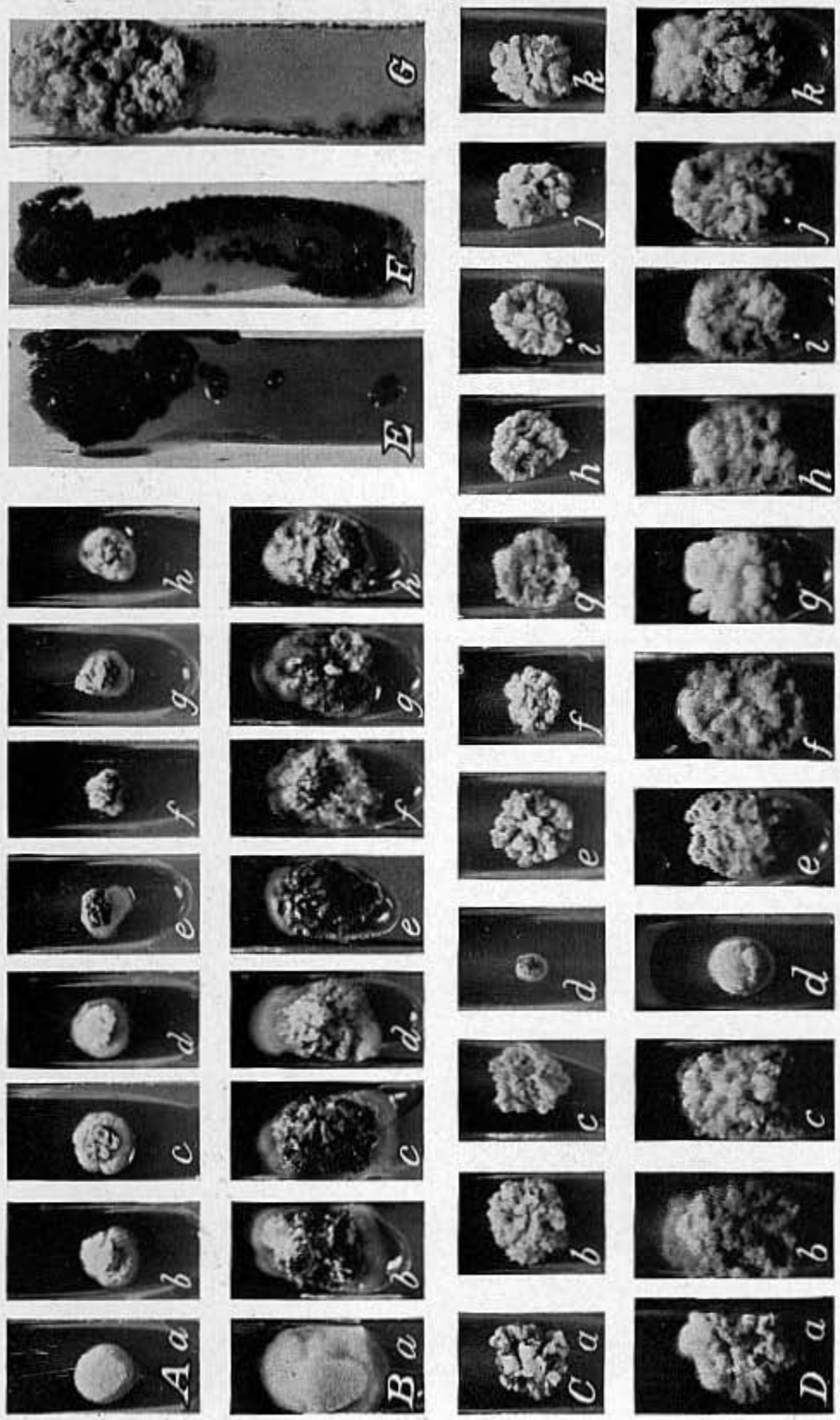
TABLE 2.—*Average diameter of potato-dextrose agar slant cultures of Elsinoë australis and E. fawcetti held for 1 month at different constant temperatures*

Organism	Strain no.	Diameter at indicated temperature							
		3.5° C.	9.5° C.	15° C.	20° C.	24.5° C.	29° C.	32.5° C.	37° C.
		Mm	*Mm*	*Mm*	*Mm*	*Mm*	*Mm*	*Mm*	*Mm*
E. australis	702A	[1] 1	5	8	9	15	14	9	[1] 1
E. australis	381B	[1] 1	5	8	13	19	17	11	[1] 1
E. fawcetti	776A	[1] 1	6	11	14	13	7	2	[1] 1

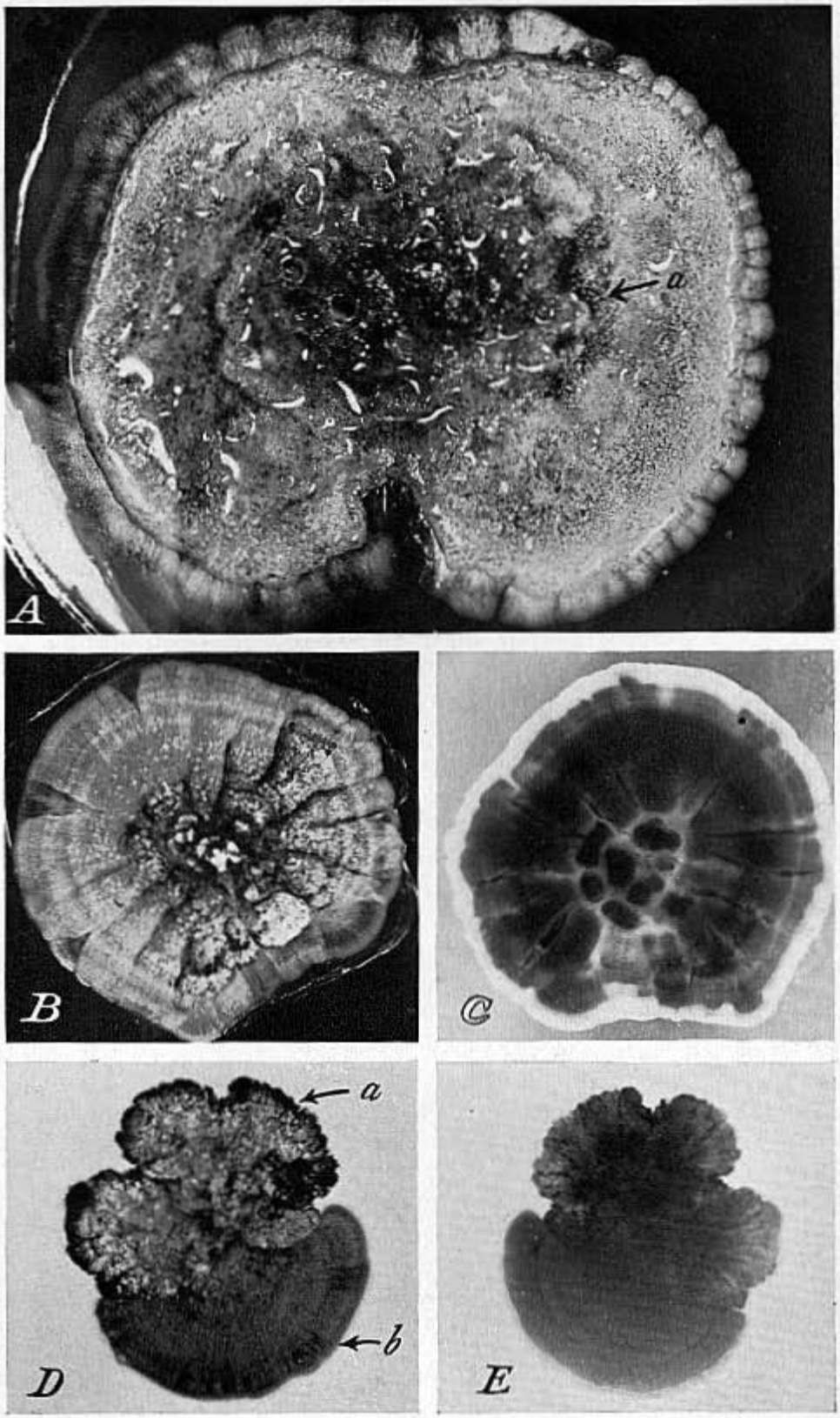
[1] Approximate diameter of original planting.

Following this preliminary experiment, a similar test was made in which was included a culture of *Elsinoë fawcetti* (strain 776A) from Sicilian lemon (table 2). Only potato-dextrose agar was used, and four tubes of each strain were prepared. The constant temperatures employed and the average diameter of the growth produced in 1 month are given in table 2, and representative cultures are shown in plate 11,

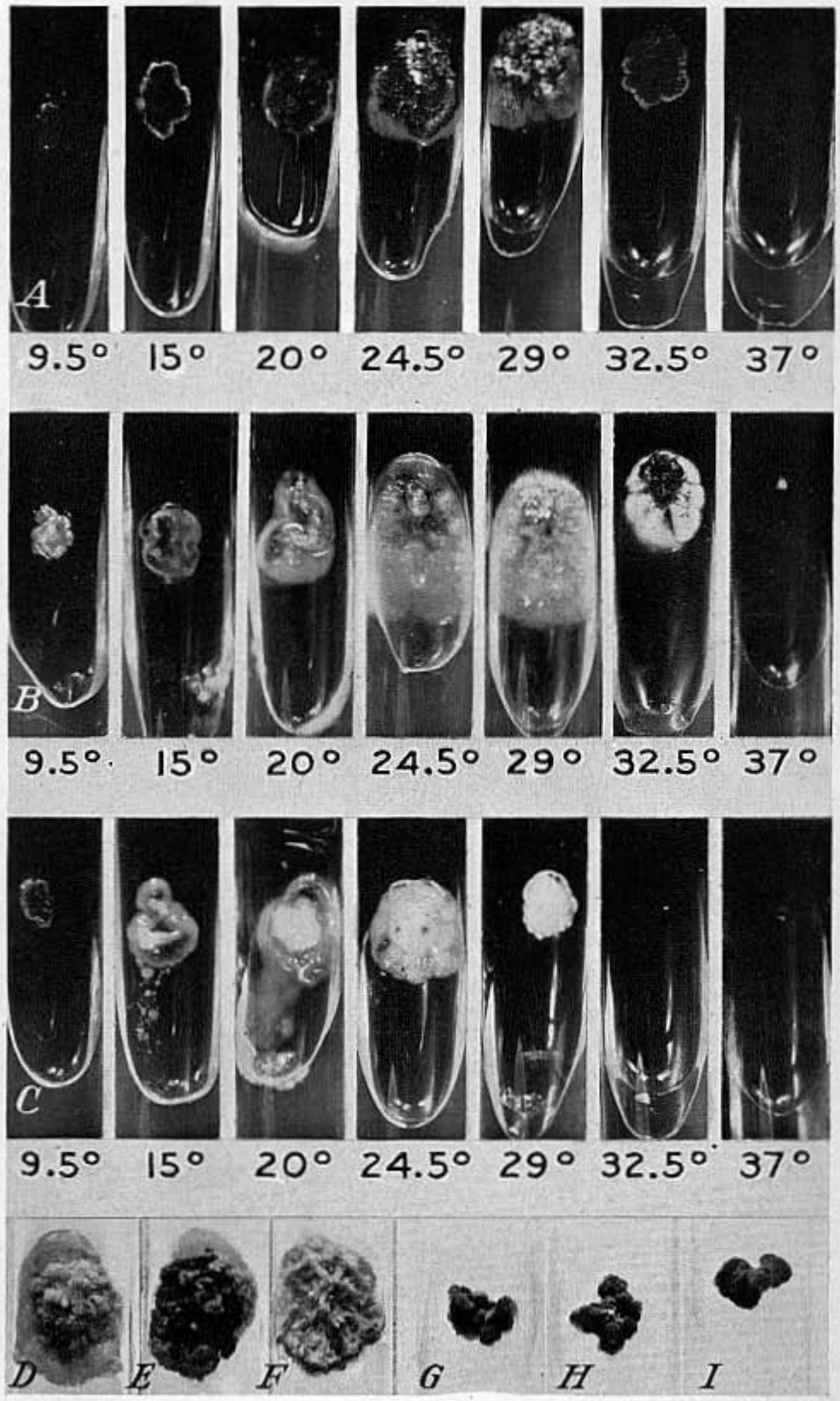
[15] This strain was obtained by Anderson and Kadow from the Department of Plant Pathology at Cornell University (*1*). It is a single ascospore isolation from Cumberland black raspberry made by Jones in 1922, and bears the number 340 of the Department of Plant Pathology, University of Wisconsin. A subculture was obtained by Jenkins and in 1927 a transfer from this was deposited in the culture collection of the Department of Plant Pathology at Cornell University.



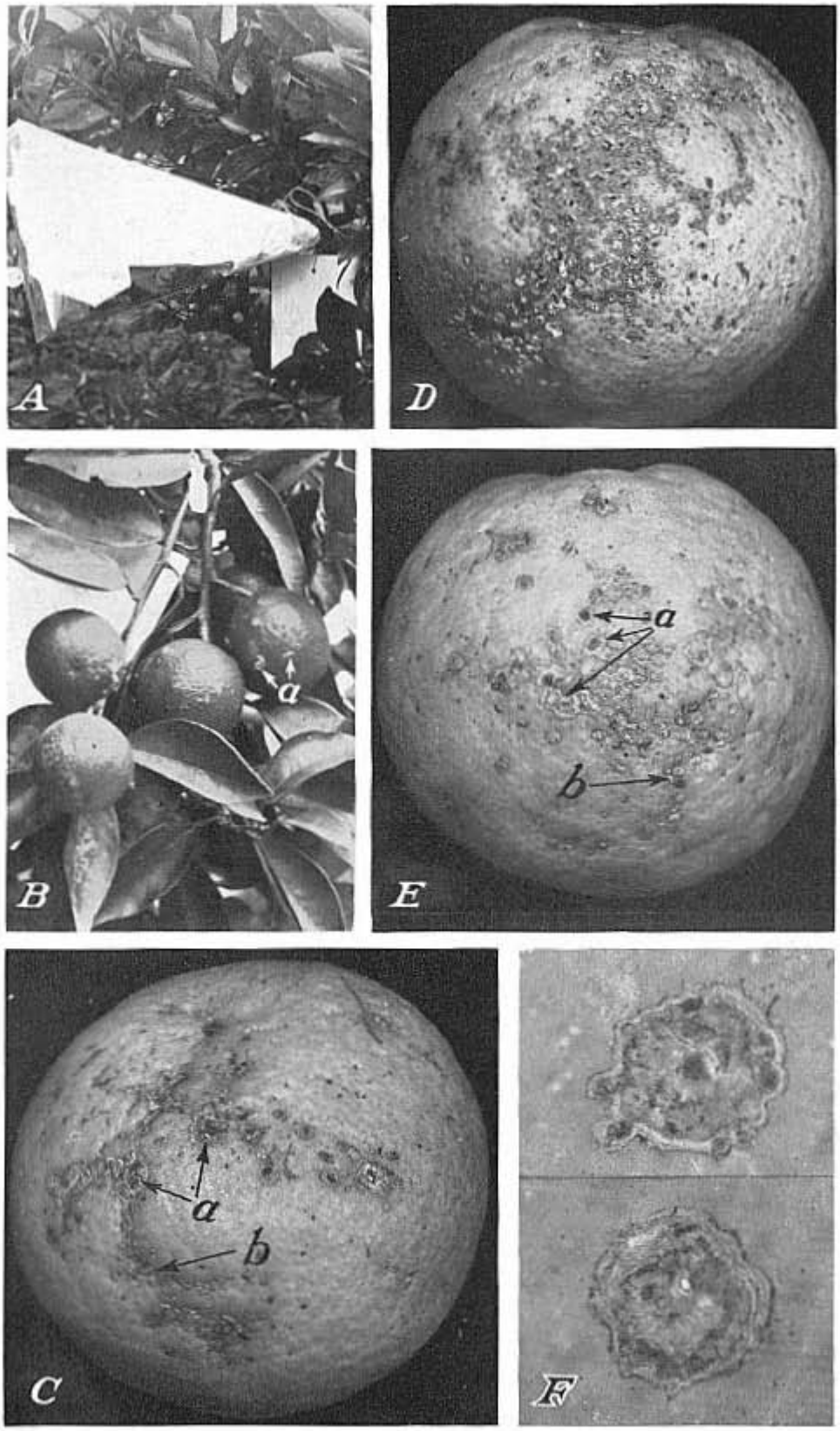
A–D, Comparison of *Elsinoë australis* (*A* and *B*) with *E. fawcetti* (*C* and *D*) on potato-dextrose agar; sources and arrangement of strains given in table 1; cultures in *A* and *C*, 12 days old; *B* and *D*, same cultures 26 days old; *E*, *F*, old cultures of *E. australis* (strain 376), and *G*, of *E. fawcetti*, showing growth from secondary colonies, *E*, on wort, *F* and *G*, on potato-dextrose agar. All × 1.



Old cultures of *Elsinoë australis* grown in Kolle flasks. × 1. *A*, Typical growth of strain 381B; spherical granules or secondary thalli shown at *a*. *B*, Saltant from 381B; *C*, lower side of same culture. *D*, *a*, Typical dark growth of strain 702A, together with a saltation, *b*; *E*, reverse of culture.



A and *B*, Potato-dextrose agar slant cultures of *Elsinoë australis* held for 1 month at indicated temperatures (° C.). *A*, Strain 702A, representing dark-colored growth of group 2; *B*, strain 381B, representing light-colored growth of group 1. *C*, *E. fawcetti*, strain 776A. *D*, *E*, and *F*, strains 345, 375, and 379 of *E. australis* grown at room temperature; *G*, *H*, and *I*, same strains grown at a cooler temperature. All × 1.



A, Triangular celluloid box employed in inoculating citrus fruits (× ⅓). *B–F*, Infection of sweet orange fruits of the variety Abacaxi inoculated with *Elsinoë australis*: *B*, photographed 3 months after inoculation (× ¾); *C*, *D*, and *E*, same fruits 1 year after inoculation (× 1); *F*, enlarged primary lesions (× 5).

A, *B*, and *C*. In this experiment the optimal temperature range for *E. fawcetti* was 20° to 24.5° C., the optimal temperature probably being near 21°. These results are in general agreement with those previously reported for this fungus (*16*, *32*, *39*). Compared with each other, the two strains of *E. australis* were in practical agreement in their temperature relations, although, as usual, culture 381B covered a greater area of the slant. The maximum growth for each strain occurred at 24.5° to 29°, the optimum probably being near 26°, as in the first experiment. There was thus a difference of approximately 5° C. between the optimal temperatures for strains of *Elsinoë fawcetti* and those of *E. australis*. At 32.5° the two fungi were readily separable by the fact that the former species produced slight growth and the latter good growth.

In a third experiment all the cultures available were grown for 1 month at 32.5°. The results obtained for the 14 strains of *E. fawcetti* and for 22 of the 25 strains of *E. australis* were in harmony with those obtained in the experiment just described, that is, *E. fawcetti* produced practically no growth and *E. australis* good growth. Of the three other strains of *E. australis* at this temperature, one produced no growth and another slight growth, while the third gave a larger amount of growth than any of the other cultures at this temperature and was different in appearance.

The results of these experiments doubtless have important practical applications. For example, other conditions being favorable, it would seem that *Elsinoë australis* might occur in districts with temperatures too high for *E. fawcetti* at the time of fruit setting or at other times of the year. Moreover, if introduced into districts where *E. fawcetti* occurs, this fungus might become established there, since it also grows at the lower temperatures favorable to *E. fawcetti*. It is therefore evident that the conclusions of H. S. Fawcett (*16*) and of Peltier and Frederich (*32*), based on the temperature relations of *E. fawcetti*, may not be applicable to *E. australis*.

INOCULATIONS

Inoculation experiments on sweet orange, variety Abacaxi, with cultures of *Elsinoë australis* showed clearly that this fungus is the cause of sweet orange fruit scab. These experiments were made in a small experimental grove at Cantareira (near São Paulo). The disease was entirely absent when the first inoculations were made, October 10, 1932, and since the introduction of the fungus in this manner there have been discovered only a few lesions on fruits not artificially inoculated. In addition to the inoculations on sweet orange with *E. australis*, certain others were made in order to obtain the comparative data shown in table 3.

The method of inoculation, adapted from Winston (*39*, *p. 32*) in his inoculation experiments in Florida with *Elsinoë fawcetti*, is as follows: Macerated cultural inoculum spread on wet cotton squares is applied to young fruits less than 1 cm in diameter or to young leaves from 1 to 3 cm in length. This is covered with another thin layer of cotton. Each cluster of fruits or leaves thus inoculated is wrapped in wet absorbent paper and then encased in a triangular celluloid box (pl. 12, *A*). From each cluster a few fruits corresponding to those inoculated are employed as controls.

TABLE 3.—*Results of inoculating young fruits of sweet orange, tangerine, and laranja cravo and young leaves of sour orange and avocado with cultures of Elsinoë australis, E. fawcetti, and Sphaceloma perseae*

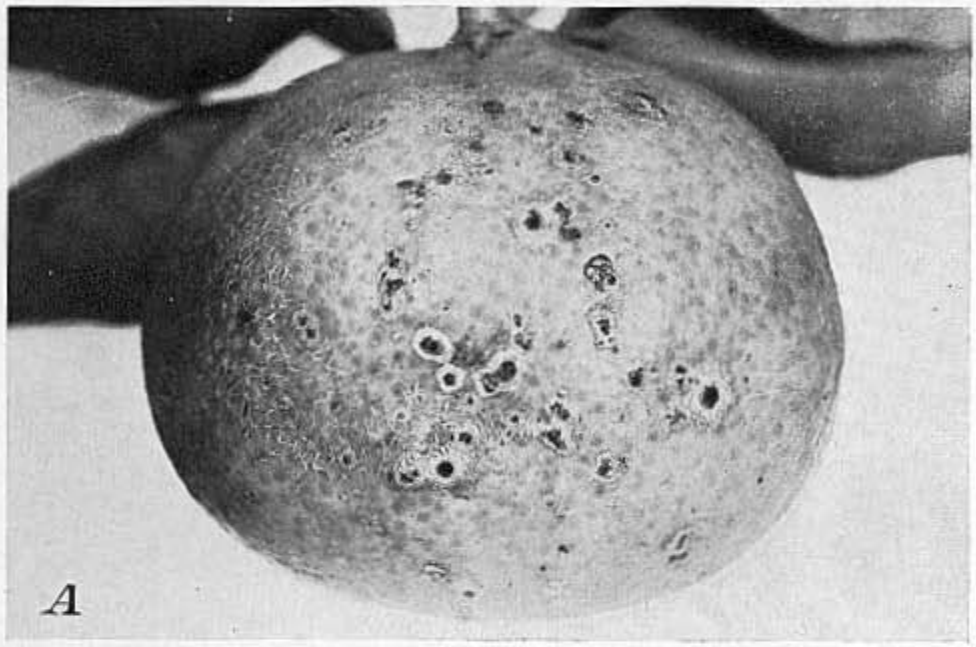
Test no.	Inoculum		Fruits or plants inoculated		Positive infections
	Source and strain no.[1]	Organism	Name	Number	
					Number
1	Sweet orange (702A and 822A)	*E. australis*	Sweet orange (fruits)	10	8
	Different kinds of citrus, but not sweet orange or tangerine.	*E. fawcetti*	do	12	0
	Avocado (830A)	*S. perseae*	do	6	0
	Sweet orange (702A and 822A)	*E. australis*	Tangerine (fruits)	8	8
	Sweet orange and tangerine (702A, 822A, and 933A).	*E. australis*	Sour orange (leaves) [2]	24	0
	Different kinds of citrus, but not sweet orange or tangerine.	*E. fawcetti*	do	16	1
	Avocado (830A)	*S. perseae*	do	2	0
2	Sweet orange fruits (822A)	*E. australis*	Sweet orange (fruits)	5	1
	Sour orange leaf (128B)	*E. fawcetti*	do	([3])	
	Avocado (830A)	*S. perseae*	do	6	0
	Sweet orange fruits (822A)	*E. australis*	Laranja cravo (fruits)	6	[4] 6
	Sour orange leaf (128B)	*E. fawcetti*	do	8	8
	Avocado (830A)	*S. perseae*	do	8	0
	Sweet orange fruit (822A)	*E. australis*	Avocado (leaves) [2]	20	0
	Sour orange leaf (128B)	*E. fawcetti*	do	20	0
	Avocado (830A)	*S. perseae*	do	40	26
3	Sweet orange leaf (381B)	*E. australis*	Sweet orange (fruits)	4	4

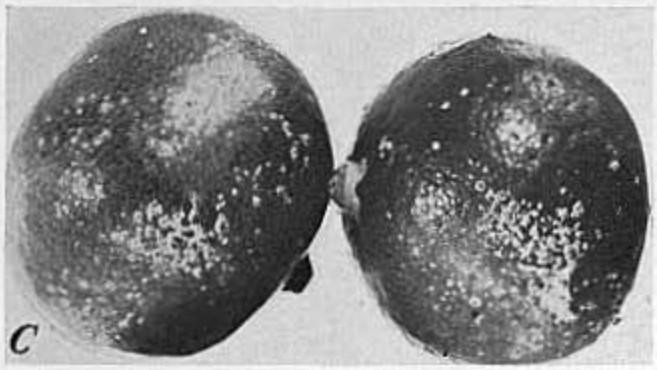
[1] See table 1.
[2] 3 to 5 leaves inoculated on each plant used.
[3] All fruits dropped.
[4] An isolation (strain 519B) was made from this set of inoculations.

Owing to conditions not connected with the experiment, heavy shedding of the fruits occurred in each of the three tests, greatly reducing the number of fruits on which infection readings could be made. It will be noted that *Elsinoë australis* gave infection on tangerine and laranja cravo as well as on sweet orange (pl. 12, *B–E;* pl. 13, *A* and *B*) and that all but 6 of the 33 inoculations with this fungus gave positive results (table 3). No infection resulted from inoculations on sweet orange with *E. fawcetti* or on sour orange with *E. australis*. Both fungi infected laranja cravo. Neither infected avocado, and *Sphaceloma perseae* gave infection only on avocado. In every case the lesions produced were typical for the disease represented. The controls all remained healthy. The single plant of sour orange that became diseased from inoculation with *E. fawcetti* showed good infection (pl. 13, *D*). On the other plants of sour orange absence of infection with this fungus was of course due to some unfavorable condition.

The lesions produced by *Elsinoë australis* on fruits of laranja cravo were larger and more prominent than those produced by *E. fawcetti*. They were also darker, owing chiefly to the presence of the black growth of the causal fungus on the lesions (pl. 13, *B*). The fruits of laranja cravo inoculated with *E. australis* were gathered 2 months after inoculation, whereas those inoculated with *E. fawcetti* were left on the tree for 2 months more. The latter fruits showed more severe infection at the end of that time than they had 2 months previously, indicating secondary infection (*C*). *E. australis*, as reisolated from the laranja cravo fruits inoculated with this fungus, constitutes the first of several reisolations of the organism. Some of these are from inoculations made with cultures from ascospores.[16]

[16] Unpublished data.





A and *B*. Infection of fruits of (*A*) tangerine and (*B*) laranja cravo, both inoculated with the same strain of *Elsinoë australis*, *A*, photographed 9 months, and *B*, approximately 2 months after inoculation. Both × 2. *C* and *D*. Infection of fruit of laranja cravo and leaf of sour orange, both inoculated with *E. fawcetti*; *C*, photographed approximately 4 months, and *D*, approximately 3 months after inoculation. *C*, × 1; *D*, × 2½.

Sweet orange fruits inoculated with *Elsinoë australis* became infected in about 10 days, and the lesions were limited in number. Such primary lesions on immature and on ripe fruits are shown in plate 12, *B*, *a*, and *F*. Primary lesions (*a*) from which secondary lesions (*b*) have evidently been formed are shown in *C* and *E*. Under grove conditions the primary infections may likewise be limited in number, as has been observed in the case of very young fruits. There are often not more than four or five primary lesions, but they are unusually large and prominent, and fructifications of the pathogen are present practically from the first. After a month or so the number of scabs on a given fruit may have greatly increased, evidently as a result of secondary infection from these primary lesions. A clear distinction between large primary and small secondary lesions is apparent when conditions are unfavorable for infection immediately following initial infection; otherwise the primary scabs are still being produced when the first secondary infections occur, and the resulting scabs are of all sizes. In nature the production of secondary lesions assists in explaining the existence of heavy infection despite the supposedly limited amount of inoculum at the beginning. This inoculum almost certainly comes from the following sources: (1) The comparatively small number of leaves showing infection; (2) out of-season green scabbed fruits; (3) ripe scabbed fruits left on the tree from the previous crop; and (4) twig infection.

SUMMARY

This paper deals with the sweet orange fruit scab, as yet identified only as it is found in South America.

The following sweet orange varieties are shown to be affected in São Paulo: Bahia Navel, Pera, Sabará, Selecta, São Sebastião, Santos, Lima, and Mangaratiba. The Abacaxi variety also has been proved to be susceptible. The disease has been observed in São Paulo on other kinds of citrus, for example, the tangerine of Brazil, tangerona, sweet lime known as lima da Persia, a sour lime known as limão seda, an unidentified citrus variety called laranja cravo, and a pointed-leaf papeda. In Argentina the sweet orange varieties, Ruby Blood, Sweet Mediterranean, Valencia, and Criolla, are known to be affected.

Sweet orange fruit scab has been identified from Argentina, Paraguay, Uruguay (apparently), and Brazil. In Brazil it is found in the States of São Paulo, Rio Grande do Sul, Minas Gereas, Rio de Janeiro, and in the Districto Federal. The earliest records of the disease are from Paraguay in 1882, São Paulo in 1900 (apparently), and Rio Grande de Sul in 1923.

The disease is of economic importance particularly because it blemishes the fruit. Beginning with the exportation of oranges to Europe (about 1929) Federal regulations were inaugurated in Brazil to prevent the shipment of low-grade fruit. The fruit scab then became a matter of concern to citrus growers of São Paulo. In some groves from 50 to 60 percent of the fruit was found blemished by the disease, some of it severely, and in numerous other groves as much as one-third of the crop was unfit for export.

The disease affects chiefly the fruits, rarely the leaves and twigs. It has the general aspect of sour orange scab, although there are appreciable differences in the character of the lesions. The symptoms of the disease are described.

In 1933 the causal fungus was described as *Sphaceloma fawcetti viscosa*. In 1936 the perfect stage was discovered and has been described as *Elsinoë australis* and the conidial stage designated *Sphaceloma australis*. The conidial stage is not characterized by the Cladosporiumlike development of *E. fawcetti* and *S. perseae*. Numerous persistent acervuli and sporodochia are produced on the lesions. They are warm buff to clove brown and fuscous-black.

Parallel cultural comparisons have shown that *Elsinoë australis* may be distinguished culturally from *E. fawcetti* and that the strains of *E. australis* may be divided into two main groups. Saltations may be produced, and these have been isolated and cultured separately.

In cultures grown at different constant temperatures, between 3.5° and 39.5° C., both *Elsinoë australis* and *E. fawcetti* grew from 9.5° to 35°. The best growth of *E. australis* occurred at 24.5° to 29°, the optimum probably being near 26°; while the best growth of *E. fawcetti* occurred at 20° to 24.5°, the optimum probably being near 21°.

In inoculation experiments *Elsinoë australis* from sweet orange gave positive results on sweet orange, tangerine, and laranja cravo. The organism was reisolated. *E. fawcetti* infected laranja cravo and sour orange, but not the sweet orange. *Sphaceloma perseae* gave good infection on avocado. Cross inoculations with this fungus on citrus gave negative results, as did cross inoculations on avocado with *E. fawcetti* and *E. australis*.

LITERATURE CITED

(1) Anderson, H. W., and Kadow, K. J.
1932. ANTHRACNOSE AND GRAY BARK OF RED RASPBERRIES. IDENTIFICATION AND CONTROL. Ill. Agr. Expt. Sta. Bull. 383, pp. 283–292, illus.

(2) Bitancourt, A. A.
1934. AS MANCHAS DAS LARANJAS. Inst. Biol. Defesa Agr. e. Anim. São Paulo, Folheto 53, 135 pp., illus.

(3) ——— Fonseca, J. P., and Autuori, M.
1933. MANUAL DE CITRICULTURA II. PARTE. DOENÇAS, PRAGAS E TRATAMENTOS. 212 pp., illus. São Paulo.

(4) ——— and Jenkins, A. E.
1936. ELSINOE FAWCETTI, THE PERFECT STAGE OF THE CITRUS SCAB FUNGUS. Phytopathology 26: 393–396, illus.

(5) ——— and Jenkins, A. E.
1936. THE PERFECT STAGE OF THE SWEET ORANGE FRUIT SCAB FUNGUS. Mycologia 28: 489–492, illus.

(6) ——— and Jenkins, A. E.
VARIACÕES DE ELSINOË AUSTRALIS BITANCOURT AND JENKINS. (Abstract.) Rodriguésia. (In press.)

(7) Bondar, G.
1929. INSECTOS DAMNINHOS E MOLESTIAS DA LARANJEIRA NO BRASIL. Lab. Path. Veg. Bahia, Bol. 7, 79 pp., illus.

(8) Butler, E. J.
1930. SOME ASPECTS OF THE MORBID ANATOMY OF PLANTS. Ann. Appl. Biol. 17: [175]–212, illus.

(9) Carvalho, R. de S.
1932. CONTRIBUIÇÃO AO ESTUDO DAS CAUSAS DE ALGUMAS PODRIDÕES DOS FRUCTOS CITRICOS NO ESTADO DE SÃO PAULO. 20 pp., illus. Piracicaba.

(10) Conant, N. F.
1936. STUDIES IN THE GENUS MICROSPORUM. I. CULTURAL STUDIES. Arch. Dermatol. and Syphilology 33: [665]–683, illus.

(11) CUNNINGHAM, H. S.
1928. THE HISTOLOGY OF LESIONS PRODUCED BY SPHACELOMA FAWCETTI JENKINS ON LEAVES OF CITRUS. Phytopathology 18: 539–545, illus.

(12) DAVIS, D. J.
1921. THE IDENTITY OF AMERICAN AND FRENCH SPOROTRICHOSIS. Wis. Univ. Studies in Sci. 2: 104–130.

(13) DORSETT, P. H., SHAMEL, A. D., and POPENOE, W.
1917. THE NAVEL ORANGE OF BAHIA; WITH NOTES ON SOME LITTLE-KNOWN BRAZILIAN FRUITS. U. S. Dept. Agr. Bull. 445, 35 pp., illus.

(14) FAWCETT, G. L.
1920. LA VERRUGA O "SCAB" DE LOS CITRUS. Rev. Indus. y. Agr. Tucumán 10: 124–128, illus.

(15) ———
1931. LA VERRUCOSIS DE LOS "CITRUS." Rev. Indus. y Agr. Tucumán 21: 59–62, illus.

(16) FAWCETT, H. S.
1921. SOME RELATIONS OF TEMPERATURE TO GROWTH AND INFECTION IN THE CITRUS SCAB FUNGUS CLADOSPORIUM CITRI. Jour. Agr. Research 21: 243–253.

(17) GIRARDI, I.
1922. LA SARNA DE LAS NARANJAS. SU DESASTROSO DESARROLLO. Uruguay Defensa Agr. Bol. 3: 108.

(18) HANSEN, H. N.
1935. A PHENOMENON IN FUNGI IMPERFECTI. Science (n. s.) 82: 593.

(19) JENKINS, A. E.
1925. THE CITRUS SCAB FUNGUS. Phytopathology 15: 99–104, illus.

(20) ———
1931. DEVELOPMENT OF THE CITRUS-SCAB ORGANISM, SPHACELOMA FAWCETTI. Jour. Agr. Research 42: 545–558, illus.

(21) ———
1933. A SPHACELOMA ATTACKING NAVEL ORANGE FROM BRAZIL. Phytopathology 23: 538–545, illus.

(22) ———
1935. SPHACELOMA PERSEAE THE CAUSE OF AVOCADO SCAB. Jour. Agr. Research 49: 859–869, illus.

(23) ———
1936. AUSTRALIAN CITRUS SCAB CAUSED BY SPHACELOMA FAWCETTI SCABIOSA. Phytopathology 26: 195–197, illus.

(24) ———
1936. A SPHACELOMA ON FRUIT OF HESPERETHUSA CRENULATA, A REMOTE CITRUS RELATIVE FROM INDIA. Phytopathology 26: 71–73, illus.

(25) ———
1936. COMPARAÇÕES CULTURAES E INOCULAÇÕES EM VIDEIRA COM OS FUNGOS "ELSINOE FAWCETTI", E AMPELINA", E "E. VENETA." Arch. Inst. Biol. [São Paulo] 7: [23]–32, illus.

(26) ——— and FAWCETT, H. S.
1933. RECORDS OF CITRUS SCAB MAINLY FROM HERBARIUM SPECIMENS OF THE GENUS CITRUS IN ENGLAND AND THE UNITED STATES. Phytopathology 23: 475–482, illus.

(27) MARCHIONATTO, J. B.
1934. ARGENTINE REPUBLIC: PLANT DISEASES OBSERVED IN THE COUNTRY. CITRUS SCAB. Internat. Inst. Agr., Internat. Bull. Plant Protect. Reprint from Internat. Rev. Agr. 8: 241.

(28) MÜLLER, A. S.
1935. BRAZIL: SOME DISEASES OBSERVED IN THE STATE OF MINAS GERAES IN 1934. Internatl. Inst. Agr., Internatl. Bull. Plant Protect. Reprint from Internatl. Rev. Agr. 9: 175–176.

(29) ——— and BITANCOURT, A. A.
1936. AS DOENÇAS DOS CITRUS NO HERBARIO A. PUTTEMANS. Biologico 2: 65–66.

(30) MUSKATBLIT, E.
1933. OBSERVATIONS ON EPIDERMOPHYTON RUBRUM OR TRICHOPHYTON PURPUREUM. Mycologia 25: 109–116, illus.

(31) NOACK, F.
1900. PILZKRANKHEITEN DER ORANGENBÄUME IN BRASILIEN. Ztschr. Pflanzenkrank. 10: [321]–335, illus.

(32) PELTIER, G. L., and FREDERICH, W. J.
1926. EFFECTS OF WEATHER ON THE WORLD DISTRIBUTION AND PREVALENCE OF CITRUS CANKER AND CITRUS SCAB. Jour. Agr. Research 32: 147–164, illus.

(33) RIDGWAY, R.
1912. COLOR STANDARDS AND COLOR NOMENCLATURE. 43 pp., illus. Washington, D. C.

(34) SILVEIRA DA MOTA, J.
1936. A SARNA OU VERRUCOSE DAS LARANJAS—SUA CAUSA E MEIOS DE COMBATE. Diario de noticias, Porto Alegre, Rio Grande do Sul., Nov. 18.

(35) SMITH, E. F.
1920. AN INTRODUCTION TO BACTERIAL DISEASES OF PLANTS. 688 pp., illus. Philadelphia and London.

(36) SPEGAZZINI, C.
1920. SOBRE ALGUNAS ENFERMEDADES Y HONGOS QUE AFECTAN LAS PLANTAS DE "AGRIOS" EN EL PARAGUAY. An. Soc. Cient. Argentina 90: [155]–188, illus.

(37) SWINGLE, W. T.
1914. CITRUS AND RELATED GENERA. In Bailey, L. H. The standard cyclopedia of horticulture, 6 v. New York. Entry under genus names.

(38) VELLARD, J.
1934. CONFÉRENCE SUR LES GUAYAKI. Bol. Mus. Nac. Rio de Janeiro 10: 71–94, illus.

(39) WINSTON, J. R.
1923. CITRUS SCAB: ITS CAUSE AND CONTROL. U. S. Dept. Agr. Bull. 1118, 39 pp., illus.

(40) ——— BOWMAN, J. J., and BACH, W. H.
1925. RELATIVE SUSCEPTIBILITY OF SOME RUTACEOUS PLANTS TO ATTACK BY THE CITRUS-SCAB FUNGUS. Jour. Agr. Research 30: 1087–1093.

(41) WRIGHT, C., and MOREIRA, S.
1934. EXPERIENCIA DE PULVERIZAÇÃO PARA SE COMBATER A VERRUGOSE DA LARANJA DOCE. (SPHACELOMA FAWCETTI VAR. VISCOSA.) Rev. Agr. [Piracicaba] 9: 3–9.